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July 1, 2024

VIA FEDEX AND E-MAIL

Suna Y. Sariscak, Chief Air Quality Permits Program
Angelo J. Bianca, Deputy Director Air & Radiation Administration
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, MD 21230

RE: Aligned Data Center Air Permit

Dear Suna and Angelo:

Enclosed please find a copy of an application for a Permit to Construct filed on behalf of Aligned Data Centers (MD) PropCo, LLC ("Aligned"). In addition to the application, this letter serves to provide confirmation and supporting documentation that the Aligned Data Center Project (the "Project") is "Critical Infrastructure" and thus, is exempt from needing to obtain a Certificate of Public Convenience and Necessity ("CPCN") or CPCN Exemption under Public Utilities Article ("PUA") § 7-207.

Under PUA §1-101, "Critical Infrastructure" means "assets, systems, and networks, whether physical or virtual, considered by the U.S. Department of Homeland Security to be so vital to the United States that their incapacitation or destruction would have a debilitating effect on one or more of the following..." The definition then specifically includes any Data Center, as defined in § 11–239 of the Tax-General Article. The Project meets that definition.

PUA § 7-207(b) requires the issuance of a "certificate of public convenience and necessity" (CPCN) for the construction of a "generating station." However, the generators covered by the attached application are not individually, nor collectively, a "generating station" and therefore do not require a CPCN pursuant to PUA § 7-207.1.

The General Assembly passed Senate Bill 474 ("SB474") during the 2024 Legislative Session, which altered the definition of "Generating Stations" for the purpose of exempting certain facilities from having to obtain a CPCN or CPCN exemption from the Maryland Public Service Commission. SB474 came into effect on July 1, 2024. In pertinent part, SB474 states that a "Generating Station" does not include a "Generating Unit or Facility" if that Unit or Facility meets three requirements – each of which are met here by the Project.

First, the generators must be intended for use only for emergency backup or test and maintenance operations. Specifically, the first approved use is "for the production of electricity for…onsite emergency backup at a facility when service from the electric company is interrupted due to electric distribution or transmission system failure or when there is equipment failure at the site where critical infrastructure is located." The second approved use is for "test and maintenance operations necessary to ensure functionality of the generating unit or facility in the event of a service interruption from the electric company due to electric distribution or transmission system failure or when there is equipment failure at a site where critical infrastructure is located."

As referenced in parts 2 and 3.1 of the Application, the generators will only be used for onsite emergency backup or testing and maintenance operations in the event of disruption of utility service to the Data Center or equipment failure, consistent with the requirements of PUA 7-207.1(a)(3)(I).

Second, PUA § 7-207.1 provides this CPCN exemption to a Generating Unit or Facility that "is installed with equipment that prevents the flow of electricity to the grid." The Project will have technology in place to prevent the flow of electricity to the grid.

Finally, PUA § 7-207.1 provides this CPCN exemption to a Generating Unit or Facility that "is installed at a facility that is part of critical infrastructure if the facility complies with all applicable regulations regarding noise level and testing hours." As referenced in Appendix D of the Application, the Project will comply with all applicable regulations regarding noise level and testing hours.

As demonstrated in this Cover Letter and the Application, the Project meets the definition of Critical Infrastructure as a Generating Unit, in addition to all requirements outlined in SB474 exempting the Project from the requirement to obtain a CPCN or CPCN Exemption.

Please do not hesitate to contact me with any questions.

Sincerely,

/s/ Michael C. Powell

Michael C. Powell

PERMIT TO CONSTRUCT APPLICATION

Aligned Data Centers (MD) PropCo, LLC / Data Center IAD04

Prepared By:

TRINITY CONSULTANTS
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Suite A
Frederick, MD 21703
240.379.7490

July 1, 2024

Project 242101.0065

Trinity Consultants

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1. EXECUTIVE SUMMARY

Aligned Data Centers (MD) PropCo, LLC (Aligned) is proposing to construct a data center in Frederick County, Maryland identified as IAD04 (the facility). Frederick County is designated as a nonattainment area for ozone and is also part of the Ozone Transport Region (OTR). Nitrogen oxides (NO_X) and volatile organic compounds (VOC) are regulated precursors of ozone in Maryland. Emissions from this facility are due to diesel fuel combustion in the emergency generators.

In this application, Aligned is proposing a fuel limit for all the stationary diesel-fired emergency generators to limit the facility-wide potential to emit (PTE) to below the applicable major source thresholds for the New Source Review (NSR) and Title V permitting programs. As such, this facility will be classified as a synthetic minor source under both the NSR and Title V programs.

This application is to the Maryland Department of the Environment (MDE) for a Permit to Construct. The remainder of this application consists of the following parts:

- Section 2 provides company background information and a description of the facility and emission units;
- Section 3 describes the emission calculation methods;
- Section 4 details potentially applicable regulations for this facility;
- Section 5 provides details of proposed monitoring and recordkeeping;
- Appendix A contains MDE application forms;
- Appendix B contains detailed emission calculations;
- Appendix C includes the manufacturer specification and emission sheets;
- Appendix D provides documentation that a Certificate of Public Convenience and Necessity (CPCN) is not required for this project;
- Appendix E contains a letter documenting zoning approval;
- Appendix F contains the Environmental Justice (EJ) screening report for the site; and
- Appendix G provides evidence of workman's compensation insurance.

2. BACKGROUND INFORMATION

2.1 Aligned Data Centers

Aligned was founded in 2013 and was the first company to offer a data center delivery model based on securing and expanding capacity as needed, so that customers could pay only for the power they used. Aligned has over 3 gigawatts combined across more than 60 data centers under management and future capacity with 23 existing data center campuses in 17 markets.

Aligned is committed to solving the world's toughest sustainability challenges associated with data center infrastructure, energy consumption and water usage. Aligned's adaptive data center platform is focused on helping companies deliver greater business value with less costly energy and infrastructure resources. Aligned matches 100% of load with renewable sources and are committed to progressing our goal of zero-carbon hosting by 2040. Aligned's data centers are designed to use no water.

2.2 IAD04 Facility

The facility will be constructed in Frederick County, Maryland, and will have the following emission units:

- One hundred sixty-eight (168) stationary diesel-fired engine-driven emergency generators rated at 3,000 kilowatts (kW) each and each equipped with a selective catalytic reduction (SCR) device to control NO_X emissions; and
- Four (4) stationary diesel-fired engine-driven emergency generators rated at 1,000 kW each.

In anticipation of supply chain restrictions, Aligned is requesting the ability to install either Caterpillar C175-16 or 3516E for the 168 3,000 kW generators and either Caterpillar C32 or MTU 16V2000 DS1000 for the four 1,000 kW generators. For each generator size, emissions from the two potential models are similar and although Aligned prefers to install all one model generator of each size, supply chain issues have caused delays at other data centers across the country. As such, Aligned will install 168 3,000 kW generators which may be all model C175-16, all model 3516E, or some combination of the two models and four 1,000 kW generators which may be all model C32, all model 16V2000 DS1000, or some combination of the two models. The proposed fuel limit and facility potential emissions are based on the worst-case emissions from all proposed model types. Aligned will include the model of each generator in the required Permit to Operate application.

Each of the 3,000 kW generators will be equipped with a closed-loop SCR system for controlling NO_X emissions. These SCR systems may be one of two models either manufactured by Safety Power or Catalytic Combustion. The two makes are very similar and will achieve the same NO_X reduction. The monitoring requirements of these system described in this report will apply to either model.

The emergency generators are composed of two distinct parts, the diesel engine and associated electric generator. These generators are used to supply power to protect critical data center functions if off-site power is lost. The diesel-fired engines will be powered by ultra-low sulfur diesel (ULSD). The emergency generators are certified as meeting the United States Environmental Protection Agency (U.S. EPA) Tier 2 emission standards. Each engine will be equipped with an individual belly tank for storage of fuel.

3. EMISSION CALCULATIONS

This section describes the methodology used to quantify the emissions from the proposed emission units at the facility. Emissions from the facility will be primarily from the combustion of fuel in the diesel-fired engines as well as from the fuel cells. These emissions include:

- Nitrogen oxides (NO_X)
- Volatile organic compounds (VOC)
- Carbon monoxide (CO)
- Sulfur dioxide (SO_2)
- Particulate matter (PM)
- Particulate matter with an aerodynamic diameter less than 10 microns (PM_{10})
- Particulate matter with an aerodynamic diameter less than 2.5 microns ($PM_{2.5}$)
- Hazardous air pollutants (HAPs)

Detailed emission calculations are included in Appendix B.

3.1 Calculation Methodology

To quantify emissions from the diesel-fired engine-driven emergency generators, Aligned is using exhaust emission data from the equipment manufacturer for the engine model and emission factors from U.S. EPA's AP-42, Section 3.4, Large Stationary Diesel and All Stationary Dual-fuel Engines (October 1996) and Title 40 of the Code of Federal Regulations (40 CFR) Part 98. The manufacturer data includes emission factors in mass per power output per hour (e.g., grams per brake horsepower hour or g/BHP-hr) at various operating loads. Emissions for CO, NO_X, VOC, PM, PM_{10}, and $PM_{2.5}$ are calculated using emission factors from the unit manufacturer. It is assumed that the manufacturer emission specifications include both condensable and filterable particulate matter. Emissions of SO_2 and HAPs are calculated using the appropriate emission factors from AP-42, Section 3.4 and GHGs using the appropriate emission factors from 40 CFR Part 98.

As stated above, 168 of the proposed stationary emergency generators will be either Caterpillar Model C175-16 or 3516E, both with an electrical output rating of 3,000 kW. The remaining four proposed stationary emergency generators at the facility will be either Caterpillar Model C32 or MTU Model 16V2000 DS1000, both with an electrical output rating of 1,000 kW. Emissions data from both potential 3,000 kW engine-generator sets and 1,000 kW engine-generator sets are included in the emissions calculations. The engine manufacturer emission specification sheets for each engine model are included in Appendix C.

3.2 Proposed Fuel Limits

Aligned is requesting the following 12-month rolling facility-wide limits to qualify as a synthetic minor source under both the NSR and Title V programs:

- 24.8 tpy of NO_X;
- 275,000 gallons of diesel fuel combined for operation of the 3,000 kW generators with SCR; and
- 90,000 gallons of diesel fuel combined for operation of the 3,000 kW generators without SCR and operation of the 1,000 kW generators.

Each generator will also be limited to 100 hours per year for maintenance, testing, and nonemergency operation in accordance with U.S. EPA regulations (refer to Section 4).

Aligned proposes to demonstrate compliance with the proposed limits by tracking actual fuel usage in the generators and using emission factors in units of pounds of NO_X emissions per gallon of diesel fuel (lb/gal). These emission factors are provided in Table B-2 of Appendix B.

The proposed fuel limits were developed based on expected maintenance and testing hours for the emergency generators while leaving an ample margin of safety to ensure continued compliance. Table 3-1 provides details of manufacturer-required routine testing on each of the generators.

Table 3-1. Maintenance Checks and Readiness Testing

Description	Frequency	Load	Duration per Event	Hours per Year per Generator
Readiness Test	Monthly	0%	15 Minutes	3
PM Checks	Quarterly	75%	30 Minutes	2
Load Test	Annual	100%	1 Hour	1
UPS Test	Annual	75%	2 Hours	2
			Total:	**8**
			Total with 20% Buffer:	**10**

PM = Preventative Maintenance
UPS = Uninterruptible Power Supply

Table 3-2 provides an analysis of the proposed fuel limits compared to fuel usage expected for the maintenance checks and readiness testing in Table 3-1.

Table 3-2. Proposed Fuel Limits Analysis

	Uncontrolled Operation	SCR-Controlled Operation
Proposed Fuel Limit	90,000 gal/yr	275,000 gal/yr
Anticipated Fuel Usage for Maintenance and Testing (with 20% buffer)	80,179 gal/yr	124,674 gal/yr
Remaining Fuel for Other Operation	9,821 gal/yr	150,326 gal/yr
Hours for Other Operation – each 3,000 kW generator	~1.2 hr/yr at 10% load	~5.3 hr/yr at 75% load
Hours of Other Operation – each 1,000 kW generator	~5.3 hr/yr at 75% load	Not Applicable

As shown in Table 3-2, the proposed facility-wide fuel limits are able to accommodate all maintenance checks and readiness testing as well as more than five hours of additional runtime for power outages, unplanned maintenance, operator training, or other necessary run types. Power outages in the area of the planned facility are expected to be well below five hours per year. In the last three years, the two 230 kilovolt lines that will provide power to the site have both experienced only one momentary (less than one minute) outage. As such, Aligned believes that the proposed fuel limits will account for all operation of the generators.

In addition to the fuel limits providing an adequate compliance margin, it is also important to note that the potential emissions for this site are calculated using a conservative method. The potential emissions shown throughout this application assume all fuel is combusted in the worst-case generator model and use emission factors, in units of pounds emitted per gallon of fuel burned, that are the worst-case across all engine loads. For example, NO_X emissions are calculated assuming all fuel is burned in the Caterpillar 3516E

generators and based on emission factors at 10% load. Data centers have stabilized power loads with high utilization of available power, emergency or unplanned generator would be at utilizations well above 10%. As shown in Tables 3-1 and 3-2, loads will vary depending on the operational reason and fuel will also be burned in the house generators that have lower emission factors. Using the load information in Tables 3-1 and 3-2, Table 3-3 below shows site-wide emissions if emission factors for each specific load are utilized (e.g., emissions for annual load testing are calculated using 100% load emission factor).

Table 3-3. Estimated Emissions with Load-Based Emission Factors

Pollutant	Facility Wide Estimated Emissions with Load-Based Emission Factors (tpy)	Facility Wide PTE (tpy)
CO	12.5	31.1
NO_X	19.1	24.8
VOC	0.8	4.1
SO_2	0.04	0.05
PM	0.8	1.4
PM_{10}	0.8	1.4
$PM_{2.5}$	0.8	1.4

As shown in Table 3-3, estimated emissions for the site would be significantly lower when using emission factors for the specific operating load and accounting for fuel burned in the house generators. However, to simplify recordkeeping requirements, the maximum emission factor across all loads will be used for compliance and therefore, are used in calculating potential emissions. As such, calculated PTE for the facility is conservative.

4. REGULATORY APPLICABILITY

This facility is subject to both federal air regulations and Maryland state air regulations. This section summarizes the various air regulatory requirements that potentially apply to the facility. The applicability of NSR, Title V, New Source Performance Standards (NSPS), National Emission Standards for Hazardous Air Pollutants (NESHAP), and Maryland state air regulations are addressed below.

4.1 Major New Source Review Applicability

Major NSR applicability is based on a stationary source's PTE. The PTE of a source can account for the effects of a proposed air pollution control device, as well as a proposed enforceable facility-wide synthetic minor limits. The PTE from this facility is calculated using the proposed fuel limits.

Frederick County, where this facility will be constructed, has been designated as nonattainment for ozone, as well as being part of the OTR. In areas designated nonattainment or part of the OTR, the major NSR program that applies is nonattainment New Source Review (NNSR) for the pollutant(s) that the area is designated as in nonattainment (i.e., NO_X and VOC as ozone precursors). For pollutants other than NO_X and VOC, the major NSR program that applies is Prevention of Significant Deterioration (PSD). To determine if this facility is subject to NNSR or PSD, the site-wide PTE is compared with the NNSR definition of Major Stationary Source from Title 26 of the Code of Maryland Regulations Subtitle 11 Chapter 17 Section 1 (COMAR 26.11.17.01) for NO_X and VOC, and the PSD definition of Major Stationary Source from 40 CFR 52.21, which is incorporated into COMAR 26.11.06.14 by reference. Table 4-1 shows that this project does not trigger NNSR or PSD as it does not meet the definition of a major stationary source.

Table 4-1. Major NSR Applicability

Pollutant	Facility Wide PTE (tpy)	Major Stationary Source Threshold (tpy)	Major NSR Program	Above Threshold?
CO	31.1	250	PSD	No
NO_X	24.8	25	NNSR	No
VOC	4.1	25	NNSR	No
SO_2	0.05	250	PSD	No
PM	1.4	250	PSD	No
PM_{10}	1.4	250	PSD	No
$PM_{2.5}$	1.4	250	PSD	No

4.2 Title V Applicability

Per COMAR 26.11.03.01A(1), major sources in Maryland are required to obtain a Title V Operating Permit. For the purposes of the Title V permitting program, the major source thresholds are found in COMAR 26.11.02.01C. Table 4-2 provides the major source thresholds applicable to the facility compared to facility potential emissions. As shown in Table 4-2, the facility is not subject to Title V permitting. This facility will be classified as a synthetic minor source for Title V due to the proposed fuel usage limits.

Table 4-2. Title V Applicability

Pollutant	Facility-Wide PTE (tpy)	Title V Applicability Threshold (tpy)	Above Threshold?
CO	31.1	100	No
NO_X	24.8	25	No
VOC	4.1	25	No
SO_2	0.05	100	No
PM	1.4	100	No
PM_{10}	1.4	100	No
$PM_{2.5}$	1.4	100	No
Single HAP	<0.1	10	No
Total HAP	<0.1	25	No

4.3 New Source Performance Standards

NSPS, promulgated in 40 CFR 60, require new, modified, or reconstructed sources to control emissions to the level achievable by the best-demonstrated technology as specified in the applicable provisions. The following section details the applicability of NSPS regulations to the proposed facility.

4.3.1 40 CFR 60 Subpart A – General Provisions

All affected sources subject to a source-specific NSPS are subject to the general provisions of NSPS Subpart A unless specifically excluded by the source-specific NSPS. Subpart A requires initial notification, performance testing, recordkeeping and monitoring, provides reference methods, and mandates general control device requirements for all other subparts as applicable.

4.3.2 40 CFR 60 Subpart Kb – Volatile Organic Liquid Storage Vessel

NSPS Subpart Kb applies to storage vessels with a capacity greater than or equal to 75 cubic meters (approximately 19,800 gallons) used to store volatile organic liquids with a maximum true vapor pressure greater than 15 kilopascals (kPa) that were constructed after July 23, 1984. All tanks being installed at the facility are below the applicability threshold of 19,800 gallons, and each will store diesel fuel which has a maximum true vapor pressure less than 1 kPa. Therefore, Subpart Kb is not applicable to any of the proposed storage tanks at the facility.

4.3.3 40 CFR 60 Subpart IIII – NSPS for CI Internal Combustion Engines

This NSPS applies to owners and operators of stationary compression ignition (CI) internal combustion engines (ICE) that are not fire pumps and are manufactured after April 1, 2006; fire pumps that are manufactured after July 1, 2006; and CI ICEs that are modified or reconstructed after July 11, 2005. The proposed diesel-fired emergency generators are subject to this NSPS because each unit has an associated CI ICE manufactured after 2006. Units subject to this subpart are also subject to the provisions of 40 CFR 60 Subpart A, except where expressly noted.

NSPS Subpart IIII has specific requirements based on several criteria, including model year, engine displacement, and status as a fire pump. Per 40 CFR 60.4219, the diesel-fired engine generators at the facility meet the definition of emergency generator under this subpart. Because the engines powering the emergency generators are newly constructed after 2006, are emergency CI ICE, and have displacements less than 30 liters per cylinder, per 40 CFR 60.4205 (b) and 40 CFR 60.4202 (a)(2), each of the engines

must meet the emission standards for Tier 2 engines in 40 CFR 89.112 and the opacity standards in 40 CFR 89.113. The engine-generators are certified as meeting Tier 2 standards under 40 CFR 89.112.

Per 40 CFR 60.4207(b), all engines must use non-road diesel fuel with a maximum sulfur content of 15 ppm. As these units are fueled using ULSD, which by definition has a maximum sulfur content of 15 ppm, all units meet this requirement.

Per 40 CFR 60.4209(a), each emergency unit must have installed a non-resettable hour meter prior to startup of the engine. As part of the proposed project, each engine will have an hour meter prior to startup. To maintain the emergency stationary reciprocating internal combustion engines (RICE) classification, each RICE must meet the operational requirements of 40 CFR 60.4211(f).

4.4 National Emission Standards for Hazardous Air Pollutants

NESHAP, located in 40 CFR 61 and 63, have been promulgated for source categories that emit HAPs. A facility that is a major source of HAP is defined as having potential emissions greater than 25 tpy of total HAPs or 10 tpy of any single HAP. Facilities with a potential to emit HAPs at an amount less than these major source thresholds are considered area sources. The facility has potential HAP emissions below the major source thresholds and is, therefore, an area source for HAP.

The NESHAP allowable emissions limits are most often established on the basis of a maximum achievable control technology (MACT) determination for the particular source. The determination of applicability to NESHAP requirements are detailed in the following sections.

4.4.1 40 CFR 63 Subpart A – General Provisions

All affected sources subject to an industrial source category NESHAP are also subject to the provisions of 40 CFR 63 Subpart A unless specifically excluded by the source-specific NESHAP.

4.4.2 40 CFR 63 Subpart ZZZZ – NESHAP for Stationary RICE

The RICE MACT is the common reference to the NESHAP for Reciprocating Internal Combustion Engines (RICE). The rule is codified in 40 CFR 63 Subpart ZZZZ. The RICE MACT applies to both area and major sources of HAPs. The proposed generators at the facility are stationary RICE constructed after June 12, 2006. These generators meet the area source requirements of the RICE MACT by meeting NSPS Subpart IIII. There are no further requirements for compliance under 40 CFR 63 Subpart ZZZZ besides compliance with 40 CFR 60 Subpart IIII.

4.5 Maryland State Regulatory Applicability

These regulations are codified under COMAR 26.11 and have been reviewed in this section where potentially applicable to the facility. The regulations are not discussed in detail where the facility is categorically exempt, or where general regulations are not specific to the proposed operations.

4.5.1 COMAR 26.11.02.09 - Source Subject to Permits to Construct and Approvals

This regulation applies to the construction or modification of potential air emission sources. Based on the COMAR regulations, air Permits to Construct are required before construction or modification can begin for various source types. The emergency generators require a Permit to Construct since they do not meet any of the exemption criteria in COMAR 26.11.02.10. Submittal of this permit application meets the

requirements of this section. The emergency generators under this project do not meet the definition of a "generating station" under the Maryland Public Service Commission (PSC) Certificate of Public Convenience and Necessity (CPCN) process since they are emergency backup units to be used at a critical infrastructure site. As such, the generators do not require a CPCN or formal CPCN exemption from the PSC. Further documentation that the CPCN process does not apply to this facility is provided in the cover letter to this application and Appendix D.

4.5.2 COMAR 26.11.06.08 & 26.11.06.09 – Nuisance and Odors

COMAR 26.11.06.08 and COMAR 26.11.06.09 establish general provisions for the control of nuisances and odor, respectively. The facility will be subject to these general requirements.

4.5.3 COMAR 26.11.09.05 – Control of Fuel Burning Equipment and Stationary Internal Combustion – Visible Emissions

The diesel-fired generators will be subject to COMAR 26.11.09.05E which limits visible emissions to 10 percent when operating at idle and to 40 percent when operating at conditions other than idle. These limits do not apply while maintenance, repair, or testing is being performed by qualified mechanics. The 10 percent limit for idling does not apply for a period of two consecutive minutes after a period of idling of 15 consecutive minutes for the purpose of clearing the exhaust system. The 10 percent limit also does not apply to emissions resulting directly from cold engine start-up and warm-up for a maximum of 30 minutes if engine is idle continuously when not in service or a maximum of 15 minutes for all other engines.

4.5.4 COMAR 26.11.09.07 – Control of Sulfur Oxides from Fuel Burning Equipment

This regulation establishes limits for SO_x emissions from fuel burning equipment. Aligned will comply with a limit of 0.3 percent sulfur content in diesel fuel burned in the generator per COMAR 26.11.09.07A(2)(b) by complying with 40 CFR 60.4207(b), as discussed in Section 4.3.3.

4.5.5 COMAR 26.11.15 & 26.11.16 – Toxic Air Pollutants (Not Applicable)

These regulations establish requirements for sources that emit Toxic Air Pollutants (TAPs). The proposed emissions sources requiring a Permit to Construct at the facility are all fuel burning equipment which are exempt from the TAP regulations as specified in COMAR 26.11.15.03B(2)(a).

4.5.6 COMAR 26.11.36 – Distributed Generation

COMAR 26.11.36.03 contains requirements for all stationary engines which will apply to the proposed diesel-fired generators. Under this regulation, the engines will need to meet the requirements under 40 CFR 60 Subpart IIII or 40 CFR 60 Subpart JJJJ. Refer to Section 4.3.3 for applicable requirements under 40 CFR 60 Subpart IIII. 40 CFR 60 Subpart JJJJ does not apply to diesel-fired engines.

5. MONITORING AND RECORDKEEPING

To ensure compliance with the limits proposed in this application, Aligned proposes monitoring and recordkeeping requirements as detailed in this section.

5.1 Generators

Aligned will follow the manufacturer's operation and maintenance (O&M) requirements for each generator and maintain records of all maintenance. Manufacturer O&M manuals have not been included in this application due to file size but can be provided upon request.

5.2 SCR Systems

Aligned will follow the manufacturer's O&M practices for each SCR system to ensure proper operation. In addition, each SCR will be equipped with monitoring equipment and a data logger. Specifically, each SCR will monitor the following:

- NO_X concentrations before and after the catalyst
  - Note that NO_X sensors are meant to ensure proper SCR operation and are not calibrated for use as a continuous emissions monitor or for determining compliance with NO_X emission rates.
- Differential pressure across the catalyst
- Catalyst bed outlet temperature
  - The SCR begins dosing with urea at a catalyst bed temperature of 520°F.

The SCR records data from these sensors as well as date, time, and operating information (run duration, urea dosing, etc.) at least every minute when the system is operating. This data will be used to show the SCR was properly operating and will also be used to determine when the SCR was dosing.

If any of the sensors is out of the manufacturer's suggested operating range, an alarm will sound to alert operators.

5.3 Fuel Limits

Each generator will be equipped with a fuel usage meter. This data will be rolled up monthly into a 12-month rolling fuel usage for each generator and a facility-wide total to ensure compliance with the proposed operating limits. Data from the SCR will be used to identify controlled versus uncontrolled fuel usage.

5.4 Hours of Operation

Each emergency generator will be equipped with a nonresettable hour meter. Hours of operation will be rolled up monthly to 12-monthly rolling total hours of operation per generator. Each run will be identified as maintenance/testing, emergency, etc. to demonstrate compliance with emergency generator operating restrictions.

5.5 Emission Limits

Aligned will use the fuel usages (refer to Section 5.2) and the emission factors in Table B-2 of Appendix B to demonstrate compliance with facility-wide emission limits. Facility-wide emissions will be calculated monthly and 12-month rolling total emissions will be used to demonstrate compliance.

Aligned will conduct stack testing as required by MDE to demonstrate compliance with the short-term emission rates provided in this application. However, due to insufficient exhaust runs prior to the SCR systems, Aligned will not be able to stack test for uncontrolled NO_X emissions or NO_X reduction efficiency of the SCRs. Only post-control emissions are able to be tested. Aligned will conduct testing based on the number of generators and pollutants identified by MDE in the Permit to Construct.

APPENDIX A. MDE APPLICATION FORMS

AIR QUALITY PERMIT TO CONSTRUCT
APPLICATION CHECKLIST

OWNER OF EQUIPMENT/PROCESS	
COMPANY NAME:	Aligned Data Centers (MD) PropCo, LLC
COMPANY ADDRESS:	2800 Summit Avenue Plano, TX 75074
LOCATION OF EQUIPMENT/PROCESS	
PREMISES NAME:	Aligned Data Centers IAD04
PREMISES ADDRESS:	5601 Manor Woods Road Frederick MD 21703
CONTACT INFORMATION FOR THIS PERMIT APPLICATION	
CONTACT NAME:	Michael Welch
JOB TITLE:	Vice President, Design and Procurement
PHONE NUMBER:	203.981.6922
EMAIL ADDRESS:	michael.welch@aligneddc.com
DESCRIPTION OF EQUIPMENT OR PROCESS	
168 emergency generators rated at 3,000 kW with Selective Catalytic Reduction (SCR) Systems and 4 emergency generators rated at 1,000 kW	

Application is hereby made to the Department of the Environment for a Permit to Construct for the following equipment or process as required by the State of Maryland Air Quality Regulation, COMAR 26.11.02.09.

Check each item that you have submitted as part of your application package.

☒ Application package cover letter describing the proposed project

☒ Complete application forms (Note the number of forms included or NA if not applicable.)

No. **NA** Form 5
No. **NA** Form 5T
No. **NA** Form 5EP
No. **1** Form 6
No. **NA** Form 10
No. **NA** Form 11
No. **NA** Form 41
No. **4** Form 42
No. **NA** Form 44

☒ Vendor/manufacturer specifications/guarantees

☒ Evidence of Workman's Compensation Insurance

☐ Process flow diagrams with emission points

☐ Site plan including the location of the proposed source and property boundary

☒ Material balance data and all emissions calculations

☐ Material Safety Data Sheets (MSDS) or equivalent information for materials processed and manufactured.

☐ Certificate of Public Convenience and Necessity (CPCN) waiver documentation from the Public Service Commission [(1)]

☒ Documentation that the proposed installation complies with local zoning and land use requirements [(2)]

[(1)] Required for emergency and non-emergency generators installed on or after October 1, 2001 and rated at 2001 kW or more. Generators providing backup power are exempt from the CPCN process.

[(2)] Required for applications subject to Expanded Public Participation Requirements.

MARYLAND DEPARTMENT OF THE ENVIRONMENT
Air and Radiation Management Administration ● Air Quality Permits Program
1800 Washington Boulevard ● Baltimore, Maryland 21230
(410)537-3230 ● 1-800-633-6101● www.mde.state.md.us

Mail application to

MDE/ARMA
1800 Washington Blvd, Suite 720
Baltimore, MD 21230-1720

Air Quality Permit to Construct & Registration Application for
EMERGENCY GENERATOR

You must check off all of the following items to be able to use this application form

☒ This generator is a dedicated emergency backup generator, and will not be used for peak or load shaving.
☒ This generator is powered by an internal combustion engine, not a turbine
☒ This generator's engine is at least 500 brake horsepower (373 kilowatts)
(Smaller emergency engines do not need a permit)

AND

You must check off one of the following items to be able to use this application form
Not applicable per Critical Infrastructure Streamlining Act of 2024

☐ I do not need a CPCN Exemption because the generator is rated at 2000 kW or less
☐ I do not need a CPCN Exemption because the generator was installed before October 1, 2001
☐ I have a CPCN Exemption from the Public Service Commission for this generator
(Contact the Public Service Commission at 410.767.8131)

1) Business/Institution/Facility where the equipment will be located ☐ **Check if this is a federal facility**

Business/Institution/Facility Name: ALIGNED DATA CENTERS IAD04 Phone: 203.981.6922

Contact Person's Name: Michael Welch Email Address: michael.welch@aligneddc.com

Street Address: 5601 Manor Woods Road

City: Frederick | State: MD | Zip Code: 21703 | County: Frederick

2) Owner ☒ **Check if different from above. If checked, complete the following:**

Name: Aligned Data Centers (MD) PropCo, LLC Phone: 203.981.6922

Mailing Address: 2800 Summit Ave

City: Plano | State: TX | Zip Code: 75074

3) Installer ☒ **Check if different from above. If checked, complete the following:**

Contact Name: Nicholas P. Gisewite Contact Company: Turner Construction Company Phone: 202.878.1364

4) Equipment Information

Manufacturer / Model: Caterpillar — Installation Date: TBD based on receipt of permit

☐ Yes ☒ No — This generator will be operated as part of an emergency demand response program.

Number Installed: 168 (of this model or 3516E, see other form)	Number Removed: 0	Stack Height (feet, estimated): 6	Stack Diameter (inches, estimated): 14	
Engine Make / Model: C175	EPA Tier Certified: 2	Engine Horsepower : 4,423	Engine Manufacture Date: ≥ 2019	Fuel Type: Diesel

5) Required Attachments (check that you've included them)

☒ Vendor literature

☐ CPCN Exemption from the Public Service Commission
(not needed for generators installed before October 1, 2001, or rated at 2000 kW or less)

6) Workers Compensation Information (Environmental Article §1-202)

Workers insurance policy or binder number: New Hampshire Insurance Co, Policy #: WC 088407056 MD, Exp: 07/01/2025

☐ Check if self-employed or otherwise exempt from this requirement

"I CERTIFY UNDER PENALTY OF LAW THAT THE INFORMATION SUBMITTED IN THIS REQUEST FOR COVERAGE IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE, AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR KNOWING VIOLATIONS."

Owners Signature	Michael Welch, Vice President, Design and Procurement	6-28-24
	Printed Name and Title	**Date**

LEAVE BLANK
MDE USE ONLY

☐ Permit
☐ Registration (Less than 1,000 brake horsepower & installed prior to 11/24/03)

Permit/Registration Number: _____ - _____ - _____ - _____

AI: _____

	Sox	NOx	CO	VOC	PM	PM-10
Emissions						
Stack	_____	_____	_____	_____	_____	_____
Fugitive	_____	_____	_____	_____	_____	_____

MARYLAND DEPARTMENT OF THE ENVIRONMENT
Air and Radiation Management Administration ● Air Quality Permits Program
1800 Washington Boulevard ● Baltimore, Maryland 21230
(410)537-3230 ● 1-800-633-6101● www.mde.state.md.us

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(Smaller emergency engines do not need a permit)

AND

You must check off one of the following items to be able to use this application form
Not applicable per Critical Infrastructure Streamlining Act of 2024

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1) Business/Institution/Facility where the equipment will be located ☐ **Check if this is a federal facility**

Business/Institution/Facility Name: ALIGNED DATA CENTERS IAD04 Phone: 203.981.6922

Contact Person's Name: Michael Welch Email Address: michael.welch@aligneddc.com

Street Address: 5601 Manor Woods Road

City: Frederick State: MD Zip Code: 21703 County: Frederick

2) Owner ☐ **Check if different from above. If checked, complete the following:**

Name: Aligned Data Centers (MD) PropCo, LLC Phone: 203.981.6922

Mailing Address: 2800 Summit Ave

City: Plano State: TX Zip Code: 75074

3) Installer ☒ **Check if different from above. If checked, complete the following:**

Contact Name: Nicholas P. Gisewite Contact Company: Turner Construction Company Phone: 202.878.1364

4) Equipment Information

Manufacturer / Model: Caterpillar 3516E — Installation Date: TBD based on receipt of permit

☐ Yes ☒ No — This generator will be operated as part of an emergency demand response program.

Number Installed: 168 (of this model or C175, see previous form)	Number Removed: 0	Stack Height (feet, estimated): TBD	Stack Diameter (inches, estimated): 12	
Engine Make / Model: Caterpillar 3516E	EPA Tier Certified: 2	Engine Horsepower : 4,393	Engine Manufacture Date: ≥ 2019	Fuel Type: Diesel

5) Required Attachments (check that you've included them)

☒ Vendor literature

☐ CPCN Exemption from the Public Service Commission
(not needed for generators installed before October 1, 2001, or rated at 2000 kW or less)

6) Workers Compensation Information (Environmental Article §1-202)

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Owners Signature	Michael Welch, Vice President, Design and Procurement	6-28-24
	Printed Name and Title	**Date**

LEAVE BLANK
MDE USE ONLY

☐ Permit
☐ Registration (Less than 1,000 brake horsepower & installed prior to 11/24/03)

Permit/Registration Number: _____ - _____ - _____ - _____

AI: _____

Emissions

	Sox	NOx	CO	VOC	PM	PM-10
Stack	_____	_____	_____	_____	_____	_____
Fugitive	_____	_____	_____	_____	_____	_____

MARYLAND DEPARTMENT OF THE ENVIRONMENT

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3) Installer ☒ **Check if different from above. If checked, complete the following:**

Contact Name: Nicholas P. Gisewite Contact Company: Turner Construction Company Phone: 202.878.1364

4) Equipment Information

Manufacturer / Model: Caterpillar — Installation Date: TBD based on receipt of permit

☐ Yes ☒ No This generator will be operated as part of an emergency demand response program.

Number Installed: 4 (of this model or MTU 16V2000 DS1000, see other form)	Number Removed: 0	Stack Height (feet, estimated): 6	Stack Diameter (inches, estimated): 8	
Engine Make / Model: C-32	EPA Tier Certified: 2	Engine Horsepower : 1.1474	Engine Manufacture Date: ≥ 2019	Fuel Type: Diesel

5) Required Attachments (check that you've included them)

☒ Vendor literature

☐ CPCN Exemption from the Public Service Commission
(not needed for generators installed before October 1, 2001, or rated at 2000 kW or less)

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Owners Signature	Michael Welch, Vice President, Design and Procurement Printed Name and Title	6-28-24 Date

LEAVE BLANK
MDE USE ONLY

☐ Permit
☐ Registration (Less than 1,000 brake horsepower & installed prior to 11/24/03)

Permit/Registration Number: _____ - _____ - _____ - _____

AI: _____

Emissions

	Sox	NOx	CO	VOC	PM	PM-10
Stack	_____	_____	_____	_____	_____	_____
Fugitive	_____	_____	_____	_____	_____	_____

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Mailing Address: 2800 Summit Ave

City: Plano State: TX Zip Code: 75074

3) Installer ☒ **Check if different from above. If checked, complete the following:**

Contact Name: Nicholas P. Gisewite Contact Company: Turner Construction Company Phone: 202.878.1364

4) Equipment Information

Manufacturer / Model: Caterpillar

Installation Date: TBD based on receipt of permit

☐ Yes ☒ No This generator will be operated as part of an emergency demand response program.

Number Installed: 4 (of this model or C-32, see previous form)	Number Removed: 0	Stack Height (feet, estimated): TBD	Stack Diameter (inches, estimated): TBD	
Engine Make / Model: MTU 16V2000 DS1000	EPA Tier Certified: 2	Engine Horsepower : 1,831	Engine Manufacture Date: ≥ 2019	Fuel Type: Diesel

5) Required Attachments (check that you've included them)

☒ Vendor literature

☐ CPCN Exemption from the Public Service Commission
(not needed for generators installed before October 1, 2001, or rated at 2000 kW or less)

6) Workers Compensation Information (Environmental Article §1-202)

Workers insurance policy or binder number: New Hampshire Insurance Co, Policy #: WC 088407056 MD, Exp: 07/01/2025

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Owners Signature	Michael Welch, Vice President, Design and Procurement Printed Name and Title	6-28-24 Date

LEAVE BLANK
MDE USE ONLY

☐ Permit
☐ Registration (Less than 1,000 brake horsepower & installed prior to 11/24/03)

Permit/Registration Number: _____ - _____ - _____ - _____

AI: _____

Emissions

	Sox	NOx	CO	VOC	PM	PM-10
Stack	_____	_____	_____	_____	_____	_____
Fugitive	_____	_____	_____	_____	_____	_____

MARYLAND DEPARTMENT OF THE ENVIRONMENT

1800 Washington Blvd ▪ Baltimore, Maryland 21230
(410) 537-3230 ▪ 1-800-633-6101 ▪ www.mde.state.md.us

Air and Radiation Management Administration ▪ Air Quality Permits Program

APPLICATION FOR PERMIT TO CONSTRUCT
GAS CLEANING OR EMISSION CONTROL EQUIPMENT

1. Owner of Installation Aligned Data Centers (MD) PropCo, LLC	**Telephone No.** 203.981.6922		**Date of Application** 6/12/2023
2. Mailing Address 2800 Summit Ave.	**City** Plano	**Zip Code** 75074	**County** Collin
3. Equipment Location 5601 Manor Woods Road	**City/Town or P.O.** Frederick		**County** Frederick
4. Signature of Owner or Operator 	**Title** VP, Design and Procurement		**Print or Type Name** Michael Welch

5. Application Type: **Alteration** ☐ **New Construction** ☒

6. Date Construction is to Start: TBD upon receipt of permit

Completion Date (Estimate): Q1 2026

7. Type of Gas Cleaning or Emission Control Equipment:

Simple Cyclone ☐ **Multiple Cyclone** ☐ **Afterburner** ☐ **Electrostatic Precipitator** ☐

Scrubber ☐ _____ (type) **Other** ☒ Selective Catalytic Reduction (SCR) Systems (type)

8. Gas Cleaning Equipment Manufacturer	**Model No.**	**Collection Efficiency (Design Criteria)**
Catalytic Combustion or Safety Power	1040200 or EcoCube	93% NOx control

9. Type of Equipment which Control Equipment is to Service:

Emergency generators. One (1) SCR System per 3,000 kW emergency generator (168 total).

10. Stack Test to be Conducted:

Yes ☐ **No** ☒ As requested by MDE (Stack Test to be Conducted By) _____ (Date)

11. Cost of Equipment TBD

Estimated Erection Cost TBD

12. The Following Shall Be Design Criteria:

	INLET		OUTLET	
Gas Flow Rate	25,320	ACFM*	25,620	ACFM*
Gas Temperature	131	°F	890	°F
Gas Pressure	91.5 in-Hg	INCHES W.G.	64.3 in-Hg	INCHES W.G.
PRESSURE DROP	27.2 in-Hg			
Dust Loading	3.279E-07	GRAINS/ACFD**	TBD	GRAINS/ACFD**
Moisture Content	7	%	TBD	%
OR				
Wet Bulb Temperature		°F		°F
Liquid Flow Rate (Wet Scrubber)		GALLONS/MINUTE		

(WHEN SCRUBBER LIQUID OTHER THAN WATER INDICATE COMPOSITION OF SCRUBBING MEDIUM IN WEIGHT %)

*= ACTUAL CUBIC FEET PER MINUTE **= ACTUAL CUBIC FEET DRY

WHEN APPLICATION INVOLVES THE REDUCTION OF GASEOUS POLLUTANTS, PROVIDE THE CONCENTRATION OF EACH POLLUTANT IN THE GAS STREAM IN VOLUME PERCENT. INCLUDE THE COMPOSITION OF THE GASES ENTERING THE CLEANING DEVICE AND THE COMPOSITION OF EXHAUSTED GASES BEING DISCHARGED INTO THE ATMOSPHERE. USE AVAILABLE SPACE IN ITEM 15 ON PAGE 3.

13. Particle Size Analysis

Size of Dust Particles Entering Cleaning Unit	% of Total Dust	% to be Collected
0 to 10 Microns		
10 to 44 Microns		
Larger than 44 Microns		

14. For Afterburner Construction Only:

Volume of Contaminated Air _____ CFM (DO NOT INCLUDE COMBUSTION AIR)

Gas Inlet Temperature _____ °F

Capacity of Afterburner _____ BTU/HR

Diameter (or area) of Afterburner Throat_____

Combustion Chamber_____ _____ Operating Temperature at Afterburner _____ °F
(diameter) (length)

Retention Time of Gases _____

15. Show Location of Dust Cleaning Equipment in the System. Draw or Sketch Flow Diagram Showing Emission Path from Source to Exhaust Point to Atmosphere.

NA

Date Received: Local _____ _____ State _____

Acknowledgement Date: _____

By _____

Reviewed By:

Local _____

State _____

Returned to Local:

Date_____

By _____

Application Returned to Applicant:

Date_____

By _____

REGISTRATION NUMBER OF ASSOCIATED EQUIPMENT: | | | | | | |

PREMISES NUMBER: | | | | | | | |

Emission Calculations Revised By _____ Date _____

APPENDIX B. POTENTIAL EMISSION CALCULATIONS

Table B-1. Facility-Wide Potential Emissions

Emission Unit	Description	Potential Annual Emissions (tpy)								
		CO	NO_X	VOC	SO_2	PM	PM_{10}	$PM_{2.5}$	Single HAP	Combined HAP
EU 1-168: 3MW Emergency Generators	C175-16 Model	16.6	18.4	3.2	0.0	1.2	1.2	1.2	1.95E-02	3.96E-02
	3516E Model	30.3	24.8	2.3	0.0	1.3	1.3	1.3	1.95E-02	3.96E-02
EU 169-172: 1MW House Emergency Generators	C32 Model	3.2	3.9	0.4	0.0	0.2	0.2	0.2	1.51E-03	3.06E-03
	16V2000 DS1000 Model	3.1	6.1	1.1	0.0	0.2	0.2	0.2	1.56E-03	3.17E-03
Facility-Wide Potential Emissions:		31.1	24.8	4.1	0.05	1.39	1.39	1.39	1.95E-02	3.96E-02

1. Potential annual emissions for each model are based on maximum fuel throughput for that model
2. A combination of the model type for each generator type (i.e., house gens and non-house gens) will be deployed for this project. The proposed fuel limit and facility potentia emissions are based on the worst-case emissions from all proposed model types.
3. Facility-wide potential emissions are based on worst-case emissions of all emission units combined while remaining in compliance with proposed fuel limits, as follows

Step 1. Review fuel throughput maximums for each engine model and operating scenario, as well as emission factors.

Table B-1a. Summary of Fuel Throughput and Emission Factors

Maximum Fuel Throughput (gal/yr)		Emission Factors (lb/gal)						
		CO	NO_X	VOC	SO_2	PM	PM_{10}	$PM_{2.5}$
C175-16 Controlled	275,000	9.09E-02	2.35E-02	1.73E-02	2.54E-04	6.39E-03	6.39E-03	6.39E-03
3516E Controlled	275,000	1.66E-01	3.18E-02	1.28E-02	2.56E-04	6.98E-03	6.98E-03	6.98E-03
C175-16 Uncontrolled	90,000	9.09E-02	3.36E-01	1.73E-02	2.54E-04	6.39E-03	6.39E-03	6.39E-03
3516E Uncontrolled	90,000	1.66E-01	4.54E-01	1.28E-02	2.56E-04	6.98E-03	6.98E-03	6.98E-03
C32	28,160	2.26E-01	2.77E-01	2.73E-02	2.56E-04	1.50E-02	1.50E-02	1.50E-02
16V2000 DS1000	29,200	2.13E-01	4.19E-01	7.88E-02	2.09E-04	1.07E-02	1.07E-02	1.07E-02
Facility-Wide Limit for Controlled Operation (gal/yr):		275,000						
Facility-Wide Limit for Uncontrolled Operation (gal/		90,000						

Table B-1. Facility-Wide Potential Emissions

Step 2. Rank emission factors from highest to lowest. Controlled and uncontrolled emission factors are ranked separately since facility-wide fuel limits for controlled and uncontrolled operation are separate.

Table B-1b. Emission Factor Ranking

	CO	NO_X	VOC	SO_2	PM	PM_{10}	$PM_{2.5}$
Controlled Emission Factors (1=Highest, 2=Lowest)							
C175-16 Controlled	2	2	1	2	2	2	2
3516E Controlled	1	1	2	1	1	1	1
Uncontrolled Emission Factors (1=Highest, 4=Lowest)							
C175-16 Uncontrolled	4	3	3	3	4	4	4
3516E Uncontrolled	3	1	4	1	3	3	3
C32	1	4	2	2	1	1	1
16V2000 DS1000	2	2	1	4	2	2	2

Step 3. Allocate controlled fuel usage. For facility-wide PTE, the entire 275,000 gallons is allocated to either the C175-16s or the 3516Es, whichever has the higher emission factor. Since the site will have a combination of these two models sharing the 275,000 gal/yr limit, this methodology provides the highest possible emissions from controlled operations.

Table B-1c. Controlled Operation Fuel Allocation and Potential Emissions

	CO	NO_X	VOC	SO_2	PM	PM_{10}	$PM_{2.5}$
Fuel Allocation for PTE (gal/yr)							
C175-16 Controlled	0	0	275,000	0	0	0	0
3516E Controlled	275,000	275,000	0	275,000	275,000	275,000	275,000
Emissions included in Facility Wide PTE (tpy)							
C175-16 Controlled	0.0	0.0	2.4	0.0	0.0	0.0	0.0
3516E Controlled	22.8	4.4	0.0	0.0	1.0	1.0	1.0
Facility-Wide PTE for Controlled Operation (tpy)							
Total	22.8	4.4	2.4	0.0	1.0	1.0	1.0

Step 4. Allocate uncontrolled fuel usage. For facility-wide PTE, the 90,000 gallons is split between the uncontrolled engine models starting with the highest emission factor and continuing to lower emission factors until the entire 90,000 gallons is used. In some cases, including NOx, the entire 90,000 gallons can be used in the highest ranked engine. In others, such as CO, the top ranked engine can only use a portion of the fuel so the remainder goes to the second ranked engine and so on. For CO and particulate matter, note that the second ranked emission factor is Model 16V2000 DS1000 after Model C32. However, Aligned is requesting to install four house generators total between those two models. As such, if the C32 model has consumed the maximum fuel for that model, no 16V2000 DS1000 engines would have been installed so the remaining fuel is allocated to the third ranked model.

Table B-1d. Uncontrolled Operation Fuel Allocation and Potential Emissions

	CO	NO_X	VOC	SO_2	PM	PM_{10}	$PM_{2.5}$
Fuel Allocation for PTE (gal/yr)							
C175-16 Uncontrolled	0	0	60,800	0	0	0	0
3516E Uncontrolled	61,840	90,000	0	90,000	61,840	61,840	61,840
C32	28,160	0	0	0	28,160	28,160	28,160
16V2000 DS1000	0	0	29,200	0	0	0	0
Emissions included in Facility Wide PTE (tpy)							
C175-16 Uncontrolled	0.0	0.0	0.5	0.0	0.0	0.0	0.0
3516E Uncontrolled	5.1	20.4	0.0	0.0	0.2	0.2	0.2
C32	3.2	0.0	0.0	0.0	0.2	0.2	0.2
16V2000 DS1000	0.0	0.0	1.1	0.0	0.0	0.0	0.0
Facility-Wide PTE for Uncontrolled Operation (tpy)							
Total	8.3	20.4	1.7	0.0	0.4	0.4	0.4

Step 5. Combine controlled and uncontrolled emissions to calculate facility-wide PTE

Table B-1e. Facility-Wide Potential Emissions

	Potential Emissions (tpy)						
	CO	NO_X	VOC	SO_2	PM	PM_{10}	$PM_{2.5}$
Total Controlled Engine PTE (from Table B-1c)	22.8	4.4	2.4	0.0	1.0	1.0	1.0
Total Uncontrolled Engine PTE (from Table B-1d)	8.3	20.4	1.7	0.0	0.4	0.4	0.4
Facility-Wide PTE	31.1	24.8	4.1	0.05	1.4	1.4	1.4

Table B-2. Emergency Generator Maximum Emissions - per Unit

Pollutant	Units	CO	Uncontrolled NO_X	Controlled NO_X	VOC	SO_2	PM	PM_{10}	$PM_{2.5}$
C175-16 Caterpillar Stationary Emergency Engine-Generators	lb/gal	9.09E-02	3.36E-01	2.35E-02	1.73E-02	2.54E-04	6.39E-03	6.39E-03	6.39E-03
3516E Caterpillar Stationary Emergency Engine-Generators	lb/gal	1.66E-01	4.54E-01	3.18E-02	1.28E-02	2.56E-04	6.98E-03	6.98E-03	6.98E-03
C32 Stationary Emergency Engine-Generator	lb/gal	2.26E-01	2.77E-01	NA	2.73E-02	2.56E-04	1.50E-02	1.50E-02	1.50E-02
MTU 16V2000 DS1000 Stationary Emergency Engine-Generator	lb/gal	2.13E-01	4.19E-01	NA	7.88E-02	2.09E-04	1.07E-02	1.07E-02	1.07E-02

Table B-3. C-175 Stationary Generators Potential to Emit

Source Designation:	Engine	Generator
Number of Emergency Generators[1]:	168	
Year Manufactured:	≥ 2019	
Manufacturer[1]:	Caterpillar	
Model No.[2]:	C175-16	
Engine Tier[2]:	2	--
Stroke Cycle[2]:	4-Stroke	--
Fuel Used[2]:	Diesel	--
Fuel Sulfur Content (%)[3]:	0.0015	--
Displacement (L per cylinder):	5.3	
Fuel Heating Value (Btu [HHV]/gal)[4]:	138,000	--
SCR NOx Reduction	93%	--
Rated Horsepower at Specified Load (bhp @ 1,800 rpm)[2]:	--	--
100%	4,423	--
75%	3,364	--
50%	2,305	--
25%	1,246	--
10%	611	--
Generating Capacity (kW)[2]:	--	3,000
Maximum Fuel Consumption at Specified Load (gal/hr)[2]:	--	--
100%	211.4	--
75%	163.2	--
50%	128.7	--
25%	79.5	--
10%	44.3	--
Heat Input (MMBtu [HHV]/hr)[5]:	--	--
100%	29.2	--
75%	22.5	--
50%	17.8	--
25%	11.0	--
10%	6.1	--

Criteria and Greenhouse Gas Emission Factors:

Pollutant	Emission Factors *100% Load*	Emission Factors *75% Load*	Emission Factors *50% Load*	Emission Factors *25% Load*	Emission Factors *10% Load*	Units	Notes
CO	0.60	1.03	0.78	1.45	2.99	g/hp-hr	6
Uncontrolled NO_X	7.29	6.42	4.09	3.05	5.47	g/hp-hr	6
Controlled NO_x	0.51	0.45	0.29	0.21	0.38	g/hp-hr	7
VOC	0.06	0.06	0.16	0.31	0.57	g/hp-hr	6, 8
SO_2	1.21E-05	1.21E-05	1.21E-05	1.21E-05	1.21E-05	lb/bhp-hr	9
PM	0.04	0.05	0.05	0.11	0.21	g/hp-hr	6, 10
PM_{10}	0.04	0.05	0.05	0.11	0.21	g/hp-hr	6, 10
$PM_{2.5}$	0.04	0.05	0.05	0.11	0.21	g/hp-hr	6, 10
CO_2	73.96	73.96	73.96	73.96	73.96	kg/MMBtu	11
CH_4	3.0E-03	3.0E-03	3.0E-03	3.0E-03	3.0E-03	kg/MMBtu	11
N_2O	6.0E-04	6.0E-04	6.0E-04	6.0E-04	6.0E-04	kg/MMBtu	11
CO_2e	74.2	74.2	74.2	74.2	74.2	kg/MMBtu	12

Operational Details:

Aggregate Fuel Usage - Controlled (gal/yr) [13]:	275,000
Aggregate Fuel Usage - Uncontrolled (gal/yr) [13]:	90,000

Table B-3. C-175 Stationary Generators Potential to Emit

Criteria and Greenhouse Gas Potential Emissions:

Pollutant	Potential Emissions[14] 100% Load (lb/gal)	Potential Emissions[14] 75% Load (lb/gal)	Potential Emissions[14] 50% Load (lb/gal)	Potential Emissions[14] 25% Load (lb/gal)	Potential Emissions[14] 10% Load (lb/gal)	Maximum Emissions[15] (lb/gal)	Potential Emissions All Units [17] (tpy)
CO	2.77E-02	4.68E-02	3.08E-02	5.01E-02	9.09E-02	9.09E-02	16.6
Uncontrolled NO_X	3.36E-01	2.92E-01	1.61E-01	1.05E-01	1.66E-01	3.36E-01	15.1
Controlled NO_X	2.35E-02	2.04E-02	1.13E-02	7.38E-03	1.16E-02	2.35E-02	3.2
VOC	2.77E-03	2.73E-03	6.32E-03	1.07E-02	1.73E-02	1.73E-02	3.2
SO_2	2.54E-04	2.50E-04	2.17E-04	1.90E-04	1.67E-04	2.54E-04	0.0
PM	1.85E-03	2.27E-03	1.97E-03	3.80E-03	6.39E-03	6.39E-03	1.2
PM_{10}	1.85E-03	2.27E-03	1.97E-03	3.80E-03	6.39E-03	6.39E-03	1.2
$PM_{2.5}$	1.85E-03	2.27E-03	1.97E-03	3.80E-03	6.39E-03	6.39E-03	1.2
CO_2	2.25E+01	2.25E+01	2.25E+01	2.25E+01	2.25E+01	2.25E+01	4106.5
CH_4	9.13E-04	9.13E-04	9.13E-04	9.13E-04	9.13E-04	9.13E-04	0.2
N_2O	1.83E-04	1.83E-04	1.83E-04	1.83E-04	1.83E-04	1.83E-04	0.0
CO_2e	2.26E+01	2.26E+01	2.26E+01	2.26E+01	2.26E+01	2.26E+01	4120.6

Hazardous Air Pollutant (HAP) Potential Emissions:

Pollutant	Emission Factor[16] (lb/MMBtu)	Potential Emissions[14] 100% Load (lb/gal)	Potential Emissions[14] 75% Load (lb/gal)	Potential Emissions[14] 50% Load (lb/gal)	Potential Emissions[14] 25% Load (lb/gal)	Potential Emissions[14] 10% Load (lb/gal)	Maximum Emissions[15] (lb/gal)	Potential Emissions All Units (tpy)[17]
Benzene	7.76E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	2.0E-02
Toluene	2.81E-04	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	7.1E-03
Xylenes	1.93E-04	2.7E-05	2.7E-05	2.7E-05	2.7E-05	2.7E-05	2.7E-05	4.9E-03
Formaldehyde	7.89E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	2.0E-03
Acetaldehyde	2.52E-05	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	6.3E-04
Acrolein	7.88E-06	1.1E-06	1.1E-06	1.1E-06	1.1E-06	1.1E-06	1.1E-06	2.0E-04
Polycyclic Aromatic Hydrocarbons (PAH)	2.12E-04	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	5.3E-03
Total HAP		2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	3.96E-02

[1] Engine specification sheet.

[2] Values come from the engine's spec sheet. Engine rating and fuel consumption on a per unit basis.

[3] Per 40 CFR 80 Subpart I, maximum sulfur content of ULSD is 15 ppm (i.e. 0.0015%).

[4] Diesel heat content is from 40 CFR 98, Subpart C, Table C-1 - Default CO2 Emission Factors and High Heat Values for Various Types of Fuel.

[5] Value is calculated from the fuel's heating value and engine's hourly fuel consumption rate and is on an individual unit basis.

[6] CO, NO_x, HC (VOC), and PM emission factors are based on "worst case" performance data at specified load from the unit's emission data sheet. Emissions data accounts for potential site variation.

[7] Controlled NO_X emissions are calculated based on uncontrolled manufacturer data and SCR control efficiency.

[8] AP-42 Table 3.4-1 indicates that as much as three-fourths of total organic compounds are methane emissions for dual fuel engines. To conservatively over-estimate emissions, all hydrocarbon (HC) emissions are assumed to be VOC.

[9] Sulfur dioxide emission factor is from AP-42 Table 3.4-1. SO2 (lb/bhp-hr) = 8.09E-03 x (sulfur content of fuel, %). Emission factor in lb/bhp-hr.

[10] All particulates are assumed to be <1 micron in size, consistent with AP-42 Section 3.3, Table 3.3-1 "Emission Factors for Uncontrolled Gasoline and Diesel Industrial Engines," Supplement B, October 1996; includes both filterable and condensable particulate.

[11] GHG emission factors from Tables C-1 and C-2, 40 CFR 98, Subpart C.

[12] CO_2e is the sum of GHG constituents multiplied by their respective global warming potential (i.e. 1 for CO_2, 25 for CH_4, and 298 for N_2O), per Table A-1, 40 CFR 98, Subpart A.

[13] Proposed facility-wide fuel usage limits. NOx emissions calculated using controlled and uncontrolled fuel limits. Other pollutants calculated based on the sum of the two limits.

[14] Emission Rate (lb/gal) = Rated Capacity (MMBtu/hr or bhp at specified load) × Emission Factor (lb/MMBtu, kg/MMBtu, g/hp-hr or lb/bhp-hr) / Fuel Consumption Rate (gal/hr). 453.592 g per lb and 2.20462 lb per kg used for conversions.

[15] Maximum lb/gal emission rate is determined across all engine loads. Emission rates for different pollutants may be used to select the highest emissions for each individual pollutant.

[16] Emission factors from AP-42 Section 3.4, Table 3.4-3 "Speciated Organic Compound Emission Factors for Large Uncontrolled Stationary Diesel Engines" and Table 3.4.-4 "PAH Emission Factors for Large Uncontrolled Stationary Diesel Engines," Supplement B, October 1996.

[17] Potential Emissions (tpy) are based on annual operating limit and highest hourly emission factor.

Table B-4. 3516E Stationary Generators Potential to Emit

Source Designation:	Engine	Generator
Number of Emergency Generators[1]:	168	
Year Manufactured:	≥ 2019	
Manufacturer[1]:	Caterpillar	
Model No.[2]:	3516E	
Engine Tier[2]:	4	--
Stroke Cycle[2]:	4-Stroke	--
Fuel Used[2]:	Diesel	--
Fuel Sulfur Content (%)[3]:	0.0015	--
Displacement (L per cylinder):	4.9	
Fuel Heating Value (Btu [HHV]/gal)[4]:	138,000	--
SCR NOx Reduction	93%	
Rated Horsepower at Specified Load (bhp @ 1,800 rpm)[2]:	--	--
100%	4,393	--
75%	3,347	--
50%	2,294	--
25%	1,236	--
10%	590	--
Generating Capacity (kW)[2]:	--	3,000
Maximum Fuel Consumption at Specified Load (gal/hr)[2]:	--	--
100%	208.2	--
75%	168.1	--
50%	125.9	--
25%	66.4	--
10%	36.7	--
Heat Input (MMBtu [HHV]/hr)[5]:	--	--
100%	28.7	--
75%	23.2	--
50%	17.4	--
25%	9.2	--
10%	5.1	--

Criteria and Greenhouse Gas Emission Factors:

Pollutant	Emission Factors *100% Load*	Emission Factors *75% Load*	Emission Factors *50% Load*	Emission Factors *25% Load*	Emission Factors *10% Load*	Units	Notes
CO	1.20	1.33	1.32	3.03	4.68	g/hp-hr	6
Uncontrolled NO_X	6.76	4.38	3.64	8.49	12.82	g/hp-hr	6
Controlled NO_x	0.47	0.31	0.25	0.59	0.90	g/hp-hr	7
VOC	0.06	0.06	0.07	0.09	0.36	g/hp-hr	6, 8
SO_2	1.21E-05	1.21E-05	1.21E-05	1.21E-05	1.21E-05	lb/bhp-hr	9
PM	0.06	0.10	0.14	0.17	0.04	g/hp-hr	6, 10
PM_{10}	0.06	0.10	0.14	0.17	0.04	g/hp-hr	6, 10
$PM_{2.5}$	0.06	0.10	0.14	0.17	0.04	g/hp-hr	6, 10
CO_2	73.96	73.96	73.96	73.96	73.96	kg/MMBtu	11
CH_4	3.0E-03	3.0E-03	3.0E-03	3.0E-03	3.0E-03	kg/MMBtu	11
N_2O	6.0E-04	6.0E-04	6.0E-04	6.0E-04	6.0E-04	kg/MMBtu	11
CO_2e	74.2	74.2	74.2	74.2	74.2	kg/MMBtu	12

Operational Details:

Aggregate Fuel Usage - Controlled (gal/yr) [13]:	275,000
Aggregate Fuel Usage - Uncontrolled (gal/yr) [13]:	90,000

Table B-4. 3516E Stationary Generators Potential to Emit

Criteria and Greenhouse Gas Potential Emissions:

Pollutant	Potential Emissions[14] 100% Load (lb/gal)	Potential Emissions[14] 75% Load (lb/gal)	Potential Emissions[14] 50% Load (lb/gal)	Potential Emissions[14] 25% Load (lb/gal)	Potential Emissions[14] 10% Load (lb/gal)	Maximum Emissions[15] (lb/gal)	Potential Emissions All Units[17] (tpy)
CO	5.58E-02	5.84E-02	5.30E-02	1.24E-01	1.66E-01	1.66E-01	30.3
Uncontrolled NO_X	3.14E-01	1.92E-01	1.46E-01	3.48E-01	4.54E-01	4.54E-01	20.4
Controlled NO_X	2.20E-02	1.35E-02	1.02E-02	2.44E-02	3.18E-02	3.18E-02	4.4
VOC	2.79E-03	2.63E-03	2.81E-03	3.69E-03	1.28E-02	1.28E-02	2.3
SO_2	2.56E-04	2.42E-04	2.21E-04	2.26E-04	1.95E-04	2.56E-04	0.0
PM	2.79E-03	4.39E-03	5.62E-03	6.98E-03	1.42E-03	6.98E-03	1.3
PM_{10}	2.79E-03	4.39E-03	5.62E-03	6.98E-03	1.42E-03	6.98E-03	1.3
$PM_{2.5}$	2.79E-03	4.39E-03	5.62E-03	6.98E-03	1.42E-03	6.98E-03	1.3
CO_2	2.25E+01	2.25E+01	2.25E+01	2.25E+01	2.25E+01	2.25E+01	4106.5
CH_4	9.13E-04	9.13E-04	9.13E-04	9.13E-04	9.13E-04	9.13E-04	0.2
N_2O	1.83E-04	1.83E-04	1.83E-04	1.83E-04	1.83E-04	1.83E-04	0.0
CO_2e	2.26E+01	2.26E+01	2.26E+01	2.26E+01	2.26E+01	2.26E+01	4120.6

Hazardous Air Pollutant (HAP) Potential Emissions:

Pollutant	Emission Factor[16] (lb/MMBtu)	Potential Emissions[14] 100% Load (lb/gal)	Potential Emissions[14] 75% Load (lb/gal)	Potential Emissions[14] 50% Load (lb/gal)	Potential Emissions[14] 25% Load (lb/gal)	Potential Emissions[14] 10% Load (lb/gal)	Maximum Emissions[15] (lb/gal)	Potential Emissions All Units (tpy)[17]
Benzene	7.76E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	2.0E-02
Toluene	2.81E-04	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	7.1E-03
Xylenes	1.93E-04	2.7E-05	2.7E-05	2.7E-05	2.7E-05	2.7E-05	2.7E-05	4.9E-03
Formaldehyde	7.89E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	2.0E-03
Acetaldehyde	2.52E-05	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	6.3E-04
Acrolein	7.88E-06	1.1E-06	1.1E-06	1.1E-06	1.1E-06	1.1E-06	1.1E-06	2.0E-04
Polycyclic Aromatic Hydrocarbons (PAH)	2.12E-04	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	5.3E-03
Total HAP		2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	4.0E-02

[1] Engine specification sheet.

[2] Values come from the engine's spec sheet. Engine rating and fuel consumption on a per unit basis.

[3] Per 40 CFR 80 Subpart I, maximum sulfur content of ULSD is 15 ppm (i.e. 0.0015%).

[4] Diesel heat content is from 40 CFR 98, Subpart C, Table C-1 - Default CO2 Emission Factors and High Heat Values for Various Types of Fuel.

[5] Value is calculated from the fuel's heating value and engine's hourly fuel consumption rate and is on an individual unit basis.

[6] CO, NO_X, HC (VOC), and PM emission factors are based on "worst case" performance data at specified load from the unit's emission data sheet. Emissions data accounts for potential site variation.

[7] Controlled NO_X emissions are calculated based on uncontrolled manufacturer data and SCR control efficiency.

[8] AP-42 Table 3.4-1 indicates that as much as three-fourths of total organic compounds are methane emissions for dual fuel engines. To conservatively over-estimate emissions, all hydrocarbon (HC) emissions are assumed to be VOC.

[9] Sulfur dioxide emission factor is from AP-42 Table 3.4-1. SO2 (lb/bhp-hr) = 8.09E-03 x (sulfur content of fuel, %). Emission factor in lb/bhp-hr.

[10] All particulates are assumed to be <1 micron in size, consistent with AP-42 Section 3.3, Table 3.3-1 "Emission Factors for Uncontrolled Gasoline and Diesel Industrial Engines," Supplement B, October 1996; includes both filterable and condensable particulate.

[11] GHG emission factors from Tables C-1 and C-2, 40 CFR 98, Subpart C.

[12] CO_2e is the sum of GHG constituents multiplied by their respective global warming potential (i.e. 1 for CO_2, 25 for CH_4, and 298 for N_2O), per Table A-1, 40 CFR 98, Subpart A.

[13] Proposed facility-wide fuel usage limits. NOx emissions calculated using controlled and uncontrolled fuel limits. Other pollutants calculated based on the sum of the two limits.

[14] Emission Rate (lb/gal) = Rated Capacity (MMBtu/hr or bhp at specified load) × Emission Factor (lb/MMBtu, kg/MMBtu, g/hp-hr or lb/bhp-hr) / Fuel Consumption Rate (gal/hr). 453.592 g per lb and 2.20462 lb per kg used for conversions.

[15] Maximum lb/gal emission rate is determined across all engine loads. Emission rates for different pollutants may be used to select the highest emissions for each individual pollutant.

[16] Emission factors from AP-42 Section 3.4, Table 3.4-3 "Speciated Organic Compound Emission Factors for Large Uncontrolled Stationary Diesel Engines" and Table 3.4.-4 "PAH Emission Factors for Large Uncontrolled Stationary Diesel Engines," Supplement B, October 1996.

[17] Potential Emissions (tpy) are based on annual operating limit and highest hourly emission factor.

Table B-5. C32 Stationary Generators Potential to Emit

Source Designation:	Engine	Generator
Number of Emergency Generators[1]:	4	
Year Manufactured:	≥ 2019	
Manufacturer[1]:	Caterpillar	
Model No.[2]:	C32	
Engine Tier[2]:	2	--
Stroke Cycle[2]:	4-Stroke	--
Fuel Used[2]:	Diesel	--
Fuel Sulfur Content (%)[3]:	0.0015	--
Displacement (L per cylinder):	2.7	
Fuel Heating Value (Btu [HHV]/gal)[4]:	138,000	--
Rated Horsepower at Specified Load (bhp @ 1,800 rpm)[2]:	--	--
100%	1,483	--
75%	1,124	--
50%	772	--
25%	426	--
10%	209	--
Generating Capacity (kW)[2]:	--	1,000
Maximum Fuel Consumption at Specified Load (gal/hr)[2]:	--	--
100%	70.4	--
75%	55.2	--
50%	37.5	--
25%	21.5	--
10%	12.3	--
Heat Input (MMBtu [HHV]/hr)[5]:	--	--
100%	9.7	--
75%	7.6	--
50%	5.2	--
25%	3.0	--
10%	1.7	--

Criteria and Greenhouse Gas Emission Factors:

Pollutant	Emission Factors *100% Load*	Emission Factors *75% Load*	Emission Factors *50% Load*	Emission Factors *25% Load*	Emission Factors 10% *Load*	Units	Notes
CO	0.24	0.21	0.64	1.91	6.03	g/hp-hr	6
NO_X	5.97	4.60	4.37	5.34	6.43	g/hp-hr	6
VOC	0.02	0.09	0.13	0.18	0.73	g/hp-hr	6, 7
SO_2	1.21E-05	1.21E-05	1.21E-05	1.21E-05	1.21E-05	lb/bhp-hr	8
PM	0.04	0.03	0.09	0.25	0.40	g/hp-hr	6, 9
PM_{10}	0.04	0.03	0.09	0.25	0.40	g/hp-hr	6, 9
$PM_{2.5}$	0.04	0.03	0.09	0.25	0.40	g/hp-hr	6, 9
CO_2	73.96	73.96	73.96	73.96	73.96	kg/MMBtu	10
CH_4	3.0E-03	3.0E-03	3.0E-03	3.0E-03	3.0E-03	kg/MMBtu	10
N_2O	6.0E-04	6.0E-04	6.0E-04	6.0E-04	6.0E-04	kg/MMBtu	10
CO_2e	74.2	74.2	74.2	74.2	74.2	kg/MMBtu	11

Operational Details:

Aggregate Fuel Usage (gal/yr) [12]:	28,160

Table B-5. C32 Stationary Generators Potential to Emit

Criteria and Greenhouse Gas Potential Emissions:

Pollutant	Potential Emissions[13] 100% Load (lb/gal)	Potential Emissions[13] 75% Load (lb/gal)	Potential Emissions[13] 50% Load (lb/gal)	Potential Emissions[13] 25% Load (lb/gal)	Potential Emissions[13] 10% Load (lb/gal)	Maximum Emissions[14] (lb/gal)	Potential Emissions All Units [16] (tpy)
CO	1.11E-02	9.43E-03	2.90E-02	8.34E-02	2.26E-01	2.26E-01	3.2
NO_X	2.77E-01	2.06E-01	1.98E-01	2.33E-01	2.41E-01	2.77E-01	3.9
VOC	9.29E-04	4.04E-03	5.90E-03	7.86E-03	2.73E-02	2.73E-02	0.4
SO_2	2.56E-04	2.47E-04	2.50E-04	2.40E-04	2.06E-04	2.56E-04	0.0
PM	1.86E-03	1.35E-03	4.08E-03	1.09E-02	1.50E-02	1.50E-02	0.2
PM_{10}	1.86E-03	1.35E-03	4.08E-03	1.09E-02	1.50E-02	1.50E-02	0.2
$PM_{2.5}$	1.86E-03	1.35E-03	4.08E-03	1.09E-02	1.50E-02	1.50E-02	0.2
CO_2	2.25E+01	2.25E+01	2.25E+01	2.25E+01	2.25E+01	2.25E+01	316.8
CH_4	9.13E-04	9.13E-04	9.13E-04	9.13E-04	9.13E-04	9.13E-04	0.0
N_2O	1.83E-04	1.83E-04	1.83E-04	1.83E-04	1.83E-04	1.83E-04	0.0
CO_2e	2.26E+01	2.26E+01	2.26E+01	2.26E+01	2.26E+01	2.26E+01	317.9

Hazardous Air Pollutant (HAP) Potential Emissions:

Pollutant	Emission Factor[15] (lb/MMBtu)	Potential Emissions[13] 100% Load (lb/gal)	Potential Emissions[13] 75% Load (lb/gal)	Potential Emissions[13] 50% Load (lb/gal)	Potential Emissions[13] 25% Load (lb/gal)	Potential Emissions[13] 10% Load (lb/gal)	Maximum Emissions[14] (lb/gal)	Potential Emissions All Units (tpy)[16]
Benzene	7.76E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.5E-03
Toluene	2.81E-04	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	5.5E-04
Xylenes	1.93E-04	2.7E-05	2.7E-05	2.7E-05	2.7E-05	2.7E-05	2.7E-05	3.8E-04
Formaldehyde	7.89E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.5E-04
Acetaldehyde	2.52E-05	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	4.9E-05
Acrolein	7.88E-06	1.1E-06	1.1E-06	1.1E-06	1.1E-06	1.1E-06	1.1E-06	1.5E-05
Polycyclic Aromatic Hydrocarbons (PAH)	2.12E-04	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	4.1E-04
Total HAP		2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	3.1E-03

[1] Engine specification sheet.

[2] Values come from the engine's spec sheet. Engine rating and fuel consumption on a per unit basis.

[3] Per 40 CFR 80 Subpart I, maximum sulfur content of ULSD is 15 ppm (i.e. 0.0015%).

[4] Diesel heat content is from 40 CFR 98, Subpart C, Table C-1 - Default CO2 Emission Factors and High Heat Values for Various Types of Fuel.

[5] Value is calculated from the fuel's heating value and engine's hourly fuel consumption rate and is on an individual unit basis.

[6] CO, NO_x, HC (VOC), and PM emission factors are based on "worst case" performance data at specified load from the unit's emission data sheet. Emissions data accounts for potential site variation.

[7] AP-42 Table 3.4-1 indicates that as much as three-fourths of total organic compounds are methane emissions for dual fuel engines. To conservatively over-estimate emissions, all hydrocarbon (HC) emissions are assumed to be VOC.

[8] Sulfur dioxide emission factor is from AP-42 Table 3.4-1. SO2 (lb/bhp-hr) = 8.09E-03 x (sulfur content of fuel, %). Emission factor in lb/bhp-hr.

[9] All particulates are assumed to be <1 micron in size, consistent with AP-42 Section 3.3, Table 3.3-1 "Emission Factors for Uncontrolled Gasoline and Diesel Industrial Engines," Supplement B, October 1996; includes both filterable and condensable particulate.

[10] GHG emission factors from Tables C-1 and C-2, 40 CFR 98, Subpart C.

[11] CO_2e is the sum of GHG constituents multiplied by their respective global warming potential (i.e. 1 for CO_2, 25 for CH_4, and 298 for N_2O), per Table A-1, 40 CFR 98, Subpart A.

[12] Maximum fuel consumption for 100 hr/yr/gen.

[13] Emission Rate (lb/gal) = Rated Capacity (MMBtu/hr or bhp at specified load) × Emission Factor (lb/MMBtu, kg/MMBtu, g/hp-hr or lb/bhp-hr) / Fuel Consumption Rate (gal/hr). 453.592 g per lb and 2.20462 lb per kg used for conversions.

[14] Maximum lb/gal emission rate is determined across all engine loads. Emission rates for different pollutants may be used to select the highest emissions for each individual pollutant.

[15] Emission factors from AP-42 Section 3.4, Table 3.4-3 "Speciated Organic Compound Emission Factors for Large Uncontrolled Stationary Diesel Engines" and Table 3.4.-4 "PAH Emission Factors for Large Uncontrolled Stationary Diesel Engines," Supplement B, October 1996.

[16] Potential Emissions (tpy) are based on annual operating limit and highest hourly emission factor.

Table B-6. 16V2000 DS1000 Stationary Generators Potential to Emit

Source Designation:	Engine	Generator
Number of Emergency Generators[1]:	4	
Year Manufactured:	≥ 2019	
Manufacturer[1]:	MTU	
Model No.[2]:	16V2000 DS1000	
Engine Tier[2]:	2	--
Stroke Cycle[2]:	4-Stroke	--
Fuel Used[2]:	Diesel	--
Fuel Sulfur Content (%)[3]:	0.0015	--
Displacement (L per cylinder):	2.2	
Fuel Heating Value (Btu [HHV]/gal)[4]:	138,000	--
Rated Engine Output at Specified Load (kWm)[2]:	--	--
100%	1,366	--
75%	1,029	--
50%	686	--
25%	343	--
10%	137	--
Generating Capacity (kWe)[2]:	--	1,000
Maximum Fuel Consumption at Specified Load (gal/hr)[2]:	--	--
100%	73.0	--
75%	56.0	--
50%	38.0	--
25%	21.8	--
10%	12.5	--
Heat Input (MMBtu [HHV]/hr)[5]:	--	--
100%	10.1	--
75%	7.7	--
50%	5.2	--
25%	3.0	--
10%	1.7	--

Criteria and Greenhouse Gas Emission Factors:

Pollutant	Emission Factors *100% Load*	Emission Factors *75% Load*	Emission Factors *50% Load*	Emission Factors *25% Load*	Emission Factors 10% *Load*	Units	Notes
CO	0.37	0.46	1.28	2.98	8.81	g/kWm-hr	6
NO_X	10.15	6.78	7.17	8.20	15.44	g/kWm-hr	6
VOC	0.14	0.18	0.29	0.95	3.25	g/kWm-hr	6, 7
SO_2	1.52E-03	1.52E-03	1.52E-03	1.52E-03	1.52E-03	lb/MMBtu	8
PM	0.02	0.04	0.09	0.16	0.44	g/kWm-hr	6, 9
PM_{10}	0.02	0.04	0.09	0.16	0.44	g/kWm-hr	6, 9
$PM_{2.5}$	0.02	0.04	0.09	0.16	0.44	g/kWm-hr	6, 9
CO_2	73.96	73.96	73.96	73.96	73.96	kg/MMBtu	10
CH_4	3.0E-03	3.0E-03	3.0E-03	3.0E-03	3.0E-03	kg/MMBtu	10
N_2O	6.0E-04	6.0E-04	6.0E-04	6.0E-04	6.0E-04	kg/MMBtu	10
CO_2e	74.2	74.2	74.2	74.2	74.2	kg/MMBtu	11

Operational Details:

Aggregate Fuel Usage (gal/yr) [12]:	29,200

Table B-6. 16V2000 DS1000 Stationary Generators Potential to Emit

Criteria and Greenhouse Gas Potential Emissions:

Pollutant	Potential Emissions[13] 100% Load (lb/gal)	Potential Emissions[13] 75% Load (lb/gal)	Potential Emissions[13] 50% Load (lb/gal)	Potential Emissions[13] 25% Load (lb/gal)	Potential Emissions[13] 10% Load (lb/gal)	Maximum Emissions[14] (lb/gal)	Potential Emissions All Units [16] (tpy)
CO	1.53E-02	1.86E-02	5.09E-02	1.03E-01	2.13E-01	2.13E-01	3.1
NO_X	4.19E-01	2.75E-01	2.85E-01	2.85E-01	3.74E-01	4.19E-01	6.1
VOC	5.78E-03	7.29E-03	1.15E-02	3.30E-02	7.88E-02	7.88E-02	1.1
SO_2	2.09E-04	2.09E-04	2.09E-04	2.09E-04	2.09E-04	2.09E-04	0.0
PM	8.66E-04	1.46E-03	3.38E-03	5.38E-03	1.07E-02	1.07E-02	0.2
PM_{10}	8.66E-04	1.46E-03	3.38E-03	5.38E-03	1.07E-02	1.07E-02	0.2
$PM_{2.5}$	8.66E-04	1.46E-03	3.38E-03	5.38E-03	1.07E-02	1.07E-02	0.2
CO_2	2.25E+01	2.25E+01	2.25E+01	2.25E+01	2.25E+01	2.25E+01	328.5
CH_4	9.13E-04	9.13E-04	9.13E-04	9.13E-04	9.13E-04	9.13E-04	0.0
N_2O	1.83E-04	1.83E-04	1.83E-04	1.83E-04	1.83E-04	1.83E-04	0.0
CO_2e	2.26E+01	2.26E+01	2.26E+01	2.26E+01	2.26E+01	2.26E+01	329.6

Hazardous Air Pollutant (HAP) Potential Emissions:

Pollutant	Emission Factor[15] (lb/MMBtu)	Potential Emissions[13] 100% Load (lb/gal)	Potential Emissions[13] 75% Load (lb/gal)	Potential Emissions[13] 50% Load (lb/gal)	Potential Emissions[13] 25% Load (lb/gal)	Potential Emissions[13] 10% Load (lb/gal)	Maximum Emissions[14] (lb/gal)	Potential Emissions All Units (tpy)[16]
Benzene	7.76E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.1E-04	1.6E-03
Toluene	2.81E-04	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	3.9E-05	5.7E-04
Xylenes	1.93E-04	2.7E-05	2.7E-05	2.7E-05	2.7E-05	2.7E-05	2.7E-05	3.9E-04
Formaldehyde	7.89E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.6E-04
Acetaldehyde	2.52E-05	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06	5.1E-05
Acrolein	7.88E-06	1.1E-06	1.1E-06	1.1E-06	1.1E-06	1.1E-06	1.1E-06	1.6E-05
Polycyclic Aromatic Hydrocarbons (PAH)	2.12E-04	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05	4.3E-04
Total HAP		2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	3.2E-03

[1] Engine specification sheet.

[2] Values come from the engine's spec sheet. Engine rating and fuel consumption on a per unit basis. Fuel usage at 25% and 10% loads are estimated based on available data for higher loads.

[3] Per 40 CFR 80 Subpart I, maximum sulfur content of ULSD is 15 ppm (i.e. 0.0015%).

[4] Diesel heat content is from 40 CFR 98, Subpart C, Table C-1 - Default CO2 Emission Factors and High Heat Values for Various Types of Fuel.

[5] Value is calculated from the fuel's heating value and engine's hourly fuel consumption rate and is on an individual unit basis.

[6] CO, NO_x, HC (VOC), and PM emission factors are based on "worst case" performance data at specified load from the unit's emission data sheet. Emissions data accounts for potential site variation.

[7] AP-42 Table 3.4-1 indicates that as much as three-fourths of total organic compounds are methane emissions for dual fuel engines. To conservatively over-estimate emissions, all hydrocarbon (HC) emissions are assumed to be VOC.

[8] Sulfur dioxide emission factor is from AP-42 Table 3.4-1. SO2 (lb/MMBtu) = 1.01 x (sulfur content of fuel, %). Emission factor in lb/MMBtu.

[9] All particulates are assumed to be <1 micron in size, consistent with AP-42 Section 3.3, Table 3.3-1 "Emission Factors for Uncontrolled Gasoline and Diesel Industrial Engines," Supplement B, October 1996; includes both filterable and condensable particulate.

[10] GHG emission factors from Tables C-1 and C-2, 40 CFR 98, Subpart C.

[11] CO_2e is the sum of GHG constituents multiplied by their respective global warming potential (i.e. 1 for CO_2, 25 for CH_4, and 298 for N_2O), per Table A-1, 40 CFR 98, Subpart A.

[12] Maximum fuel consumption for 100 hr/yr/gen.

[13] Emission Rate (lb/gal) = Rated Capacity (MMBtu/hr or kWm at specified load) × Emission Factor (lb/MMBtu, kg/MMBtu, g/kWm-hr) / Fuel Consumption Rate (gal/hr). 453.592 g per lb and 2.20462 lb per kg used for conversions.

[14] Maximum lb/gal emission rate is determined across all engine loads. Emission rates for different pollutants may be used to select the highest emissions for each individual pollutant.

[15] Emission factors from AP-42 Section 3.4, Table 3.4-3 "Speciated Organic Compound Emission Factors for Large Uncontrolled Stationary Diesel Engines" and Table 3.4.-4 "PAH Emission Factors for Large Uncontrolled Stationary Diesel Engines," Supplement B, October 1996.

[16] Potential Emissions (tpy) are based on annual operating limit and highest hourly emission factor.

APPENDIX C. UNIT SPECIFICATION SHEETS

PERFORMANCE DATA [175DRA9]

Perf No: DM8448 **Change Level:** 17

General | Heat Rejection | Sound | Emissions | Regulatory | Altitude Derate | Cross Reference | Perf Param Ref

View PDF

SALES MODEL:	C175-16	**COMBUSTION:**	DIRECT INJECTION
BRAND:	CAT	**ENGINE SPEED (RPM):**	1,800
MACHINE SALES MODEL:		**HERTZ:**	60
ENGINE POWER (BHP):	4,423	**FAN POWER (HP):**	187.7
GEN POWER WITH FAN (EKW):	3,000.0	**ASPIRATION:**	TA
COMPRESSION RATIO:	15.3	**AFTERCOOLER TYPE:**	SCAC
RATING LEVEL:	STANDBY	**AFTERCOOLER CIRCUIT TYPE:**	JW+OC+1AC, 2AC
PUMP QUANTITY:	2	**AFTERCOOLER TEMP (F):**	115
FUEL TYPE:	DIESEL	**JACKET WATER TEMP (F):**	210.2
MANIFOLD TYPE:	DRY	**TURBO CONFIGURATION:**	PARALLEL
GOVERNOR TYPE:	ADEM4	**TURBO QUANTITY:**	4
ELECTRONICS TYPE:	ADEM4	**TURBOCHARGER MODEL:**	GTB6251BN-48T-1.38
CAMSHAFT TYPE:	STANDARD	**CERTIFICATION YEAR:**	2014
IGNITION TYPE:	CI	**CRANKCASE BLOWBY RATE (FT3/HR):**	2,436.4
INJECTOR TYPE:	CR	**FUEL RATE (RATED RPM) NO LOAD (GAL/HR):**	22.9
FUEL INJECTOR:	4439455	**PISTON SPD @ RATED ENG SPD (FT/MIN):**	2,598.4
REF EXH STACK DIAMETER (IN):	14		

INDUSTRY	SUB INDUSTRY	APPLICATION
ELECTRIC POWER	STANDARD	PACKAGED GENSET
OIL AND GAS	LAND PRODUCTION	PACKAGED GENSET

General Performance Data Top

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	BRAKE MEAN EFF PRES (BMEP)	BRAKE SPEC FUEL CONSUMPTN (BSFC)	ISO BRAKE SPEC FUEL CONSUMPTN (BSFC)	VOL FUEL CONSUMPTN (VFC)	ISO VOL FUEL CONSUMPTN (VFC)	ELEC SPEC FUEL CONSUMPTN (ESFC)	ISO ELEC SPEC FUEL CONSUMPTN (ESFC)
EKW	%	BHP	PSI	LB/BHP-HR	LB/BHP-HR	GAL/HR	GAL/HR	LB/EKW-HR	LB/EKW-HR
3,000.0	100	4,423	377	0.339	0.333	211.4	207.3	0.500	0.490
2,700.0	90	3,999	341	0.338	0.331	190.4	186.8	0.500	0.491
2,400.0	80	3,576	305	0.340	0.334	171.6	168.3	0.507	0.498
2,250.0	75	3,364	286	0.344	0.338	163.2	160.1	0.514	0.505
2,100.0	70	3,152	268	0.351	0.345	156.1	153.1	0.527	0.517
1,800.0	60	2,729	232	0.371	0.364	142.6	139.9	0.562	0.551
1,500.0	50	2,305	196	0.396	0.388	128.7	126.2	0.609	0.597
1,200.0	40	1,882	160	0.417	0.409	110.7	108.6	0.654	0.642
900.0	30	1,458	124	0.440	0.431	90.4	88.7	0.713	0.699
750.0	25	1,246	106	0.453	0.444	79.5	78.0	0.752	0.738
600.0	20	1,035	88	0.467	0.458	68.2	66.9	0.806	0.791
300.0	10	611	52	0.514	0.504	44.3	43.5	1.048	1.028

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	INLET MFLD PRES	INLET MFLD TEMP	EXH MFLD TEMP	EXH MFLD PRES	ENGINE OUTLET TEMP	COMPRESSOR OUTLET PRES	COMPRESSOR OUTLET TEMP
EKW	%	BHP	IN-HG	DEG F	DEG F	IN-HG	DEG F	IN-HG	DEG F
3,000.0	100	4,423	91.5	131.3	1,229.8	64.3	891.9	92	451.5
2,700.0	90	3,999	81.4	129.6	1,193.4	56.5	879.2	82	414.6
2,400.0	80	3,576	73.0	128.3	1,163.0	50.0	869.4	74	384.7
2,250.0	75	3,364	69.5	127.8	1,150.7	47.5	865.8	70	373.0
2,100.0	70	3,152	67.1	127.6	1,142.6	45.8	864.2	68	366.1
1,800.0	60	2,729	62.7	127.3	1,127.7	42.8	861.6	65	354.0
1,500.0	50	2,305	57.5	126.9	1,109.9	39.5	858.0	60	339.0
1,200.0	40	1,882	46.4	125.8	1,083.9	32.9	848.4	50	308.0
900.0	30	1,458	34.8	124.5	1,041.6	25.3	834.7	39	267.2
750.0	25	1,246	29.0	123.8	1,014.2	21.3	826.5	33	243.5
600.0	20	1,035	23.2	123.2	961.6	17.6	797.3	27	217.8
300.0	10	611	11.7	122.1	752.4	10.6	649.3	14	160.9

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	WET INLET AIR VOL FLOW RATE	ENGINE OUTLET WET EXH GAS VOL FLOW RATE	WET INLET AIR MASS FLOW RATE	WET EXH GAS MASS FLOW RATE	WET EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)	DRY EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)
EKW	%	BHP	CFM	CFM	LB/HR	LB/HR	FT3/MIN	FT3/MIN
3,000.0	100	4,423	9,772.2	25,620.0	42,761.1	44,259.6	9,320.0	8,667.2
2,700.0	90	3,999	8,943.0	23,086.1	38,888.2	40,238.8	8,477.9	7,889.0
2,400.0	80	3,576	8,243.6	20,980.8	35,642.2	36,860.0	7,761.6	7,230.7
2,250.0	75	3,364	7,953.8	20,121.0	34,304.6	35,462.7	7,463.6	6,958.6
2,100.0	70	3,152	7,753.3	19,531.3	33,379.1	34,486.9	7,254.0	6,770.2
1,800.0	60	2,729	7,382.3	18,480.5	31,695.8	32,707.6	6,876.9	6,433.3
1,500.0	50	2,305	6,952.0	17,314.7	29,788.0	30,700.3	6,460.8	6,059.1
1,200.0	40	1,882	6,076.8	15,264.4	25,920.8	26,704.4	5,737.4	5,392.5
900.0	30	1,458	5,160.3	12,786.8	21,909.9	22,550.1	4,857.0	4,574.5
750.0	25	1,246	4,701.8	11,409.7	19,919.4	20,483.0	4,361.8	4,112.2
600.0	20	1,035	4,243.2	9,964.4	17,938.9	18,422.6	3,897.7	3,682.5
300.0	10	611	3,325.6	6,901.7	14,007.7	14,322.1	3,060.0	2,917.8

Heat Rejection Data Top

Note(s)

PUMP POWER IS INCLUDED IN HEAT REJECTION BALANCE, BUT IS NOT SHOWN.

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	REJECTION TO JACKET WATER	REJECTION TO ATMOSPHERE	REJECTION TO EXH	EXHAUST RECOVERY TO 350F	FROM OIL COOLER	FROM 2ND STAGE AFTERCOOLER	WORK ENERGY	LOW HEAT VALUE ENERGY	HIGH HEAT VALUE ENERGY
EKW	%	BHP	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN
3,000.0	100	4,423	78,059	8,307	178,226	101,475	24,373	27,992	187,548	457,607	487,466
2,700.0	90	3,999	69,753	7,694	159,943	89,988	21,844	22,735	169,590	410,123	436,884
2,400.0	80	3,576	62,814	7,204	144,872	80,799	19,611	18,646	151,631	368,192	392,217
2,250.0	75	3,364	59,856	7,005	138,541	77,146	18,605	17,040	142,651	349,309	372,102
2,100.0	70	3,152	57,690	6,871	134,338	74,726	17,781	16,060	133,672	333,838	355,621
1,800.0	60	2,729	54,063	6,651	127,402	70,419	16,278	14,739	115,714	305,626	325,568
1,500.0	50	2,305	50,535	6,481	119,941	65,533	14,768	13,646	97,755	277,263	295,355
1,200.0	40	1,882	45,772	6,336	107,141	55,828	12,870	11,188	79,796	241,627	257,393
900.0	30	1,458	39,631	6,219	90,342	45,754	10,669	8,349	61,838	200,308	213,378
750.0	25	1,246	36,078	6,172	80,662	40,805	9,471	7,028	52,858	177,821	189,424
600.0	20	1,035	31,984	6,027	70,162	34,336	8,207	5,910	43,879	154,087	164,142
300.0	10	611	21,611	5,163	46,779	17,588	5,475	4,318	25,920	102,790	109,497

Sound Data Top

Note(s)

SOUND DATA REPRESENTATIVE OF NOISE PRODUCED BY THE "ENGINE ONLY"

EXHAUST:SOUND POWER(1/3 Octave Frequencies)

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	OVERALL SOUND	100 HZ	125 HZ	160 HZ	200 HZ	250 HZ	315 HZ	400 HZ	500 HZ	630 HZ	800 HZ
EKW	%	BHP	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
3,000.0	100	4,423	134.5	109.7	115.8	113.7	115.5	116.0	119.0	119.9	121.5	120.4	121.2
2,700.0	90	3,999	133.2	110.2	116.1	112.6	114.3	114.5	117.3	118.4	120.1	118.3	119.5
2,400.0	80	3,576	132.0	111.6	116.6	111.0	112.7	113.0	115.6	116.9	118.4	116.5	117.7
2,250.0	75	3,364	131.4	112.4	116.8	110.2	111.9	112.3	114.8	116.2	117.6	115.6	116.8
2,100.0	70	3,152	130.7	113.2	117.1	109.3	111.1	111.6	114.0	115.5	116.8	114.7	115.9
1,800.0	60	2,729	129.5	114.8	117.6	107.5	109.4	110.2	112.3	114.1	115.1	113.0	114.0
1,500.0	50	2,305	128.2	116.3	118.1	105.8	107.8	108.7	110.6	112.6	113.4	111.2	112.2
1,200.0	40	1,882	127.0	117.9	118.6	104.1	106.1	107.3	108.9	111.2	111.8	109.5	110.3
900.0	30	1,458	125.7	119.5	119.1	102.3	104.4	105.9	107.3	109.8	110.1	107.7	108.5
750.0	25	1,246	125.1	120.2	119.3	101.4	103.6	105.2	106.4	109.1	109.3	106.8	107.6
600.0	20	1,035	124.4	121.0	119.6	100.6	102.8	104.5	105.6	108.4	108.4	105.9	106.7
300.0	10	611	123.2	122.6	120.0	98.8	101.1	103.0	103.9	106.9	106.8	104.2	104.8

EXHAUST:SOUND POWER(1/3 Octave Frequencies)

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	1000 HZ	1250 HZ	1600 HZ	2000 HZ	2500 HZ	3150 HZ	4000 HZ	5000 HZ	6300 HZ	8000 HZ	10000 HZ
EKW	%	BHP	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
3,000.0	100	4,423	122.2	122.6	123.5	124.9	124.7	123.1	122.4	121.6	120.1	119.0	123.4
2,700.0	90	3,999	120.7	121.0	122.2	123.5	123.2	121.5	120.8	120.0	118.7	117.8	123.8
2,400.0	80	3,576	119.4	119.7	120.8	122.5	121.9	120.4	119.8	119.0	117.7	117.1	123.5
2,250.0	75	3,364	118.8	119.1	120.1	122.0	121.3	119.9	119.4	118.6	117.2	116.8	123.3
2,100.0	70	3,152	118.1	118.5	119.4	121.5	120.6	119.3	119.0	118.2	116.7	116.5	123.1
1,800.0	60	2,729	116.9	117.3	118.0	120.4	119.4	118.3	118.1	117.3	115.6	115.9	122.6
1,500.0	50	2,305	115.6	116.2	116.6	119.4	118.1	117.3	117.2	116.4	114.6	115.3	122.1
1,200.0	40	1,882	114.3	115.0	115.1	118.4	116.8	116.3	116.4	115.6	113.6	114.7	121.6
900.0	30	1,458	113.1	113.8	113.7	117.4	115.6	115.3	115.5	114.7	112.6	114.1	121.1
750.0	25	1,246	112.4	113.2	113.0	116.9	114.9	114.8	115.1	114.3	112.1	113.8	120.9
600.0	20	1,035	111.8	112.6	112.3	116.4	114.3	114.2	114.7	113.9	111.6	113.5	120.7
300.0	10	611	110.5	111.4	110.9	115.4	113.0	113.2	113.8	113.0	110.6	112.9	120.2

MECHANICAL:SOUND POWER(1/3 Octave Frequencies)

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	OVERALL SOUND	100 HZ	125 HZ	160 HZ	200 HZ	250 HZ	315 HZ	400 HZ	500 HZ	630 HZ	800 HZ
EKW	%	BHP	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
3,000.0	100	4,423	125.9	89.8	105.6	98.4	100.6	104.5	108.3	111.6	113.3	112.5	114.1
2,700.0	90	3,999	125.8	89.4	105.5	97.9	100.9	103.3	108.7	111.1	112.7	112.2	113.8
2,400.0	80	3,576	126.0	89.0	105.0	97.8	99.8	102.4	108.0	111.0	111.8	111.9	113.0
2,250.0	75	3,364	126.1	88.8	104.7	97.8	99.1	102.1	107.5	111.0	111.3	111.7	112.6
2,100.0	70	3,152	126.2	88.5	104.3	97.8	98.4	101.7	107.0	111.0	110.8	111.6	112.2
1,800.0	60	2,729	126.5	88.1	103.7	97.8	96.9	100.9	106.0	111.0	109.8	111.2	111.4
1,500.0	50	2,305	126.7	87.7	103.0	97.8	95.4	100.2	105.1	111.0	108.8	110.9	110.5
1,200.0	40	1,882	127.0	87.3	102.4	97.7	94.0	99.4	104.1	110.9	107.8	110.6	109.7
900.0	30	1,458	127.2	86.9	101.7	97.7	92.5	98.6	103.1	110.9	106.8	110.2	108.9
750.0	25	1,246	127.3	86.7	101.4	97.7	91.8	98.2	102.6	110.9	106.3	110.1	108.5
600.0	20	1,035	127.4	86.4	101.0	97.7	91.0	97.9	102.1	110.9	105.8	109.9	108.1
300.0	10	611	127.7	86.0	100.4	97.7	89.6	97.1	101.2	110.9	104.8	109.6	107.2

MECHANICAL:SOUND POWER(1/3 Octave Frequencies)

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	1000 HZ	1250 HZ	1600 HZ	2000 HZ	2500 HZ	3150 HZ	4000 HZ	5000 HZ	6300 HZ	8000 HZ	10000 HZ
EKW	%	BHP	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
3,000.0	100	4,423	112.7	113.9	114.6	115.3	115.0	112.7	110.9	111.9	114.3	113.4	117.8
2,700.0	90	3,999	112.5	113.7	114.5	115.0	114.5	112.3	110.4	111.1	113.6	112.9	119.2
2,400.0	80	3,576	112.2	113.2	113.8	114.4	114.2	111.9	110.0	110.7	113.2	112.6	121.4
2,250.0	75	3,364	112.0	112.9	113.4	114.0	114.2	111.7	109.8	110.5	112.9	112.6	122.6
2,100.0	70	3,152	111.8	112.6	113.0	113.7	114.1	111.4	109.6	110.3	112.7	112.5	123.8
1,800.0	60	2,729	111.3	112.1	112.2	113.1	113.9	111.0	109.3	110.0	112.3	112.3	126.2
1,500.0	50	2,305	110.9	111.5	111.4	112.4	113.7	110.6	109.0	109.6	111.9	112.1	128.6
1,200.0	40	1,882	110.5	110.9	110.5	111.7	113.5	110.2	108.6	109.3	111.5	111.9	131.0
900.0	30	1,458	110.1	110.3	109.7	111.1	113.4	109.8	108.3	109.0	111.0	111.8	133.4
750.0	25	1,246	109.9	110.0	109.3	110.7	113.3	109.6	108.1	108.8	110.8	111.7	134.6
600.0	20	1,035	109.7	109.7	108.9	110.4	113.2	109.3	107.9	108.6	110.6	111.6	135.8
300.0	10	611	109.3	109.2	108.1	109.7	113.0	108.9	107.6	108.3	110.2	111.4	138.2

Emissions Data Top

Units Filter All Units

DIESEL

RATED SPEED NOMINAL DATA: 1800 RPM

GENSET POWER WITH FAN ENGINE POWER		EKW BHP	3,000.0 4,423	2,700.0 3,999	2,250.0 3,364	1,500.0 2,305	750.0 1,246	300.0 611
PERCENT LOAD		%	100	90	75	50	25	10
TOTAL NOX (AS NO2)		G/HR	26,766	23,378	17,949	7,858	3,175	2,792
TOTAL CO		G/HR	1,477	1,812	1,917	994	1,008	1,017
TOTAL HC		G/HR	184	146	139	269	289	261
TOTAL CO2		KG/HR	2,236	1,976	1,651	1,287	779	428
PART MATTER		G/HR	115.0	122.3	121.5	87.6	96.1	92.4
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	3,103.2	3,082.7	2,787.9	1,561.9	1,050.9	1,867.9
TOTAL CO	(CORR 5% O2)	MG/NM3	149.2	215.1	257.1	167.9	279.0	557.1
TOTAL HC	(CORR 5% O2)	MG/NM3	15.7	13.1	16.2	40.1	72.0	121.7
PART MATTER	(CORR 5% O2)	MG/NM3	10.0	12.2	14.2	13.1	24.2	45.9
TOTAL NOX (AS NO2)	(CORR 15% O2)	MG/NM3	1,151.5	1,143.9	1,034.5	579.6	390.0	693.1
TOTAL CO	(CORR 15% O2)	MG/NM3	55.4	79.8	95.4	62.3	103.5	206.7
TOTAL HC	(CORR 15% O2)	MG/NM3	5.8	4.9	6.0	14.9	26.7	45.1
PART MATTER	(CORR 15% O2)	MG/NM3	3.7	4.5	5.3	4.9	9.0	17.0
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,512	1,502	1,358	761	512	910
TOTAL CO	(CORR 5% O2)	PPM	119	172	206	134	223	446
TOTAL HC	(CORR 5% O2)	PPM	29	24	30	75	134	227
TOTAL NOX (AS NO2)	(CORR 15% O2)	PPM	561	557	504	282	190	338
TOTAL CO	(CORR 15% O2)	PPM	44	64	76	50	83	165
TOTAL HC	(CORR 15% O2)	PPM	11	9	11	28	50	84
TOTAL NOX (AS NO2)		G/HP-HR	6.07	5.86	5.35	3.41	2.55	4.56
TOTAL CO		G/HP-HR	0.34	0.45	0.57	0.43	0.81	1.66
TOTAL HC		G/HP-HR	0.04	0.04	0.04	0.12	0.23	0.43
PART MATTER		G/HP-HR	0.03	0.03	0.04	0.04	0.08	0.15
TOTAL NOX (AS NO2)		G/KW-HR	8.25	7.97	7.27	4.64	3.46	6.20
TOTAL CO		G/KW-HR	0.46	0.62	0.78	0.59	1.10	2.26
TOTAL HC		G/KW-HR	0.06	0.05	0.06	0.16	0.32	0.58
PART MATTER		G/KW-HR	0.04	0.04	0.05	0.05	0.10	0.21
TOTAL NOX (AS NO2)		LB/HR	59.01	51.54	39.57	17.32	7.00	6.16
TOTAL CO		LB/HR	3.26	3.99	4.23	2.19	2.22	2.24
TOTAL HC		LB/HR	0.41	0.32	0.31	0.59	0.64	0.57
TOTAL CO2		LB/HR	4,930	4,357	3,639	2,836	1,717	943
PART MATTER		LB/HR	0.25	0.27	0.27	0.19	0.21	0.20
OXYGEN IN EXH		%	9.6	9.8	10.2	11.6	12.7	14.5
DRY SMOKE OPACITY		%	0.3	0.6	0.8	0.0	0.5	1.9
BOSCH SMOKE NUMBER			0.70	0.73	0.74	0.64	0.71	0.85

RATED SPEED POTENTIAL SITE VARIATION: 1800 RPM

GENSET POWER WITH FAN ENGINE POWER		EKW BHP	3,000.0 4,423	2,700.0 3,999	2,250.0 3,364	1,500.0 2,305	750.0 1,246	300.0 611
PERCENT LOAD		%	100	90	75	50	25	10
TOTAL NOX (AS NO2)		G/HR	32,120	28,053	21,539	9,430	3,810	3,351
TOTAL CO		G/HR	2,658	3,261	3,451	1,789	1,814	1,830
TOTAL HC		G/HR	245	194	185	358	385	347
PART MATTER		G/HR	160.9	171.2	170.2	122.6	134.5	129.4
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	3,723.8	3,699.3	3,345.5	1,874.3	1,261.1	2,241.5
TOTAL CO	(CORR 5% O2)	MG/NM3	268.6	387.2	462.8	302.2	502.2	1,002.8
TOTAL HC	(CORR 5% O2)	MG/NM3	20.9	17.4	21.5	53.3	95.7	161.8
PART MATTER	(CORR 5% O2)	MG/NM3	14.0	17.1	19.8	18.4	33.9	64.3
TOTAL NOX (AS NO2)	(CORR 15% O2)	MG/NM3	1,381.8	1,372.7	1,241.4	695.5	468.0	831.7
TOTAL CO	(CORR 15% O2)	MG/NM3	99.7	143.7	171.7	112.1	186.3	372.1
TOTAL HC	(CORR 15% O2)	MG/NM3	7.7	6.5	8.0	19.8	35.5	60.0
PART MATTER	(CORR 15% O2)	MG/NM3	5.2	6.4	7.4	6.8	12.6	23.8
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,814	1,802	1,630	913	614	1,092
TOTAL CO	(CORR 5% O2)	PPM	215	310	370	242	402	802
TOTAL HC	(CORR 5% O2)	PPM	39	33	40	100	179	302
TOTAL NOX (AS NO2)	(CORR 15% O2)	PPM	673	669	605	339	228	405
TOTAL CO	(CORR 15% O2)	PPM	80	115	137	90	149	298
TOTAL HC	(CORR 15% O2)	PPM	14	12	15	37	66	112
TOTAL NOX (AS NO2)		G/HP-HR	7.29	7.03	6.42	4.09	3.05	5.47
TOTAL CO		G/HP-HR	0.60	0.82	1.03	0.78	1.45	2.99
TOTAL HC		G/HP-HR	0.06	0.05	0.06	0.16	0.31	0.57
PART MATTER		G/HP-HR	0.04	0.04	0.05	0.05	0.11	0.21
TOTAL NOX (AS NO2)		G/KW-HR	9.91	9.56	8.73	5.57	4.15	7.44
TOTAL CO		G/KW-HR	0.82	1.11	1.40	1.06	1.98	4.07
TOTAL HC		G/KW-HR	0.08	0.07	0.08	0.21	0.42	0.77
PART MATTER		G/KW-HR	0.05	0.06	0.07	0.07	0.15	0.29
TOTAL NOX (AS NO2)		LB/HR	70.81	61.85	47.49	20.79	8.40	7.39
TOTAL CO		LB/HR	5.86	7.19	7.61	3.94	4.00	4.03
TOTAL HC		LB/HR	0.54	0.43	0.41	0.79	0.85	0.76
PART MATTER		LB/HR	0.35	0.38	0.38	0.27	0.30	0.29

Regulatory Information Top

EPA TIER 2 — **2006 - 2010**

GASEOUS EMISSIONS DATA MEASUREMENTS PROVIDED TO THE EPA ARE CONSISTENT WITH THOSE DESCRIBED IN EPA 40 CFR PART 89 SUBPART D AND ISO 8178 FOR MEASURING HC, CO, PM, AND NOX. THE "MAX LIMITS" SHOWN BELOW ARE WEIGHTED CYCLE AVERAGES AND ARE IN COMPLIANCE WITH THE NON-ROAD REGULATIONS.

Locality	Agency	Regulation	Tier/Stage	Max Limits - G/BKW - HR
U.S. (INCL CALIF)	EPA	NON-ROAD	TIER 2	CO: 3.5 NOx + HC: 6.4 PM: 0.20

EPA EMERGENCY STATIONARY — **2011 - ----**

GASEOUS EMISSIONS DATA MEASUREMENTS PROVIDED TO THE EPA ARE CONSISTENT WITH THOSE DESCRIBED IN EPA 40 CFR PART 60 SUBPART IIII AND ISO 8178 FOR MEASURING HC, CO, PM, AND NOX. THE "MAX LIMITS" SHOWN BELOW ARE WEIGHTED CYCLE AVERAGES AND ARE IN COMPLIANCE WITH THE EMERGENCY STATIONARY REGULATIONS.

Locality	Agency	Regulation	Tier/Stage	Max Limits - G/BKW - HR
U.S. (INCL CALIF)	EPA	STATIONARY	EMERGENCY STATIONARY	CO: 3.5 NOx + HC: 6.4 PM: 0.20

Altitude Derate Data Top

Note(s)

ALTITUDE DERATE DATA IS BASED ON THE ASSUMPTION OF A 20 DEGREES CELSIUS(36 DEGREES FAHRENHEIT) DIFFERENCE BETWEEN AMBIENT OPERATING TEMPERATURE AND ENGINE INLET SCAC TEMPERATURE. AMBIENT OPEF

STANDARD

ALTITUDE CORRECTED POWER CAPABILITY (BHP)

AMBIENT OPERATING TEMP (F)	30	40	50	60	70	80	90	100	110	120	130	140	NORMAL
ALTITUDE (FT)													
0	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423
1,000	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,405	4,423
2,000	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,355	4,423
3,000	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,423	4,376	4,309	4,216	4,423
4,000	4,345	4,345	4,345	4,345	4,345	4,345	4,344	4,344	4,343	4,280	4,190	4,100	4,345
5,000	4,174	4,174	4,174	4,174	4,174	4,174	4,173	4,172	4,170	4,130	4,073	4,017	4,174
6,000	4,015	4,015	4,015	4,015	4,015	4,015	4,013	4,011	4,008	3,988	3,960	3,933	4,015
7,000	3,868	3,868	3,868	3,868	3,868	3,868	3,866	3,863	3,859	3,853	3,847	3,840	3,868
8,000	3,751	3,751	3,751	3,751	3,751	3,751	3,749	3,745	3,742	3,736	3,729	3,723	3,751
9,000	3,634	3,634	3,634	3,634	3,634	3,634	3,633	3,628	3,624	3,618	3,612	3,606	3,634
10,000	3,523	3,523	3,523	3,523	3,523	3,523	3,521	3,517	3,512	3,506	3,500	3,495	3,523
11,000	3,417	3,417	3,417	3,417	3,417	3,417	3,415	3,411	3,406	3,400	3,394	3,388	3,417
12,000	3,312	3,312	3,312	3,312	3,312	3,312	3,310	3,304	3,299	3,294	3,288	3,282	3,312
13,000	3,206	3,206	3,206	3,206	3,206	3,206	3,204	3,198	3,193	3,188	3,182	3,176	3,206
14,000	3,100	3,100	3,100	3,100	3,100	3,100	3,098	3,093	3,088	3,083	3,079	3,074	3,100
15,000	2,993	2,993	2,993	2,993	2,993	2,993	2,991	2,988	2,984	2,981	2,977	2,974	2,993

Cross Reference Top

Test Spec	Setting	Engine Arrangement	Engineering Model	Engineering Model Version	Start Effective Serial Number	End Effective Serial Number
0K8532	LL6018	3079788	GS265	-	WYB01883	
0K8532	LL6018	5683569	PG323	-	TB800177	
0K8532	LL6018	5717349	PG323	-	TB800100	

Performance Parameter Reference Top

Parameters Reference: DM9600 - 14

PERFORMANCE DEFINITIONS

PERFORMANCE DEFINITIONS DM9600

APPLICATION: Engine performance tolerance values below are representative of a typical production engine tested in a calibrated dynamometer test cell at SAE J1995 standard reference conditions. Caterpillar maintains ISO9001:2000 certified quality management systems for engine test Facilities to assure accurate calibration of test equipment. Engine test data is corrected in accordance with SAE J1995. Additional reference material SAE J1228, J1349, ISO 8665, 3046-1:2002E, 3046-3:1989, 1585, 2534, 2288, and 9249 may apply in part or are similar to SAE J1995. Special engine rating request (SERR) test data shall be noted.

PERFORMANCE PARAMETER TOLERANCE FACTORS: Power +/- 3% Torque +/- 3% Exhaust stack temperature +/- 8% Inlet airflow +/- 5% Intake manifold pressure-gage +/- 10% Exhaust flow +/- 6% Specific fuel consumption +/- 3% Fuel rate +/- 5% Specific DEF consumption +/- 3% DEF rate +/- 5% Heat rejection +/- 5% Heat rejection exhaust only +/- 10% Heat rejection CEM only +/- 10%
Heat Rejection values based on using treated water.
Torque is included for truck and industrial applications, do not use for Gen Set or steady state applications.
On C7 - C18 engines, at speeds of 1100 RPM and under these values are provided for reference only, and may not meet the tolerance listed.
On 3500 and C175 engines, at speeds below Peak Torque these values are provided for reference only, and may not meet the tolerance listed.
These values do not apply to C280/3600. For these models, see the tolerances listed below.

C280/3600 HEAT REJECTION TOLERANCE FACTORS: Heat rejection +/- 10% Heat rejection to Atmosphere +/- 50% Heat rejection to Lube Oil +/- 20% Heat rejection to Aftercooler +/- 5%

TEST CELL TRANSDUCER TOLERANCE FACTORS: Torque +/- 0.5% Speed +/- 0.2% Fuel flow +/- 1.0% Temperature +/- 2.0 C degrees Intake manifold pressure +/- 0.1 kPa
OBSERVED ENGINE PERFORMANCE IS CORRECTED TO SAE J1995 REFERENCE AIR AND FUEL CONDITIONS.

REFERENCE ATMOSPHERIC INLET AIR FOR 3500 ENGINES AND SMALLER SAE J1228 AUG2002 for marine engines, and J1995 JAN2014 for other engines, reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity at the stated aftercooler water temp, or inlet manifold temp.
FOR 3600 ENGINES Engine rating obtained and presented in accordance with ISO 3046/1 and SAE J1995 JANJAN2014 reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity and 150M altitude at the stated aftercooler water temperature.

MEASUREMENT LOCATION FOR INLET AIR TEMPERATURE Location for air temperature measurement air cleaner inlet at stabilized operating conditions.

REFERENCE EXHAUST STACK DIAMETER The Reference Exhaust Stack Diameter published with this dataset is only used for the calculation of Smoke Opacity values displayed in this dataset. This value does not necessarily represent the actual stack diameter of the engine due to the variety of exhaust stack adapter options available. Consult the price list, engine order or general dimension drawings for the actual stack diameter size ordered or options available.

REFERENCE FUEL DIESEL Reference fuel is #2 distillate diesel with a 35API gravity; A lower heating value is 42,780 KJ/KG (18,390 BTU/LB) when used at 15 deg C (59 deg F), where the density is 850 G/Liter (7.0936 Lbs/Gal).
GAS Reference natural gas fuel has a lower heating value of 33.74 KJ/L (905 BTU/CU Ft). Low BTU ratings are based on 18.64 KJ/L (500 BTU/CU FT) lower heating value gas. Propane ratings are based on 87.56 KJ/L (2350 BTU/CU Ft) lower heating value gas.

ENGINE POWER (NET) IS THE CORRECTED FLYWHEEL POWER (GROSS) LESS EXTERNAL AUXILIARY LOAD Engine corrected gross output includes the power required to drive standard equipment; lube oil, scavenge lube oil, fuel transfer, common rail fuel, separate circuit aftercooler and jacket water pumps. Engine net power available for the external (flywheel) load is calculated by subtracting the sum of auxiliary load from the corrected gross flywheel out put power. Typical auxiliary loads are radiator cooling fans, hydraulic pumps, air compressors and battery charging alternators. For Tier 4 ratings additional Parasitic losses would also include Intake, and Exhaust Restrictions.

ALTITUDE CAPABILITY Altitude capability is the maximum altitude above sea level at standard temperature and standard pressure at which the engine could develop full rated output power on the current performance data set.
Standard temperature values versus altitude could be seen on TM2001.
When viewing the altitude capability chart the ambient temperature is the inlet air temp at the compressor inlet.
Engines with ADEM MEUI and HEUI fuel systems operating at conditions above the defined altitude capability derate for atmospheric pressure and temperature conditions outside the values defined, see TM2001.
Mechanical governor controlled unit injector engines require a setting change for operation at conditions above the altitude defined on the engine performance sheet. See your Caterpillar technical representative for non standard ratings.

REGULATIONS AND PRODUCT COMPLIANCE TMI Emissions information is presented at 'nominal' and 'Potential Site Variation' values for standard ratings. No tolerances are applied to the emissions data. These values are subject to change at any time. The controlling federal and local emission requirements need to be verified by your Caterpillar technical representative.
Customer's may have special emission site requirements that need to be verified by the Caterpillar Product Group engineer.

EMISSION CYCLE LIMITS: Cycle emissions Max Limits apply to cycle-weighted averages only. Emissions at individual load points may exceed the cycle-weighted limit.

WET & DRY EXHAUST/EMISSIONS DESCRIPTION: Wet - Total exhaust flow or concentration of total exhaust flow Dry - Total exhaust flow minus water vapor or concentration of exhaust flow with water vapor excluded

EMISSIONS DEFINITIONS: Emissions : DM1176

EMISSION CYCLE DEFINITIONS
1. For constant-speed marine engines for ship main propulsion, including,diesel-electric drive, test cycle E2 shall be applied, for controllable-pitch propeller sets test cycle E2 shall be applied.
2. For propeller-law-operated main and propeller-law-operated auxiliary engines the test cycle E3 shall be applied.
3. For constant-speed auxiliary engines test cycle D2 shall be applied.
4. For variable-speed, variable-load auxiliary engines, not included above, test cycle C1 shall be applied.

HEAT REJECTION DEFINITIONS: Diesel Circuit Type and HHV Balance : DM9500

HIGH DISPLACEMENT (HD) DEFINITIONS: 3500: EM1500

RATING DEFINITIONS: Agriculture : TM6008
Fire Pump : TM6009
Generator Set : TM6035
Generator (Gas) : TM6041
Industrial Diesel : TM6010
Industrial (Gas) : TM6040
Irrigation : TM5749
Locomotive : TM6037
Marine Auxiliary : TM6036
Marine Prop (Except 3600) : TM5747
Marine Prop (3600 only) : TM5748
MSHA : TM6042
Oil Field (Petroleum) : TM6011
Off-Highway Truck : TM6039
On-Highway Truck : TM6038

SOUND DEFINITIONS: Sound Power : DM8702
Sound Pressure : TM7080

Date Released : 10/27/21

PERFORMANCE DATA[EM4716]

August 10, 2022

Performance Number: EM4716 **Change Level: 02**

SALES MODEL:	3516E	**COMBUSTION:**	DIRECT INJECTION
BRAND:	CAT	**ENGINE SPEED (RPM):**	1,800
MACHINE SALES MODEL:		**HERTZ:**	60
ENGINE POWER (BHP):	4,393	**FAN POWER (HP):**	154.2
GEN POWER WITH FAN (EKW):	3,000.0	**ASPIRATION:**	TA
COMPRESSION RATIO:	13.9	**AFTERCOOLER TYPE:**	ATAAC
RATING LEVEL:	STANDBY	**AFTERCOOLER CIRCUIT TYPE:**	JW+OC, ATAAC
PUMP QUANTITY:	1	**INLET MANIFOLD AIR TEMP (F):**	122
FUEL TYPE:	DIESEL	**JACKET WATER TEMP (F):**	219.2
MANIFOLD TYPE:	DRY	**TURBO CONFIGURATION:**	PARALLEL
GOVERNOR TYPE:	ADEM5	**TURBO QUANTITY:**	4
ELECTRONICS TYPE:	ADEM5	**TURBOCHARGER MODEL:**	TPX44-H32-CT70-CA50-TT70-TA80
IGNITION TYPE:	CI	**CERTIFICATION YEAR:**	2020
INJECTOR TYPE:	MEUI-C	**CRANKCASE BLOWBY RATE (FT3/HR):**	4,390.2
FUEL INJECTOR:	5816980	**FUEL RATE (RATED RPM) NO LOAD (GAL/HR):**	17.2
UNIT INJECTOR TIMING (IN):	0.88	**PISTON SPD @ RATED ENG SPD (FT/MIN):**	2,539.4
REF EXH STACK DIAMETER (IN):	12		
MAX OPERATING ALTITUDE (FT):	6,562		

INDUSTRY	SUBINDUSTRY	APPLICATION
ELECTRIC POWER	STANDARD	PACKAGED GENSET

General Performance Data

THE INLET MANIFOLD AIR TEMP LISTED IN THE HEADER, AND IN THE GENERAL PERFORMANCE DATA, IS THE AVERAGE INLET MANIFOLD TEMP FRONT TO REAR ON THE ENGINE.

THIS STANDBY RATING IS FOR A STANDBY ONLY ENGINE ARRANGEMENT. RERATING THE ENGINE TO A STANDARD PRIME OR CONTINUOUS RATING IS NOT PERMITTED.

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	BRAKE MEAN EFF PRES (BMEP)	BRAKE SPEC FUEL CONSUMPTN (BSFC)	ISO BRAKE SPEC FUEL CONSUMPTN (BSFC)	VOL FUEL CONSUMPTN (VFC)	ISO VOL FUEL CONSUMPTN (VFC)	ELEC SPEC FUEL CONSUMPTN (ESFC)	ISO ELEC SPEC FUEL CONSUMPTN (ESFC)
EKW	%	BHP	PSI	LB/BHP-HR	LB/BHP-HR	GAL/HR	GAL/HR	LB/EKW-HR	LB/EKW-HR
3,000.0	100	4,393	406	0.336	0.330	208.2	204.3	0.492	0.483
2,700.0	90	3,976	367	0.340	0.333	190.3	186.7	0.500	0.491
2,400.0	80	3,557	328	0.349	0.343	175.1	171.7	0.517	0.508
2,250.0	75	3,347	309	0.356	0.349	168.1	164.9	0.530	0.520
2,100.0	70	3,137	290	0.362	0.355	160.2	157.1	0.541	0.531
1,800.0	60	2,716	251	0.370	0.363	141.7	139.0	0.559	0.548
1,500.0	50	2,294	212	0.389	0.382	125.9	123.5	0.595	0.584
1,200.0	40	1,872	173	0.406	0.398	107.2	105.2	0.634	0.622
900.0	30	1,449	134	0.401	0.393	81.8	80.3	0.645	0.633
750.0	25	1,236	114	0.381	0.374	66.4	65.1	0.628	0.616
600.0	20	1,022	94	0.392	0.384	56.4	55.4	0.667	0.655
300.0	10	590	55	0.441	0.433	36.7	36.0	0.869	0.852

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	INLET MFLD PRES	INLET MFLD TEMP	EXH MFLD TEMP	EXH MFLD PRES	ENGINE OUTLET TEMP	COMPRESSOR OUTLET PRES	COMPRESSOR OUTLET TEMP
EKW	%	BHP	IN-HG	DEG F	DEG F	IN-HG	DEG F	IN-HG	DEG F
3,000.0	100	4,393	91.7	119.6	1,263.2	61.5	901.9	100	451.3
2,700.0	90	3,976	82.2	119.3	1,247.8	54.4	904.4	90	423.5
2,400.0	80	3,557	74.9	118.9	1,242.3	48.9	913.3	82	403.8
2,250.0	75	3,347	72.1	119.0	1,240.1	46.9	917.3	79	395.9
2,100.0	70	3,137	67.8	119.3	1,240.0	43.8	925.8	74	384.0
1,800.0	60	2,716	56.0	120.2	1,245.9	35.5	953.4	62	348.0
1,500.0	50	2,294	47.1	118.6	1,248.2	29.9	973.6	52	318.8
1,200.0	40	1,872	33.9	114.2	1,255.9	21.9	1,002.7	38	269.7
900.0	30	1,449	16.7	112.4	1,203.6	12.3	984.1	20	191.4
750.0	25	1,236	8.9	110.5	1,091.8	8.1	915.3	11	150.2
600.0	20	1,022	5.8	108.3	1,004.5	6.6	847.7	8	133.3
300.0	10	590	0.9	104.2	780.2	4.2	671.9	3	108.0

General Performance Data (Continued)

GENSET POWER	PERCENT LOAD	ENGINE POWER	WET INLET AIR VOL	ENGINE OUTLET	WET INLET AIR	WET EXH GAS	WET EXH VOL	DRY EXH VOL

PERFORMANCE DATA[EM4716]

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WITH FAN			FLOW RATE	WET EXH GAS VOL FLOW RATE	MASS FLOW RATE	MASS FLOW RATE	FLOW RATE (32 DEG F AND 29.98 IN HG)	FLOW RATE (32 DEG F AND 29.98 IN HG)
EKW	%	BHP	CFM	CFM	LB/HR	LB/HR	FT3/MIN	FT3/MIN
3,000.0	100	4,393	8,689.8	22,803.0	37,643.0	39,120.1	8,234.2	7,508.7
2,700.0	90	3,976	8,100.6	21,092.5	34,770.1	36,119.8	7,602.7	6,941.1
2,400.0	80	3,557	7,618.2	19,872.8	32,572.6	33,813.7	7,116.5	6,503.0
2,250.0	75	3,347	7,434.9	19,421.7	31,724.7	32,917.4	6,934.8	6,343.9
2,100.0	70	3,137	7,140.4	18,713.3	30,413.9	31,551.3	6,641.0	6,078.0
1,800.0	60	2,716	6,316.6	16,737.0	26,667.4	27,671.7	5,823.4	5,324.6
1,500.0	50	2,294	5,698.5	15,244.3	23,951.1	24,844.2	5,229.6	4,787.6
1,200.0	40	1,872	4,748.1	12,895.5	19,832.8	20,593.5	4,335.7	3,959.7
900.0	30	1,449	3,421.3	9,198.1	14,210.7	14,791.0	3,132.4	2,847.7
750.0	25	1,236	2,813.2	7,143.6	11,655.6	12,126.4	2,554.4	2,323.7
600.0	20	1,022	2,588.4	6,214.7	10,705.5	11,105.8	2,337.3	2,139.1
300.0	10	590	2,189.5	4,545.1	9,126.5	9,387.3	1,974.8	1,838.2

Heat Rejection Data

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	REJECTION TO JACKET WATER	REJECTION TO ATMOSPHERE	REJECTION TO EXH	EXHAUST RECOVERY TO 350F	FROM OIL COOLER	FROM AFTERCOOLER	WORK ENERGY	LOW HEAT VALUE ENERGY	HIGH HEAT VALUE ENERGY
EKW	%	BHP	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN
3,000.0	100	4,393	52,144	8,993	175,769	91,810	23,854	53,683	186,315	447,861	477,084
2,700.0	90	3,976	48,348	8,755	162,671	85,129	21,755	46,560	168,590	408,442	435,094
2,400.0	80	3,557	45,188	8,663	152,310	80,972	19,852	39,923	150,835	372,717	397,037
2,250.0	75	3,347	43,721	8,625	147,003	79,360	18,929	37,161	141,942	355,388	378,578
2,100.0	70	3,137	42,430	8,593	141,837	77,229	18,002	34,024	133,031	337,986	360,040
1,800.0	60	2,716	40,153	8,591	130,286	71,150	16,087	27,442	115,184	302,034	321,742
1,500.0	50	2,294	37,137	8,662	118,761	66,069	14,137	20,821	97,288	265,422	282,742

Emissions Data

PARTICULATE EMISSIONS WERE NOT MEASURED FOR THIS RATING. PUBLISHED PM DATA IS ESTIMATED FROM MEASURED SMOKE METER DATA.

DIESEL

RATED SPEED NOMINAL DATA: 1800 RPM

GENSET POWER WITH FAN		EKW	3,000.0	2,250.0	1,500.0	750.0	300.0
PERCENT LOAD		%	100	75	50	25	10
ENGINE POWER		BHP	4,393	3,347	2,294	1,236	590
TOTAL NOX (AS NO2)		G/HR	24,589	12,160	6,934	8,735	6,302
TOTAL CO		G/HR	2,899	2,470	1,673	2,077	1,535
TOTAL HC		G/HR	190	142	118	84	160
TOTAL CO2		KG/HR	2,097	1,691	1,268	673	371
PART MATTER		G/HR	200.9	249.8	229.1	153.7	16.6
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	2,610.4	1,597.8	1,214.4	2,955.6	3,548.5
TOTAL CO	(CORR 5% O2)	MG/NM3	305.9	319.2	290.7	686.3	917.4
TOTAL HC	(CORR 5% O2)	MG/NM3	17.4	16.0	17.7	24.0	84.5
PART MATTER	(CORR 5% O2)	MG/NM3	17.6	27.2	33.4	41.1	11.3
TOTAL NOX (AS NO2)	(CORR 15% O2)	MG/NM3	968.6	592.9	450.6	1,096.7	1,316.7
TOTAL CO	(CORR 15% O2)	MG/NM3	113.5	118.5	107.9	254.7	340.4
TOTAL HC	(CORR 15% O2)	MG/NM3	6.4	5.9	6.6	8.9	31.4
PART MATTER	(CORR 15% O2)	MG/NM3	6.5	10.1	12.4	15.3	4.2
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,272	778	592	1,440	1,728
TOTAL CO	(CORR 5% O2)	PPM	245	255	233	549	734
TOTAL HC	(CORR 5% O2)	PPM	32	30	33	45	158
TOTAL NOX (AS NO2)	(CORR 15% O2)	PPM	472	289	219	534	641
TOTAL CO	(CORR 15% O2)	PPM	91	95	86	204	272
TOTAL HC	(CORR 15% O2)	PPM	12	11	12	17	59
TOTAL NOX (AS NO2)		G/HP-HR	5.63	3.65	3.03	7.07	10.68
TOTAL CO		G/HP-HR	0.66	0.74	0.73	1.68	2.60
TOTAL HC		G/HP-HR	0.04	0.04	0.05	0.07	0.27

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PART MATTER	G/HP-HR	0.05	0.07	0.10	0.12	0.03
TOTAL NOX (AS NO2)	G/KW-HR	7.66	4.96	4.12	9.61	14.53
TOTAL CO	G/KW-HR	0.90	1.01	0.99	2.29	3.54
TOTAL HC	G/KW-HR	0.06	0.06	0.07	0.09	0.37
PART MATTER	G/KW-HR	0.06	0.10	0.14	0.17	0.04
TOTAL NOX (AS NO2)	LB/HR	54.21	26.81	15.29	19.26	13.89
TOTAL CO	LB/HR	6.39	5.44	3.69	4.58	3.38
TOTAL HC	LB/HR	0.42	0.31	0.26	0.18	0.35
TOTAL CO2	LB/HR	4,623	3,728	2,794	1,484	819
PART MATTER	LB/HR	0.44	0.55	0.51	0.34	0.04
OXYGEN IN EXH	%	8.9	9.4	9.5	8.5	12.0
DRY SMOKE OPACITY	%	2.0	2.6	2.9	4.3	0.2
BOSCH SMOKE NUMBER		0.86	0.96	1.02	1.16	0.70

RATED SPEED POTENTIAL SITE VARIATION: 1800 RPM

GENSET POWER WITH FAN		**EKW**	**3,000.0**	**2,250.0**	**1,500.0**	**750.0**	**300.0**
PERCENT LOAD		**%**	**100**	**75**	**50**	**25**	**10**
ENGINE POWER		**BHP**	**4,393**	**3,347**	**2,294**	**1,236**	**590**
TOTAL NOX (AS NO2)		G/HR	29,507	14,592	8,321	10,482	7,562
TOTAL CO		G/HR	5,219	4,446	3,012	3,738	2,763
TOTAL HC		G/HR	253	188	157	111	213
PART MATTER		G/HR	281.2	349.8	320.7	215.1	23.3
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	3,132.5	1,917.4	1,457.3	3,546.7	4,258.2
TOTAL CO	(CORR 5% O2)	MG/NM3	550.6	574.6	523.3	1,235.4	1,651.3
TOTAL HC	(CORR 5% O2)	MG/NM3	23.1	21.3	23.6	31.9	112.4
PART MATTER	(CORR 5% O2)	MG/NM3	24.6	38.1	46.7	57.6	15.8
TOTAL NOX (AS NO2)	(CORR 15% O2)	MG/NM3	1,162.4	711.5	540.8	1,316.1	1,580.1
TOTAL CO	(CORR 15% O2)	MG/NM3	204.3	213.2	194.2	458.4	612.8
TOTAL HC	(CORR 15% O2)	MG/NM3	8.6	7.9	8.8	11.8	41.7
PART MATTER	(CORR 15% O2)	MG/NM3	9.1	14.1	17.3	21.4	5.9
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,526	934	710	1,728	2,074
TOTAL CO	(CORR 5% O2)	PPM	441	460	419	988	1,321
TOTAL HC	(CORR 5% O2)	PPM	43	40	44	60	210
TOTAL NOX (AS NO2)	(CORR 15% O2)	PPM	566	347	263	641	770
TOTAL CO	(CORR 15% O2)	PPM	163	171	155	367	490
TOTAL HC	(CORR 15% O2)	PPM	16	15	16	22	78
TOTAL NOX (AS NO2)		G/HP-HR	6.76	4.38	3.64	8.49	12.82
TOTAL CO		G/HP-HR	1.20	1.33	1.32	3.03	4.68
TOTAL HC		G/HP-HR	0.06	0.06	0.07	0.09	0.36
PART MATTER		G/HP-HR	0.06	0.10	0.14	0.17	0.04
TOTAL NOX (AS NO2)		G/KW-HR	9.19	5.95	4.94	11.54	17.43
TOTAL CO		G/KW-HR	1.63	1.81	1.79	4.11	6.37
TOTAL HC		G/KW-HR	0.08	0.08	0.09	0.12	0.49
PART MATTER		G/KW-HR	0.09	0.14	0.19	0.24	0.05
TOTAL NOX (AS NO2)		LB/HR	65.05	32.17	18.34	23.11	16.67
TOTAL CO		LB/HR	11.51	9.80	6.64	8.24	6.09
TOTAL HC		LB/HR	0.56	0.42	0.35	0.25	0.47
PART MATTER		LB/HR	0.62	0.77	0.71	0.47	0.05

Regulatory Information

EPA EMERGENCY STATIONARY		**2011 - ----**		
GASEOUS EMISSIONS DATA MEASUREMENTS PROVIDED TO THE EPA ARE CONSISTENT WITH THOSE DESCRIBED IN EPA 40 CFR PART 60 SUBPART IIII AND ISO 8178 FOR MEASURING HC, CO, PM, AND NOX. THE "MAX LIMITS" SHOWN BELOW ARE WEIGHTED CYCLE AVERAGES AND ARE IN COMPLIANCE WITH THE EMERGENCY STATIONARY REGULATIONS.				
Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max Limits - G/BKW - HR**
U.S. (INCL CALIF)	EPA	STATIONARY	EMERGENCY STATIONARY	CO: 3.5 NOx + HC: 6.4 PM: 0.20

Altitude Derate Data

A BLANK IN THE ALTITUDE DERATE TABLE SIGNIFIES THAT NO RATING IS AVAILABLE AT THAT SPECIFIED ALTITUDE AND AMBIENT TEMPERATURE.

THE TEMPERATURES LISTED IN THE CHART ARE AMBIENT TEMPERATURES. THE FOLLOWING DERATE CHART WAS CALCULATED ASSUMING A 5 DEG C RISE IN AIR TEMPERATURE BETWEEN AMBIENT AND THE TURBOCHARGER INLET.

PERFORMANCE DATA[EM4716]

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STANDARD

ALTITUDE CORRECTED POWER CAPABILITY (BHP)

AMBIENT OPERATING TEMP (F)	30	40	50	60	70	80	90	100	110	120	130	140	NORMAL
ALTITUDE (FT)													
0	4,393	4,393	4,393	4,393	4,393	4,393	4,393	4,393	4,393	4,393	1,927		4,393
1,000	4,393	4,393	4,393	4,393	4,393	4,393	4,393	4,393	4,393	4,393	1,860		4,393
2,000	4,393	4,393	4,393	4,393	4,393	4,393	4,393	4,393	4,393	4,304			4,393
3,000	4,393	4,393	4,393	4,393	4,393	4,393	4,393	4,393	4,313	2,786			4,393
4,000	4,393	4,393	4,393	4,393	4,393	4,393	4,393	4,355	4,037	1,625			4,393
5,000	4,393	4,393	4,393	4,393	4,393	4,383	4,334	4,221	3,517				4,393
6,000	4,393	4,393	4,393	4,356	4,307	4,246	4,183	4,064	2,023				4,393
7,000	4,393	4,380	4,306	4,226	4,160	4,072	3,968	3,778					4,378
8,000	4,347	4,247	4,153	4,051	3,974	3,836	3,573	3,093					4,274
9,000	4,203	4,068	3,954	3,831	3,738	3,550	3,208	2,621					4,152
10,000	3,990	3,831	3,691	3,541	3,442	3,250	2,968	2,196					3,986
11,000	3,755	3,560	3,390	3,239	3,162	3,018	2,762	1,678					3,815
12,000	3,413	3,252	3,123	3,015	2,940	2,762	2,300	1,104					3,539
13,000	3,070	2,977	2,897	2,829	2,750	2,477	1,702						3,198
14,000	2,754	2,728	2,691	2,660	2,553	2,240							2,841
15,000	2,454	2,461	2,285	2,143	2,057	1,713							2,523

Cross Reference

Test Spec	Setting	Engine Arrangement	Engineering Model	Engineering Model Version	Start Effective Serial Number	End Effective Serial Number
5643811	LL2327	5577462	PG296	-	ZNL00001	

Supplementary Data

Type	Classification	Performance Number
ALTITUDE DATA	HIGH RESOLUTION	EM5585

Performance Parameter Reference

Parameters Reference:DM9600-14

PERFORMANCE DEFINITIONS

PERFORMANCE DEFINITIONS DM9600
APPLICATION:
Engine performance tolerance values below are representative of a typical production engine tested in a calibrated dynamometer test cell at SAE J1995 standard reference conditions. Caterpillar maintains ISO9001:2000 certified quality management systems for engine test Facilities to assure accurate calibration of test equipment. Engine test data is corrected in accordance with SAE J1995. Additional reference material SAE J1228, J1349, ISO 8665, 3046-1:2002E, 3046-3:1989, 1585, 2534, 2288, and 9249 may apply in part or are similar to SAE J1995. Special engine rating request (SERR) test data shall be noted.
PERFORMANCE PARAMETER TOLERANCE FACTORS:
Power +/- 3%
Torque +/- 3%
Exhaust stack temperature +/- 8%
Inlet airflow +/- 5%
Intake manifold pressure-gage +/- 10%
Exhaust flow +/- 6%
Specific fuel consumption +/- 3%
Fuel rate +/- 5%
Specific DEF consumption +/- 3%
DEF rate +/- 5%
Heat rejection +/- 5%

PERFORMANCE DATA[EM4716]

Heat rejection exhaust only +/- 10%
Heat rejection CEM only +/- 10%
Heat Rejection values based on using treated water.
Torque is included for truck and industrial applications, do not use for Gen Set or steady state applications.
On C7 - C18 engines, at speeds of 1100 RPM and under these values are provided for reference only, and may not meet the tolerance listed.
On 3500 and C175 engines, at speeds below Peak Torque these values are provided for reference only, and may not meet the tolerance listed.
These values do not apply to C280/3600. For these models, see the tolerances listed below.
C280/3600 HEAT REJECTION TOLERANCE FACTORS:
Heat rejection +/- 10%
Heat rejection to Atmosphere +/- 50%
Heat rejection to Lube Oil +/- 20%
Heat rejection to Aftercooler +/- 5%
TEST CELL TRANSDUCER TOLERANCE FACTORS:
Torque +/- 0.5%
Speed +/- 0.2%
Fuel flow +/- 1.0%
Temperature +/- 2.0 C degrees
Intake manifold pressure +/- 0.1 kPa
OBSERVED ENGINE PERFORMANCE IS CORRECTED TO SAE J1995 REFERENCE AIR AND FUEL CONDITIONS.
REFERENCE ATMOSPHERIC INLET AIR
FOR 3500 ENGINES AND SMALLER
SAE J1228 AUG2002 for marine engines, and J1995 JAN2014 for other engines, reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity at the stated aftercooler water temp, or inlet manifold temp.
FOR 3600 ENGINES
Engine rating obtained and presented in accordance with ISO 3046/1 and SAE J1995 JANJAN2014 reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity and 150M altitude at the stated aftercooler water temperature.
MEASUREMENT LOCATION FOR INLET AIR TEMPERATURE
Location for air temperature measurement air cleaner inlet at stabilized operating conditions.
REFERENCE EXHAUST STACK DIAMETER
The Reference Exhaust Stack Diameter published with this dataset is only used for the calculation of Smoke Opacity values displayed in this dataset. This value does not necessarily represent the actual stack diameter of the engine due to the variety of exhaust stack adapter options available. Consult the price list, engine order or general dimension drawings for the actual stack diameter size ordered or options available.
REFERENCE FUEL
DIESEL
Reference fuel is #2 distillate diesel with a 35API gravity;
A lower heating value is 42,780 KJ/KG (18,390 BTU/LB) when used at 15 deg C (59 deg F), where the density is 850 G/Liter (7.0936 Lbs/Gal).
GAS
Reference natural gas fuel has a lower heating value of 33.74 KJ/L (905 BTU/CU Ft). Low BTU ratings are based on 18.64 KJ/L (500 BTU/CU FT) lower heating value gas. Propane ratings are based on 87.56 KJ/L (2350 BTU/CU Ft) lower heating value gas.
ENGINE POWER (NET) IS THE CORRECTED FLYWHEEL POWER (GROSS) LESS EXTERNAL AUXILIARY LOAD
Engine corrected gross output includes the power required to drive standard equipment; lube oil, scavenge lube oil, fuel transfer, common rail fuel, separate circuit aftercooler and jacket water pumps. Engine net power available for the external (flywheel) load is calculated by subtracting the sum of auxiliary load from the corrected gross flywheel out put power. Typical auxiliary loads are radiator cooling fans, hydraulic pumps, air compressors and battery charging alternators. For Tier 4 ratings additional Parasitic losses would also include Intake, and Exhaust Restrictions.
ALTITUDE CAPABILITY
Altitude capability is the maximum altitude above sea level at standard temperature and standard pressure at which the engine could develop full rated output power on the current performance data set.
Standard temperature values versus altitude could be seen on TM2001.
When viewing the altitude capability chart the ambient temperature is the inlet air temp at the compressor inlet.
Engines with ADEM MEUI and HEUI fuel systems operating at conditions above the defined altitude capability derate for atmospheric pressure and temperature conditions outside the values defined, see TM2001.
Mechanical governor controlled unit injector engines require a setting change for operation at conditions above the altitude

PERFORMANCE DATA[EM4716]

defined on the engine performance sheet. See your Caterpillar technical representative for non standard ratings.
REGULATIONS AND PRODUCT COMPLIANCE
TMI Emissions information is presented at 'nominal' and 'Potential Site Variation' values for standard ratings. No tolerances are applied to the emissions data. These values are subject to change at any time. The controlling federal and local emission requirements need to be verified by your Caterpillar technical representative.
Customer's may have special emission site requirements that need to be verified by the Caterpillar Product Group engineer.
EMISSION CYCLE LIMITS:
Cycle emissions Max Limits apply to cycle-weighted averages only. Emissions at individual load points may exceed the cycle-weighted limit.
WET & DRY EXHAUST/EMISSIONS DESCRIPTION:
Wet - Total exhaust flow or concentration of total exhaust flow
Dry - Total exhaust flow minus water vapor or concentration of exhaust flow with water vapor excluded
EMISSIONS DEFINITIONS:
Emissions : DM1176
EMISSION CYCLE DEFINITIONS
1. For constant-speed marine engines for ship main propulsion, including,diesel-electric drive, test cycle E2 shall be applied, for controllable-pitch propeller sets
test cycle E2 shall be applied.
2. For propeller-law-operated main and propeller-law-operated auxiliary engines the test cycle E3 shall be applied.
3. For constant-speed auxiliary engines test cycle D2 shall be applied.
4. For variable-speed, variable-load auxiliary engines, not included above, test cycle C1 shall be applied.
HEAT REJECTION DEFINITIONS:
Diesel Circuit Type and HHV Balance : DM9500
HIGH DISPLACEMENT (HD) DEFINITIONS:
3500: EM1500
RATING DEFINITIONS:
Agriculture : TM6008
Fire Pump : TM6009
Generator Set : TM6035
Generator (Gas) : TM6041
Industrial Diesel : TM6010
Industrial (Gas) : TM6040
Irrigation : TM5749
Locomotive : TM6037
Marine Auxiliary : TM6036
Marine Prop (Except 3600) : TM5747
Marine Prop (3600 only) : TM5748
MSHA : TM6042
Oil Field (Petroleum) : TM6011
Off-Highway Truck : TM6039
On-Highway Truck : TM6038
SOUND DEFINITIONS:
Sound Power : DM8702
Sound Pressure : TM7080
Date Released : 10/27/21

PERFORMANCE DATA[DM9933]

Performance Number: DM9933 **Change Level: 04**

SALES MODEL:	C32	**COMBUSTION:**	DIRECT INJECTION
BRAND:	CAT	**ENGINE SPEED (RPM):**	1,800
MACHINE SALES MODEL:		**HERTZ:**	60
ENGINE POWER (BHP):	1,474	**FAN POWER (HP):**	56.3
GEN POWER WITH FAN (EKW):	1,000.0	**ASPIRATION:**	TA
COMPRESSION RATIO:	15.0	**AFTERCOOLER TYPE:**	ATAAC
RATING LEVEL:	STANDBY	**AFTERCOOLER CIRCUIT TYPE:**	JW+OC, ATAAC
PUMP QUANTITY:	1	**INLET MANIFOLD AIR TEMP (F):**	120
FUEL TYPE:	DIESEL	**JACKET WATER TEMP (F):**	210.2
MANIFOLD TYPE:	DRY	**TURBO CONFIGURATION:**	PARALLEL
GOVERNOR TYPE:	ADEM4	**TURBO QUANTITY:**	2
ELECTRONICS TYPE:	ADEM4	**TURBOCHARGER MODEL:**	GTB45518BS-52T-1.37
IGNITION TYPE:	CI	**CERTIFICATION YEAR:**	2007
INJECTOR TYPE:	EUI	**PISTON SPD @ RATED ENG SPD (FT/MIN):**	1,913.4
REF EXH STACK DIAMETER (IN):	8		
MAX OPERATING ALTITUDE (FT):	997		

INDUSTRY	SUBINDUSTRY	APPLICATION
ELECTRIC POWER	STANDARD	PACKAGED GENSET
OIL AND GAS	LAND PRODUCTION	PACKAGED GENSET

General Performance Data

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	BRAKE MEAN EFF PRES (BMEP)	BRAKE SPEC FUEL CONSUMPTN (BSFC)	ISO BRAKE SPEC FUEL CONSUMPTN (BSFC)	VOL FUEL CONSUMPTN (VFC)	ISO VOL FUEL CONSUMPTN (VFC)
EKW	%	BHP	PSI	LB/BHP-HR	LB/BHP-HR	GAL/HR	GAL/HR
1,000.0	100	1,483	333	0.342	0.337	71.5	70.4
900.0	90	1,338	301	0.341	0.336	64.2	63.3
800.0	80	1,195	268	0.348	0.343	58.7	57.9
750.0	75	1,124	252	0.353	0.348	56.0	55.2
700.0	70	1,053	237	0.354	0.349	52.6	51.9
600.0	60	912	205	0.353	0.348	45.4	44.8
500.0	50	772	173	0.350	0.345	38.1	37.5
400.0	40	635	143	0.351	0.346	31.4	30.9
300.0	30	496	111	0.357	0.352	25.0	24.6
250.0	25	426	96	0.363	0.358	21.8	21.5
200.0	20	355	80	0.373	0.367	18.7	18.4
100.0	10	209	47	0.424	0.418	12.5	12.3

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	INLET MFLD PRES	INLET MFLD TEMP	EXH MFLD TEMP	EXH MFLD PRES	ENGINE OUTLET TEMP	COMPRESSOR OUTLET PRES	COMPRESSOR OUTLET TEMP
EKW	%	BHP	IN-HG	DEG F	DEG F	IN-HG	DEG F	IN-HG	DEG F
1,000.0	100	1,483	70.8	118.8	1,214.1	58.6	892.5	76	424.5
900.0	90	1,338	64.3	111.4	1,153.5	52.2	856.8	70	392.7
800.0	80	1,195	60.6	106.7	1,117.9	48.8	833.4	66	375.9
750.0	75	1,124	58.4	104.2	1,102.3	47.0	822.2	63	366.1
700.0	70	1,053	54.2	100.0	1,080.1	43.6	811.1	59	345.5
600.0	60	912	44.3	90.6	1,028.7	35.7	789.8	49	304.7
500.0	50	772	33.5	81.3	968.0	27.4	769.5	37	264.3
400.0	40	635	24.3	74.9	899.7	20.8	733.5	27	224.9
300.0	30	496	16.1	70.5	816.3	15.3	679.6	19	185.5
250.0	25	426	12.3	69.0	768.2	12.9	646.0	15	165.6
200.0	20	355	8.9	67.9	713.3	10.7	605.3	11	147.2
100.0	10	209	4.5	67.5	572.6	7.8	491.3	6	123.0

General Performance Data (Continued)

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	WET INLET AIR VOL FLOW RATE	ENGINE OUTLET WET EXH GAS VOL FLOW RATE	WET INLET AIR MASS FLOW RATE	WET EXH GAS MASS FLOW RATE	WET EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)	DRY EXH VOL FLOW RATE (32 DEG F AND 29.98 IN HG)
EKW	%	BHP	CFM	CFM	LB/HR	LB/HR	FT3/MIN	FT3/MIN
1,000.0	100	1,483	3,105.2	8,115.3	13,517.7	14,024.8	2,950.9	2,698.6

PERFORMANCE DATA[DM9933]

900.0	90	1,338	2,944.7	7,443.4	12,775.8	13,231.6	2,780.0	2,550.6
800.0	80	1,195	2,860.8	7,069.3	12,380.1	12,796.7	2,687.9	2,475.7
750.0	75	1,124	2,799.4	6,858.4	12,094.1	12,491.0	2,630.6	2,427.3
700.0	70	1,053	2,654.6	6,439.5	11,425.3	11,795.7	2,491.4	2,301.6
600.0	60	912	2,369.9	5,618.4	10,126.3	10,445.3	2,210.8	2,046.3
500.0	50	772	2,090.3	4,815.2	8,871.8	9,141.4	1,926.2	1,786.0
400.0	40	635	1,819.3	4,039.9	7,654.2	7,876.2	1,664.7	1,547.4
300.0	30	496	1,549.9	3,272.7	6,487.7	6,664.2	1,412.4	1,317.4
250.0	25	426	1,414.6	2,888.8	5,920.9	6,075.3	1,284.6	1,200.7
200.0	20	355	1,292.4	2,528.2	5,413.4	5,545.9	1,167.2	1,094.3
100.0	10	209	1,149.4	1,989.9	4,805.1	4,893.7	1,028.8	975.8

Heat Rejection Data

GENSET POWER WITH FAN	PERCENT LOAD	ENGINE POWER	REJECTION TO JACKET WATER	REJECTION TO ATMOSPHERE	REJECTION TO EXH	EXHAUST RECOVERY TO 350F	FROM OIL COOLER	FROM AFTERCOOLER	WORK ENERGY	LOW HEAT VALUE ENERGY	HIGH HEAT VALUE ENERGY
EKW	%	BHP	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN	BTU/MIN
1,000.0	100	1,483	20,153	7,292	58,664	32,275	8,277	16,551	62,887	155,406	165,547
900.0	90	1,338	18,470	6,522	52,678	28,324	7,440	14,394	56,743	139,692	148,807
800.0	80	1,195	16,970	5,949	49,043	26,036	6,799	13,345	50,677	127,654	135,984
750.0	75	1,124	16,223	6,124	47,027	24,781	6,486	12,683	47,666	121,777	129,723
700.0	70	1,053	15,326	6,876	43,772	22,824	6,093	11,231	44,653	114,394	121,858
600.0	60	912	13,529	6,786	37,588	19,231	5,263	8,681	38,675	98,811	105,259
500.0	50	772	11,822	5,357	31,812	16,013	4,411	6,504	32,735	82,825	88,230
400.0	40	635	10,869	4,421	25,935	12,562	3,637	4,598	26,908	68,277	72,732
300.0	30	496	9,934	3,738	20,129	9,084	2,892	2,986	21,049	54,294	57,837
250.0	25	426	9,352	3,463	17,322	7,412	2,525	2,290	18,081	47,414	50,508
200.0	20	355	8,620	3,178	14,651	5,809	2,162	1,718	15,065	40,584	43,232
100.0	10	209	6,683	2,334	9,950	2,795	1,444	1,067	8,853	27,118	28,888

Emissions Data

DIESEL

RATED SPEED NOMINAL DATA: 1800 RPM

GENSET POWER WITH FAN		EKW	1,000.0	750.0	500.0	250.0	100.0
PERCENT LOAD		%	100	75	50	25	10
ENGINE POWER		BHP	1,483	1,124	772	426	209
TOTAL NOX (AS NO2)		G/HR	7,256	4,250	2,777	1,877	1,108
TOTAL CO		G/HR	192	123	265	435	672
TOTAL HC		G/HR	19	55	53	40	80
TOTAL CO2		KG/HR	726	568	384	219	125
PART MATTER		G/HR	26.9	19.9	34.3	53.7	43.0
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	2,346.5	1,746.8	1,683.5	2,004.0	1,999.0
TOTAL CO	(CORR 5% O2)	MG/NM3	62.1	49.6	159.5	470.0	1,358.8
TOTAL HC	(CORR 5% O2)	MG/NM3	5.4	19.7	27.7	36.7	147.6
PART MATTER	(CORR 5% O2)	MG/NM3	7.3	6.9	17.8	53.8	69.4
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,143	851	820	976	974
TOTAL CO	(CORR 5% O2)	PPM	50	40	128	376	1,087
TOTAL HC	(CORR 5% O2)	PPM	10	37	52	68	275
TOTAL NOX (AS NO2)		G/HP-HR	4.93	3.81	3.61	4.41	5.32
TOTAL CO		G/HP-HR	0.13	0.11	0.34	1.02	3.22
TOTAL HC		G/HP-HR	0.01	0.05	0.07	0.09	0.38
PART MATTER		G/HP-HR	0.02	0.02	0.04	0.13	0.21
TOTAL NOX (AS NO2)		LB/HR	16.00	9.37	6.12	4.14	2.44
TOTAL CO		LB/HR	0.42	0.27	0.58	0.96	1.48
TOTAL HC		LB/HR	0.04	0.12	0.12	0.09	0.18
TOTAL CO2		LB/HR	1,600	1,252	847	484	275
PART MATTER		LB/HR	0.06	0.04	0.08	0.12	0.09
OXYGEN IN EXH		%	10.0	11.4	12.2	13.4	15.7
DRY SMOKE OPACITY		%	0.7	0.7	1.3	3.0	2.2

PERFORMANCE DATA[DM9933]

BOSCH SMOKE NUMBER		0.18	0.16	0.57	1.30	1.00

RATED SPEED POTENTIAL SITE VARIATION: 1800 RPM

GENSET POWER WITH FAN		**EKW**	**1,000.0**	**750.0**	**500.0**	**250.0**	**100.0**
PERCENT LOAD		**%**	**100**	**75**	**50**	**25**	**10**
ENGINE POWER		**BHP**	**1,483**	**1,124**	**772**	**426**	**209**
TOTAL NOX (AS NO2)		G/HR	8,780	5,143	3,360	2,272	1,341
TOTAL CO		G/HR	359	231	495	813	1,256
TOTAL HC		G/HR	36	104	100	76	151
PART MATTER		G/HR	52.5	38.7	66.9	104.7	83.8
TOTAL NOX (AS NO2)	(CORR 5% O2)	MG/NM3	2,839.3	2,113.6	2,037.0	2,424.8	2,418.8
TOTAL CO	(CORR 5% O2)	MG/NM3	116.2	92.7	298.2	879.0	2,541.0
TOTAL HC	(CORR 5% O2)	MG/NM3	10.2	37.3	52.3	69.3	278.9
PART MATTER	(CORR 5% O2)	MG/NM3	14.2	13.4	34.8	104.9	135.3
TOTAL NOX (AS NO2)	(CORR 5% O2)	PPM	1,383	1,030	992	1,181	1,178
TOTAL CO	(CORR 5% O2)	PPM	93	74	239	703	2,033
TOTAL HC	(CORR 5% O2)	PPM	19	70	98	129	521
TOTAL NOX (AS NO2)		G/HP-HR	5.97	4.60	4.37	5.34	6.43
TOTAL CO		G/HP-HR	0.24	0.21	0.64	1.91	6.03
TOTAL HC		G/HP-HR	0.02	0.09	0.13	0.18	0.73
PART MATTER		G/HP-HR	0.04	0.03	0.09	0.25	0.40
TOTAL NOX (AS NO2)		LB/HR	19.36	11.34	7.41	5.01	2.96
TOTAL CO		LB/HR	0.79	0.51	1.09	1.79	2.77
TOTAL HC		LB/HR	0.08	0.23	0.22	0.17	0.33
PART MATTER		LB/HR	0.12	0.09	0.15	0.23	0.18

Regulatory Information

EPA TIER 2			**2006 - 2010**	
GASEOUS EMISSIONS DATA MEASUREMENTS PROVIDED TO THE EPA ARE CONSISTENT WITH THOSE DESCRIBED IN EPA 40 CFR PART 89 SUBPART D AND ISO 8178 FOR MEASURING HC, CO, PM, AND NOX. THE "MAX LIMITS" SHOWN BELOW ARE WEIGHTED CYCLE AVERAGES AND ARE IN COMPLIANCE WITH THE NON-ROAD REGULATIONS.				
Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max Limits - G/BKW - HR**
U.S. (INCL CALIF)	EPA	NON-ROAD	TIER 2	CO: 3.5 NOx + HC: 6.4 PM: 0.20

EPA EMERGENCY STATIONARY			**2011 - ----**	
GASEOUS EMISSIONS DATA MEASUREMENTS PROVIDED TO THE EPA ARE CONSISTENT WITH THOSE DESCRIBED IN EPA 40 CFR PART 60 SUBPART IIII AND ISO 8178 FOR MEASURING HC, CO, PM, AND NOX. THE "MAX LIMITS" SHOWN BELOW ARE WEIGHTED CYCLE AVERAGES AND ARE IN COMPLIANCE WITH THE EMERGENCY STATIONARY REGULATIONS.				
Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max Limits - G/BKW - HR**
U.S. (INCL CALIF)	EPA	STATIONARY	EMERGENCY STATIONARY	CO: 3.5 NOx + HC: 6.4 PM: 0.20

Altitude Derate Data

STANDARD

ALTITUDE CORRECTED POWER CAPABILITY (BHP)

AMBIENT OPERATING TEMP (F)	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**NORMAL**
ALTITUDE (FT)										
0	1,474	1,474	1,474	1,474	1,474	1,468	1,442	1,417	1,393	1,474
1,000	1,474	1,474	1,474	1,466	1,439	1,413	1,388	1,364	1,341	1,474
2,000	1,474	1,465	1,438	1,411	1,385	1,360	1,336	1,314	1,291	1,434
3,000	1,438	1,410	1,383	1,358	1,333	1,309	1,286	1,264	1,242	1,389
4,000	1,383	1,356	1,331	1,306	1,282	1,259	1,237	1,216	1,195	1,345
5,000	1,330	1,304	1,280	1,256	1,233	1,211	1,190	1,169	1,149	1,302
6,000	1,278	1,254	1,230	1,207	1,185	1,164	1,144	1,124	1,105	1,260
7,000	1,228	1,205	1,182	1,160	1,139	1,119	1,099	1,080	1,062	1,220
8,000	1,180	1,157	1,135	1,114	1,094	1,074	1,056	1,037	1,020	1,180
9,000	1,133	1,111	1,090	1,070	1,050	1,032	1,014	996	979	1,141

PERFORMANCE DATA[DM9933]

10,000	1,087	1,066	1,046	1,027	1,008	990	973	956	940	1,103
11,000	1,043	1,023	1,004	985	967	950	933	917	902	1,066
12,000	1,001	981	963	945	928	911	895	880	865	1,029
13,000	959	941	923	906	889	874	858	843	829	994
14,000	919	901	884	868	852	837	822	808	794	959
15,000	880	863	847	831	816	802	788	774	761	926

Cross Reference

Test Spec	Setting	Engine Arrangement	Engineering Model	Engineering Model Version	Start Effective Serial Number	End Effective Serial Number
0K8987	PP6050	2537557	GS277	-	SYC00001	
0K7838	GG0346	3208618	GS490	-	JDB00001	
0K8987	PP6050	3249750	GS277	-	SYC00001	
0K8987	PP6050	3367659	GS471	-	PRH00001	
0K8987	PP6050	3801431	GS471	-	PRH00001	
0K8987	PP6050	4391323	GS471	-	PRH03719	
0K8987	PP6050	4447558	GS471	-	PRH00001	
0K8987	PP6050	4447562	GS471	-	PRH00001	
0K8987	PP6050	5233431	GS471	-	PRH00001	
0K8987	PP6050	5612763	GS471	DK	PRH00001	
0K8987	PP6050	6034725	PG457	-	PRH00001	

Performance Parameter Reference

Parameters Reference:DM9600-14

PERFORMANCE DEFINITIONS

PERFORMANCE DEFINITIONS DM9600
APPLICATION:
Engine performance tolerance values below are representative of a typical production engine tested in a calibrated dynamometer test cell at SAE J1995 standard reference conditions. Caterpillar maintains ISO9001:2000 certified quality management systems for engine test Facilities to assure accurate calibration of test equipment. Engine test data is corrected in accordance with SAE J1995. Additional reference material SAE J1228, J1349, ISO 8665, 3046-1:2002E, 3046-3:1989, 1585, 2534, 2288, and 9249 may apply in part or are similar to SAE J1995. Special engine rating request (SERR) test data shall be noted.
PERFORMANCE PARAMETER TOLERANCE FACTORS:
Power +/- 3%
Torque +/- 3%
Exhaust stack temperature +/- 8%
Inlet airflow +/- 5%
Intake manifold pressure-gage +/- 10%
Exhaust flow +/- 6%
Specific fuel consumption +/- 3%
Fuel rate +/- 5%
Specific DEF consumption +/- 3%
DEF rate +/- 5%
Heat rejection +/- 5%
Heat rejection exhaust only +/- 10%
Heat rejection CEM only +/- 10%
Heat Rejection values based on using treated water.
Torque is included for truck and industrial applications, do not use for Gen Set or steady state applications.
On C7 - C18 engines, at speeds of 1100 RPM and under these values are provided for reference only, and may not meet the tolerance listed.
On 3500 and C175 engines, at speeds below Peak Torque these values are provided for reference only, and may not meet the tolerance listed.
These values do not apply to C280/3600. For these models, see the tolerances listed below.
C280/3600 HEAT REJECTION TOLERANCE FACTORS:
Heat rejection +/- 10%
Heat rejection to Atmosphere +/- 50%
Heat rejection to Lube Oil +/- 20%
Heat rejection to Aftercooler +/- 5%
TEST CELL TRANSDUCER TOLERANCE FACTORS:
Torque +/- 0.5%
Speed +/- 0.2%
Fuel flow +/- 1.0%
Temperature +/- 2.0 C degrees
Intake manifold pressure +/- 0.1 kPa

PERFORMANCE DATA[DM9933]

OBSERVED ENGINE PERFORMANCE IS CORRECTED TO SAE J1995 REFERENCE AIR AND FUEL CONDITIONS.

REFERENCE ATMOSPHERIC INLET AIR

FOR 3500 ENGINES AND SMALLER

SAE J1228 AUG2002 for marine engines, and J1995 JAN2014 for other engines, reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity at the stated aftercooler water temp, or inlet manifold temp.

FOR 3600 ENGINES

Engine rating obtained and presented in accordance with ISO 3046/1 and SAE J1995 JANJAN2014 reference atmospheric pressure is 100 KPA (29.61 in hg), and standard temperature is 25deg C (77 deg F) at 30% relative humidity and 150M altitude at the stated aftercooler water temperature.

MEASUREMENT LOCATION FOR INLET AIR TEMPERATURE

Location for air temperature measurement air cleaner inlet at stabilized operating conditions.

REFERENCE EXHAUST STACK DIAMETER

The Reference Exhaust Stack Diameter published with this dataset is only used for the calculation of Smoke Opacity values displayed in this dataset. This value does not necessarily represent the actual stack diameter of the engine due to the variety of exhaust stack adapter options available. Consult the price list, engine order or general dimension drawings for the actual stack diameter size ordered or options available.

REFERENCE FUEL

DIESEL

Reference fuel is #2 distillate diesel with a 35API gravity; A lower heating value is 42,780 KJ/KG (18,390 BTU/LB) when used at 15 deg C (59 deg F), where the density is 850 G/Liter (7.0936 Lbs/Gal).

GAS

Reference natural gas fuel has a lower heating value of 33.74 KJ/L (905 BTU/CU Ft). Low BTU ratings are based on 18.64 KJ/L (500 BTU/CU FT) lower heating value gas. Propane ratings are based on 87.56 KJ/L (2350 BTU/CU Ft) lower heating value gas.

ENGINE POWER (NET) IS THE CORRECTED FLYWHEEL POWER (GROSS) LESS EXTERNAL AUXILIARY LOAD

Engine corrected gross output includes the power required to drive standard equipment; lube oil, scavenge lube oil, fuel transfer, common rail fuel, separate circuit aftercooler and jacket water pumps. Engine net power available for the external (flywheel) load is calculated by subtracting the sum of auxiliary load from the corrected gross flywheel out put power. Typical auxiliary loads are radiator cooling fans, hydraulic pumps, air compressors and battery charging alternators. For Tier 4 ratings additional Parasitic losses would also include Intake, and Exhaust Restrictions.

ALTITUDE CAPABILITY

Altitude capability is the maximum altitude above sea level at standard temperature and standard pressure at which the engine could develop full rated output power on the current performance data set.

Standard temperature values versus altitude could be seen on TM2001.

When viewing the altitude capability chart the ambient temperature is the inlet air temp at the compressor inlet.

Engines with ADEM MEUI and HEUI fuel systems operating at conditions above the defined altitude capability derate for atmospheric pressure and temperature conditions outside the values defined, see TM2001.

Mechanical governor controlled unit injector engines require a setting change for operation at conditions above the altitude defined on the engine performance sheet. See your Caterpillar technical representative for non standard ratings.

REGULATIONS AND PRODUCT COMPLIANCE

TMI Emissions information is presented at 'nominal' and 'Potential Site Variation' values for standard ratings. No tolerances are applied to the emissions data. These values are subject to change at any time. The controlling federal and local emission requirements need to be verified by your Caterpillar technical representative.

Customer's may have special emission site requirements that need to be verified by the Caterpillar Product Group engineer.

EMISSION CYCLE LIMITS:

Cycle emissions Max Limits apply to cycle-weighted averages only. Emissions at individual load points may exceed the cycle-weighted limit.

WET & DRY EXHAUST/EMISSIONS DESCRIPTION:

Wet - Total exhaust flow or concentration of total exhaust flow

Dry - Total exhaust flow minus water vapor or concentration of exhaust flow with water vapor excluded

EMISSIONS DEFINITIONS:

Emissions : DM1176

EMISSION CYCLE DEFINITIONS

1. For constant-speed marine engines for ship main propulsion, including,diesel-electric drive, test cycle E2 shall be applied,

DIESEL GENERATOR SET
MTU 16V2000 DS1000

1000 kWe / 60 Hz / Standby
208 - 4160V

Reference MTU 16V2000 DS1000 (900 kWe) for Prime Rating Technical Data

SYSTEM RATINGS

Standby

Voltage (L-L)	208V**	240V**	380V**	480V**	600V**	4160V
Phase	3	3	3	3	3	3
PF	0.8	0.8	0.8	0.8	0.8	0.8
Hz	60	60	60	60	60	60
kW	1000	1000	1000	1000	1000	1000
kVA	1250	1250	1250	1250	1250	1250
Amps	3470	3007	1899	1504	1203	173
skVA@30% Voltage Dip	2475	2475	2310	2830	3625	2270
Generator Model*	LSA 50.2 M6	LSA 50.2 M6	LSA 50.2 S4	LSA 49.1 L11	LSA 50.2 M6	LS 50.2 VL7
Temp Rise	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C
Connection	12 LEAD WYE	12 LEAD DELTA	6 LEAD WYE	6 LEAD WYE	6 LEAD WYE	6 LEAD WYE

* Consult the factory for alternate configuration.
** UL 2200 Offered

CERTIFICATIONS AND STANDARDS

// **Emissions –** EPA Tier 2 Certified

// **Generator set is designed and manufactured in facilities certified to standards ISO 9001:2008 and ISO 14001:2004**

// **Seismic Certification – Optional**
– IBC Certification

// **UL 2200 / CSA – Optional**
– UL 2200 Listed
– CSA Certified

// **Performance Assurance Certification (PAC)**
- Generator Set Tested to ISO 8528-5 for Transient Response
- Verified product design, quality and performance integrity
- All engine systems are prototype and factory tested

// **Power Rating**
- Accepts Rated Load in One Step Per NFPA 110
- Permissible average power output during 24 hours of operation is approved up to 85%.

STANDARD FEATURES*

// MTU Onsite Energy is a single source supplier
// Global Product Support
// 2 Year Standard Warranty
// 16V 2000 Diesel Engine
- 35.7 Liter Displacement
- Electronic Unit Pump Injection
- 4-Cycle

// Complete Range of Accessories
// Generator
- Brushless, Rotating Field Generator
- 2/3 Pitch Windings
- AREP supply to regulator
- 300% Short Circuit Capability

// Digital Control Panel(s)
- UL Recognized, CSA Certified, NFPA 110
- Complete System Metering
- LCD Display

// Cooling System
- Integral Set-Mounted
- Engine Driven Fan

STANDARD EQUIPMENT*

// Engine

Air Cleaners
Oil Pump
Oil Drain Extension & S/O Valve
Full Flow Oil Filter
Closed Crankcase Ventilation
Jacket Water Pump
Inter Cooler Water Pump
Thermostats
Blower Fan & Fan Drive
Radiator - Unit Mounted
Electric Starting Motor - 24V
Governor – Electronic Isochronous
Base - Structural Steel
SAE Flywheel & Bell Housing
Charging Alternator - 24V
Battery Rack & Cables
Flexible Fuel Connectors
Flexible Exhaust Connection
EPA Certified Engine

// Generator

NEMA MG1, IEEE and ANSI standards compliance for temperature rise and motor starting
Sustained short circuit current of up to 300% of the rated current for up to 10 seconds
Self-Ventilated and Drip-Proof
Superior Voltage Waveform
Digital, Solid State, Volts-per-Hertz Regulator
No Load to Full Load Regulation
Brushless Alternator with Brushless Pilot Exciter
4 Pole, Rotating Field
130 °C Maximum Standby Temperature Rise
1 Bearing, Sealed
Flexible Coupling
Full Amortisseur Windings
125% Rotor Balancing
3-Phase Voltage Sensing
±0.25% Voltage Regulation
100% of Rated Load - One Step
5% Maximum Total Harmonic Distortion

// Digital Control Panel(s)

Digital Metering
Engine Parameters
Generator Protection Functions
Engine Protection
CANBus ECU Communications
Windows®-Based Software
Multilingual Capability
Remote Communications to RDP-110 Remote Annunciator
Programmable Input and Output Contacts
UL Recognized, CSA Certified, CE Approved
Event Recording
IP 54 Front Panel Rating with Integrated Gasket
NFPA110 Compatible

* Represents standard product only. Consult Factory/MTU Onsite Energy Distributor for additional configurations.

APPLICATION DATA

// Engine

Manufacturer	MTU
Model	16V 2000 G86S
Type	4-Cycle
Arrangement	16-V
Displacement: L (in^3)	35.7 (2,179)
Bore: cm (in)	13.5 (5.3)
Stroke: cm (in)	15.6 (6.1)
Compression Ratio	16:1
Rated RPM	1,800
Engine Governor	Electronic Isochronous (ADEC)
Maximum Power: kWm (bhp)	1,371 (1,839)
Speed Regulation	±0.25%
Air Cleaner	Dry

// Liquid Capacity (Lubrication)

Total Oil System: L (gal)	114 (30.1)
Engine Jacket Water Capacity: L (gal)	70 (18.5)
After Cooler Water Capacity: L (gal)	25 (6.6)
System Coolant Capacity: L (gal)	188 (50)

// Electrical

Electric Volts DC	24
Cold Cranking Amps Under -17.8 °C (0 °F)	2,800

// Fuel System

Fuel Supply Connection Size	#12 JIC 37° Male
Fuel Return Connection Size	#12 JIC 37° Male
Maximum Fuel Lift: m (ft)	5 (16)
Recommended Fuel	Diesel #2
Total Fuel Flow: L/hr (gal/hr)	1,500 (396)

// Fuel Consumption

At 100% of Power Rating: L/hr (gal/hr)	276 (73)
At 75% of Power Rating: L/hr (gal/hr)	211 (56)
At 50% of Power Rating: L/hr (gal/hr)	146 (38)

// Cooling - Radiator System

Ambient Capacity of Radiator: °C (°F)	50 (122)
Maximum Restriction of Cooling Air, Intake, and Discharge Side of Rad.: kPa (in. H_20)	0.12 (0.5)
Water Pump Capacity: L/min (gpm)	783 (207)
After Cooler Pump Capacity: L/min (gpm)	258 (68)
Heat Rejection to Coolant: kW (BTUM)	444 (25,272)
Heat Rejection to After Cooler: kW (BTUM)	293 (16,677)
Heat Radiated to Ambient: kW (BTUM)	91 (5,289)
Fan Power: kW (hp)	49 (65.7)

// Air Requirements

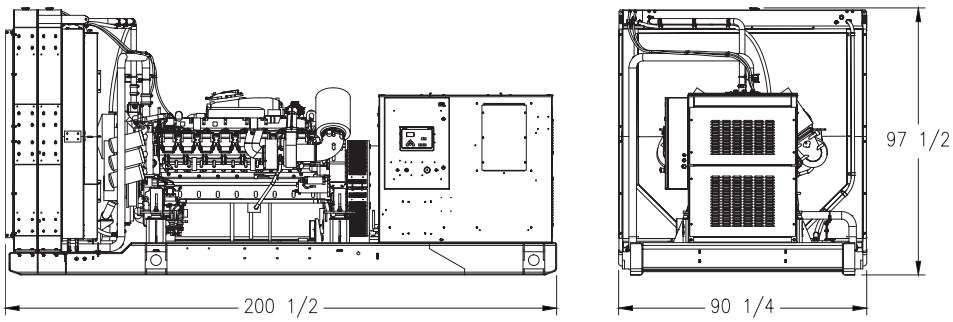
Aspirating: *m^3/min (SCFM)	102 (3,602)
Air Flow Required for Rad. Cooled Unit: *m^3/min (SCFM)	1,709 (60,350)
Remote Cooled Applications; Air Flow Required for Dissipation of Radiated Gen-set Heat for a Max of 25 °F Rise: *m^3/min (SCFM)	338 (11,925)

* Air density = 1.184 kg/m^3 (0.0739 lbm/ft^3)

// Exhaust System

Gas Temp. (Stack): °C (°F)	505 (941)
Gas Volume at Stack Temp: m^3/min (CFM)	270 (9,535)
Maximum Allowable Back Pressure: kPa (in. H_20)	8.5 (34.1)

WEIGHTS AND DIMENSIONS



Drawing above for illustration purposes only, based on standard open power 480 volt generator set. Lengths may vary with other voltages. Do not use for installation design. See website for unit specific template drawings.

System	Dimensions (L x W x H)	Weight (less tank)
Open Power Unit (OPU)	5,093 x 2,292 x 2,477 mm (200.5 x 90.3 x 97.5 in)	8,525 kg (18,795 lb)

Weights and dimensions are based on open power units and are estimates only. Consult the factory for accurate weights and dimensions for your specific generator set.

SOUND DATA

Unit Type	Standby Full Load
Level 0: Open Power Unit dB(A)	95.1

Sound data is provided at 7 m (23 ft). Generator set tested in accordance with ISO 8528-10 and with infinite exhaust.

EMISSIONS DATA

NO_x + NMHC	CO	PM
5.88	0.01	0.01

All units are in g/hp-hr and shown at 100% load (not comparable to EPA weighted cycle values). Emission levels of the engine may vary with ambient temperature, barometric pressure, humidity, fuel type and quality, installation parameters, measuring instrumentation, etc. The data was obtained in compliance with US EPA regulations. The weighted cycle value (not shown) from each engine is guaranteed to be within the US EPA Standards.

RATING DEFINITIONS AND CONDITIONS

// Standby ratings apply to installations served by a reliable utility source. The standby rating is applicable to varying loads for the duration of a power outage. No overload capability for this rating. Ratings are in accordance with ISO 8528-1, ISO 3046-1, BS 5514, and AS 2789. Average load factor: ≤ 85%.

// Deration Factor:
Altitude: Consult your local MTU Onsite Energy Power Generation Distributor for altitude derations.
Temperature: Consult your local MTU Onsite Energy Power Generation Distributor for temperature derations.

C/F = Consult Factory/MTU Onsite Energy Distributor
N/A = Not Available

Contents

	Genset	Marine	O & G	Rail	C & I
Application	X				
Engine model	16V2000G86S - TB				
Rated power [kW]	1371				
Rated speed [rpm]	1800				
Application Group	3D				
Legislative body	EPA Stationary EMERG T2 (40CFR60)				
Test cycle	D2				
Data Set No.	XZ 545 541 002 53				
Data Set Basis	EPA Stationary EMERG T2 (40CFR60)				
Fuel sulphur content [ppm]	360				

Content **Page**

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Configurator	Lenhof, Torsten (WMAG-RRS)	Order no. **na**	
Approver1	Kneifel, Alexander (TSLE)	EDS-ID **1982-24.10.2022**	
Approver2	Koliwer, Michael (TV)		
Approver3			
Approver4			
User	NA\schroederch		

Engine model **16V2000G86S**

Title **Emission data sheet**

Description of Revision	Frequency

Data generated by EDS Creator version 1.0 and uniplot.
Ref.-dataset: 216187_009_Parent-Engine_1371kW - TESP_D2.nc for 178 in EDS platfrom.

Emissionstage **EPA Stationary EMERG T2 (40CFR60)**

Sheet **1** of **6**

Configuration-ID	Documentation
178	For John Clark with United Engines LLC by Adam Fjerstad

Emissionstage basis **EPA Stationary EMERG T2 (40CFR60)**

General Disclaimers (valid for Measured and NTE values)

Please note that these data are physical and/or technical values only referring to and representing a normative defined operating condition. Any change in operating time and conditions will have impact on physical values and engine behavior, which must be considered and assessed within the complete propulsion system especially in regard to emission compliance and product safety.

Measurements listed in this EDS are representative of the listed engine rating at the time of testing. These measurements and results can change according to instrumentation, boundary condition, and engine to engine variability. In addition - changes to the engine family hard or software may occur which could result in changes to some of the listed values.

Emissions data measurement procedures are conducted according to applicable rules and standards as per “Emission Stage/Optimization”. Potential deviations from these procedures are documented internally.

The listed emission values relate to the corresponding certification data. Seller doesn´t take any responsibility or liability neither out or in connection with the contract nor on any other basis
- beyond these specified operating conditions of the engine
- and for any installation/modification of the entire propulsion system by the customer itself or any third party
and the customer will indemnify MTU on first demand for any third party claim out or in connection with this.

Seller reserves the right to amend specifications and information without notice and without obligation or liability. No liability for any errors, facts or opinions is accepted. Customers must satisfy themselves as to the suitability of this product for their application. No responsibility for any loss as a result of any person placing reliance on any material contained in this data sheet will be accepted.

Seller reserves all rights in the information contained in this data sheet. It shall not be reproduced, made available to a third party or otherwise used in any way whatsoever.

When applicable, emission values are measured after combined exhaust streams.

Measured Emissions data is based on single operating points and thus cannot be used to compare to regulations which use values based on a weighted cycle.

Field emission test data are not guaranteed to these levels. Actual field test results may vary due to test site conditions, installation, fuel specification, test procedures, and instrumentation. Over time deterioration may occur which may have an impact on emission levels.

The SO2 emission rates comprehend exclusively the SO2 content as found in the fuel source, oil consumption effects are not included. Variation of sulfur content in the fuel changes only the stated SO2 emissions, cross sensitivity to other emissions (e.g. particulates) is not possible.

All values based on metric units, inaccuracies for non metric values can occur, values are not binding.

Specific to gas engines: The listed emission values are based on gas composition at the time of certification measurement. Gas composition is as displayed in the EDS-document. Carbon dioxide and methane concentrations have direct influence on the corresponding displayed carbon dioxide and methane emissions.

EAT Specific Disclaimers (valid for EDS values)

NH3 emissions levels measured with AVL SESAM i60/ 4 FT Multi Component Exhaust Measurement System (FTIR) including EPA 40 CFR 1065 legislation compliant automated checks for linearity.
Generators or engines with exhaust after-treatment systems require a stabilization period of approximately 1 hour to ensure stable temperatures across SCR prior to performing an emissions test. Performing emissions measurements before a stable temperature has been achieved can result in inconsistent emission values. NOx Values only applicable if temperatures across SCR reached for DEF Dosing.

NTE Disclaimers (valid for NTE calculated values)

Calculated not to exceed values (NTE) are not proven by tests and therefore the accuracy is not guaranteed.

All emission data shown in chapters Emission Data Sheet, Not to Exceed Values, and Type Approval were gathered from a corresponding certification engine under test conditions shown above and complying to corresponding TEN data.

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Approver2	Koliwer, Michael (TV)	**1982-24.10.2022**	
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Approver4			
User	NA\schroederch		

Engine model
16V2000G86S

Title
Emission data sheet

Description of Revision	Frequency

Data generated by EDS Creator version 1.0 and uniplot.
Ref.-dataset: 216187_009_Parent-Engine_1371kW - TESP_D2.nc for 178 in EDS platfrom.

Emissionstage
EPA Stationary EMERG T2 (40CFR60)

Sheet **2** of **6**

Configuration-ID	Documentation
178	For John Clark with United Engines LLC by Adam Fjerstad

Emissionstage basis
EPA Stationary EMERG T2 (40CFR60)

Engine data

	Genset	Marine	O & G	Rail	C & I
Application	X				
Engine model	16V2000G86S				
Application Group	3D				
Legislative body	EPA Stationary EMERG T2 (40CFR60)				
Test cycle	D2				
Fuel sulphur content [ppm]	360				
mg/mN^3 values base on residual oxygen value of [%]	Measured				

Engine raw emissions*

Cycle point	[-]	n1	n2	n3	n4	n5
Power	kW	1366	1029	686	343	137
Power relative	[-]	1	0.75	0.5	0.25	0.1
Engine speed	1/min	1800	1801	1801	1800	1800
Engine speed relative	[-]	1	1	1	1	1
Filter smoke number	[-]	0.09	0.17	0.54	0.69	0.41
Exhaust temperature after ETC	grdC	522.1	485.6	463.4	410.4	276
Exhaust back pressure after ETC (static)	mbar	45	33	14	4	1
Exhaust mass flow wet	kg/h	7173.8	6415.2	4505.9	3025.2	2273
NOX-Emissions specific	g/kWh	7.8	5.22	5.52	5.47	8.12
SO2-Emissions specific	g/kWh	0.146	0.153	0.152	0.169	0.205
CO-Emissions specific	g/kWh	0.22	0.27	0.68	1.49	4.4
HC1-Emissions specific	g/kWh	0.08	0.11	0.15	0.48	1.12
NMHC-Emissions specific	g/kWh	0.08	0.11	0.15	0.47	1.1
NOX+HC1-Emissions specific	g/kWh	7.89	5.32	5.67	5.94	9.25
NOX+NMHC-Emissions specific	g/kWh	7.89	5.32	5.66	5.93	9.22

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EPA Stationary EMERG T2 (40CFR60)

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Configuration-ID	Documentation
178	For John Clark with United Engines LLC by Adam Fjerstad

Emissionstage basis
EPA Stationary EMERG T2 (40CFR60)

CO2-Emissions specific	g/kWh	643.4	672.5	665.8	742.1	891.1
PM-Emissions specific (Meas.)	g/kWh	0.014	0.023	0.057	0.103	0.119
NOX-Emissions (based on O2 meas)	mg/m3N	2266	1264	1266	926	717
NOX+HC1-Emissions (based on O2 meas)	mg/m3N	2289	1289	1298	1000	808
NOX+NMHC-Emissions (based on O2 meas)	mg/m3N	2288	1288	1297	998	806
CO2-Emissions (based on O2 meas)	mg/m3N	173143	150889	141178	115753	72570
CO-Emissions (based on O2 meas)	mg/m3N	58.3	60.4	144.5	232.5	358.8
HC1-Emissions (based on O2 meas)	mg/m3N	22.5	24	31.8	74	91.1
SO2-Emissions (based on O2 meas)	mg/m3N	39.4	34.3	32.1	26.4	16.7
PM-Emissions (based on O2 meas)	mg/m3N	3.7	5.1	12	16.1	9.7
Oxygen (O2)	%	8.7	10.2	10.9	12.7	15.7

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Engine model
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Configuration-ID	Documentation
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Emissionstage basis
EPA Stationary EMERG T2 (40CFR60)

Engine data

	Genset	Marine	O & G	Rail	C & I
Application	X				
Engine model	16V2000G86S				
Application Group	3D				
Legislative body	EPA Stationary EMERG T2 (40CFR60)				
Test cycle	D2				
Fuel sulphur content [ppm]	360				
mg/mN^3 values base on residual oxygen value of [%]	Measured				

Not to exceed emission values*

Cycle point	[-]	n1	n2	n3	n4	n5
Power	kW	1366	1029	686	343	137
Power relative	[-]	1	0.75	0.5	0.25	0.1
Engine speed	1/min	1800	1801	1801	1800	1800
Engine speed relative	[-]	1	1	1	1	1
NOX-Emissions specific	g/kWh	10.15	6.78	7.17	8.2	15.44
CO-Emissions specific	g/kWh	0.37	0.46	1.29	2.98	8.81
HC1-Emissions specific	g/kWh	0.14	0.18	0.29	0.95	3.25
NMHC-Emissions specific	g/kWh	0.14	0.18	0.28	0.93	
NOX+HC1-Emissions specific	g/kWh	10.29	6.96	7.45	9.15	18.69
NOX+NMHC-Emissions specific	g/kWh	10.29	6.96	7.45	9.13	
PM-Emissions specific (Meas.)	g/kWh	0.021	0.036	0.085	0.155	0.44
NOX-Emissions (based on O2 meas)	mg/m3N	2946	1644	1646	1389	1362
NOX+HC1-Emissions (based on O2 meas)	mg/m3N	2984	1685	1706	1537	1626
NOX+NMHC-Emissions (based on O2 meas)	mg/m3N	2984	1684	1705	1534	

PDF	Name	Project no.	Size
		na	**A4**
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Ref.-dataset: 216187_009_Parent-Engine_1371kW - TESP_D2.nc for 178 in EDS platfrom.

Emissionstage
EPA Stationary EMERG T2 (40CFR60)

Sheet
5
of
6

Configuration-ID	Documentation
178	For John Clark with United Engines LLC by Adam Fjerstad

Emissionstage basis
EPA Stationary EMERG T2 (40CFR60)

CO-Emissions (based on O2 meas)	mg/m3N	99.1	102.7	274.5	465	717.6
HC1-Emissions (based on O2 meas)	mg/m3N	38.3	40.8	60.3	148.1	264.2
PM-Emissions (based on O2 meas)	mg/m3N	5.6	8.1	18	24.1	35.8

PDF	Name	Project no.	Size
		na	**A4**
Configurator	Lenhof, Torsten (WMAG-RRS)	Order no. **na**	
Approver1	Kneifel, Alexander (TSLE)	EDS-ID	
Approver2	Koliwer, Michael (TV)	**1982-24.10.2022**	
Approver3			
Approver4			
User	NA\schroederch		

Engine model
16V2000G86S

Title
Emission data sheet

Description of Revision	Frequency

Data generated by EDS Creator version 1.0 and uniplot.
Ref.-dataset: 216187_009_Parent-Engine_1371kW - TESP_D2.nc for 178 in EDS platfrom.

Emissionstage
EPA Stationary EMERG T2 (40CFR60)

Sheet
6
of
6

Configuration-ID	Documentation
178	For John Clark with United Engines LLC by Adam Fjerstad

Emissionstage basis
EPA Stationary EMERG T2 (40CFR60)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
2023 MODEL YEAR
CERTIFICATE OF CONFORMITY
WITH THE CLEAN AIR ACT

OFFICE OF TRANSPORTATION AND AIR QUALITY
ANN ARBOR, MICHIGAN 48105

Certificate Issued To: **Caterpillar Inc.**
(U.S. Manufacturer or Importer)

Certificate Number: PCPXL106.NZS-010

Effective Date: 06/08/2022

Expiration Date: 12/31/2023

Byron J. Bunker, Division Director
Compliance Division

Issue Date: 06/08/2022

Revision Date: N/A

Model Year: 2023
Manufacturer Type: Original Engine Manufacturer
Engine Family: PCPXL106.NZS

Mobile/Stationary Indicator: Stationary
Emissions Power Category: kW>560
Fuel Type: Diesel
After Treatment Devices: No After Treatment Devices Installed
Non-after Treatment Devices: Electronic Control, Engine Design Modification

Pursuant to Section 111 and Section 213 of the Clean Air Act (42 U.S.C. sections 7411 and 7547) and 40 CFR Part 60, and subject to the terms and conditions prescribed in those provisions, this certificate of conformity is hereby issued with respect to the test engines which have been found to conform to applicable requirements and which represent the following engines, by engine family, more fully described in the documentation required by 40 CFR Part 60 and produced in the stated model year.

This certificate of conformity covers only those new compression-ignition engines which conform in all material respects to the design specifications that applied to those engines described in the documentation required by 40 CFR Part 60 and which are produced during the model year stated on this certificate of the said manufacturer, as defined in 40 CFR Part 60.

It is a term of this certificate that the manufacturer shall consent to all inspections described in 40 CFR 1068 and authorized in a warrant or court order. Failure to comply with the requirements of such a warrant or court order may lead to revocation or suspension of this certificate for reasons specified in 40 CFR Part 60. It is also a term of this certificate that this certificate may be revoked or suspended or rendered void *ab initio* for other reasons specified in 40 CFR Part 60.

This certificate does not cover engines sold, offered for sale, or introduced, or delivered for introduction, into commerce in the U.S. prior to the effective date of the certificate.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
2024 MODEL YEAR
CERTIFICATE OF CONFORMITY
WITH THE CLEAN AIR ACT

OFFICE OF TRANSPORTATION AND AIR QUALITY
ANN ARBOR, MICHIGAN 48105

Certificate Issued To: **Caterpillar Inc.**
(U.S. Manufacturer or Importer)

Certificate Number: RCPXL78.1NZS-030

Effective Date: 07/26/2023

Expiration Date: 12/31/2024

Byron J. Bunker, Division Director
Compliance Division

Issue Date: 07/26/2023

Revision Date: N/A

Model Year: 2024
Manufacturer Type: Original Engine Manufacturer
Engine Family: RCPXL78.1NZS

Mobile/Stationary Indicator: Stationary
Emissions Power Category: kW>560
Fuel Type: Diesel
After Treatment Devices: No After Treatment Devices Installed
Non-after Treatment Devices: Electronic Control, Engine Design Modification

Pursuant to Section 111 and Section 213 of the Clean Air Act (42 U.S.C. sections 7411 and 7547) and 40 CFR Part 60, and subject to the terms and conditions prescribed in those provisions, this certificate of conformity is hereby issued with respect to the test engines which have been found to conform to applicable requirements and which represent the following engines, by engine family, more fully described in the documentation required by 40 CFR Part 60 and produced in the stated model year.

This certificate of conformity covers only those new compression-ignition engines which conform in all material respects to the design specifications that applied to those engines described in the documentation required by 40 CFR Part 60 and which are produced during the model year stated on this certificate of the said manufacturer, as defined in 40 CFR Part 60.

It is a term of this certificate that the manufacturer shall consent to all inspections described in 40 CFR 1068 and authorized in a warrant or court order. Failure to comply with the requirements of such a warrant or court order may lead to revocation or suspension of this certificate for reasons specified in 40 CFR Part 60. It is also a term of this certificate that this certificate may be revoked or suspended or rendered void *ab initio* for other reasons specified in 40 CFR Part 60.

This certificate does not cover engines sold, offered for sale, or introduced, or delivered for introduction, into commerce in the U.S. prior to the effective date of the certificate.

APPENDIX D. CPCN NONAPPLICABILITY INFORMATION

Effective July 1, 2024, the definition of “generating station” under the Certificate of Public Convenience and Necessity (CPCN) regulations does not include the proposed IAD04 as detailed in the cover letter to this application. As such, this project is not subject to the CPCN process and Aligned is applying for a Permit to Construct directly from the Maryland Department of the Environment (MDE). This appendix provides further information on PUA § 7-207.1.

As required by PUA § 7-207.1, Aligned will comply with applicable regulations regarding noise level and testing hours. Frederick County requires and approves a noise study for each phase of the construction process. The first building is in full compliance with applicable noise level regulations and has been approved by Frederick County. Aligned has done a preliminary facility-wide noise analysis which is attached and shows compliance with noise levels at full facility build-out. The site plan for future buildings is not yet finalized. This noise analysis will be updated for each phase of construction and approved by Frederick County.

Aligned Data Centers
Quantum Loop Campus

Master Plan
Acoustic Assessment

Prepared for: Corgan

Prepared by: Wrightson, Johnson, Haddon & Williams, Inc.

June 28, 2024

WJHW

WJHW

Contents

WJHW

Summary

Wrightson, Johnson, Haddon, and Williams, Inc. (WJHW) was retained to perform a review of the environmental acoustic impact of the new 4-building Aligned data center and substation to the adjacent industrial properties in Frederick County, MD. This report reviews useful acoustic terminology and the applicable local sound standards for the project, then discusses the modeled sound-producing equipment and modeling assumptions. Finally, WJHW provides a comparison of the modelled sound levels from the project equipment to the sound ordinance requirements and provide recommendations – as necessary – to meet the applicable standards.

Upon reviewing the three operating conditions for the data center equipment (only chillers operating, chillers and one generator per building operating, and all chillers and generators operating), we predict that the sound levels will be less than 70 dBA and the county maximum sound requirements will be met. At the nearest residential locations, sound levels are less than 55 dBA.

Useful Acoustics Terminology

Sound is, technically speaking, pressure variation in air that human hearing can detect. The number of pressure variations per second is called the frequency of sound and is expressed as cycles per second or Hertz (Hz). The frequency content is called the sound spectrum and describes the character of the sound.

The decibel scale is the logarithmic scale used to define sound pressure levels. It uses the threshold of human hearing (20 micropascals of pressure) as a point of reference, defined as 0 dB. Other sound pressures are then compared to the reference pressure, and the logarithm of the ratio is taken to keep the numbers within a practical range. Since dB is based on a logarithmic scale, the addition of dB versus the perceived sound level increase is not linear. For example, a 3 dB difference is considered the just noticeable difference, while 10 dB is twice/half as loud.

The perceived loudness of any particular sound is dependent on many factors, including sound pressure level, the ambient sound environment (sound from other noise sources, or the pre-existing sound levels in the area), and frequency content. Perception of loudness can be approximated by filtering the sound signal using the standardized A-weighting[1] network which

[1] The A-weighting spectral adjustment factors are defined in accordance with IEC 61672:2014

tailors the measured frequency response to the loudness level sensitivity of the human ear. There is a well-documented correlation between A-weighted sound levels (expressed as dBA) and community response to noise. For this reason, the A-weighted sound level has become the standard descriptor for environmental noise assessment and used by many national, state, and local noise ordinances. All noise levels reported in this section are in terms of A-weighted levels.

Equivalent continuous sound level, Leq, a statistical noise level descriptor, is used to assess environmental noise level in this report. Leq is defined as the steady state sound pressure level which, over a period of time, has the same total energy as the fluctuating noise level and is colloquially referred to as the average sound level over a period of time.

Applicable Noise Standards

Local – City of Frederick

From our review of the site plan, the data center property is located outside of the city boundaries, and therefore the City of Frederick ordinance does not apply.

Regional - Frederick County, MD

The Frederick County, MD County Code, Chapter 1-11: Health and Sanitation, Article I: In General, Section 1-11-6: Nuisance – Noise Levels limits the A-weighted sound of sound producing sources based on the time of day and receiving land use categories. These are summarized in Table 1 below

Table 1: Frederick County Maximum Allowable Noise Levels (dBA) for Receiving Land Use Categories

Day/Night	Industrial	Commercial	Residential
Day	75 dBA	67 dBA	65 dBA
Night	75 dBA	62 dBA	55 dBA

Included within the exemptions listed in the county ordinance are emergency operations; the emergency generators are understood to only be full operation all at once in a power outage which would be considered an emergency use.

Within the Frederick County, MD County Code, Chapter 1-19: Zoning, Article VII Supplementary District Regulations, Section 1-19-7.610 Industrial District Performance Standards, separate sound requirements are set out for sound specifically produced by general and limited industrial zoned

properties. The slow-meter response sound levels, intended for continuous sound sources such as HVAC equipment, are presented in Table 2.

Table 2: Industrial District Maximum Permissible Sound Levels (dBA)

Sound Measured to:	Limited Industrial	General Industrial
Residential District	55 dBA	55 dBA
Commercial District	64 dBA	64 dBA
LI District Lot, adjacent to noise source	70 dBA	75 dBA

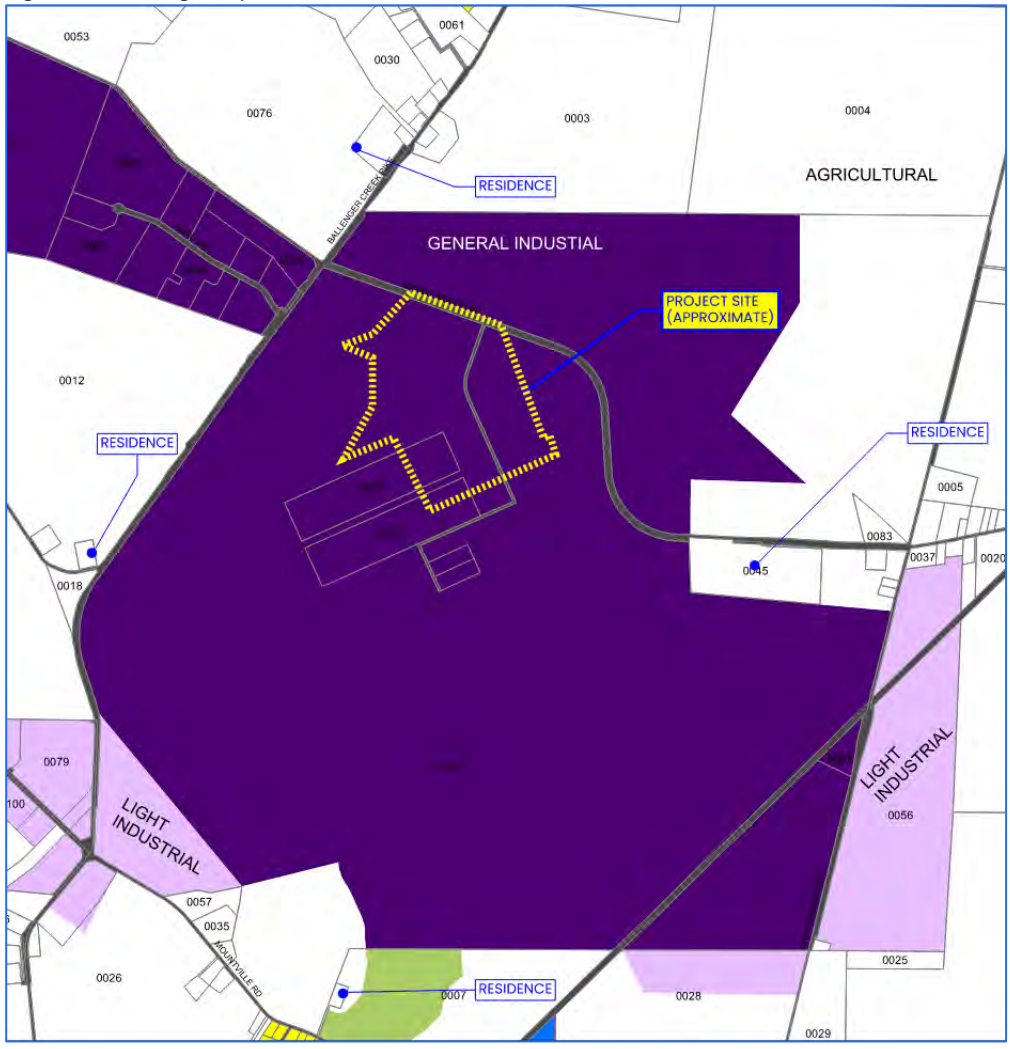
State – Maryland

The State of Maryland transferred sound enforcement authority to local governments from the state Department of the Environment. However, the guideline sound levels provided by the state are the same as the county sound limits

Discussion

The zoning around the project site, from the Frederick County zoning atlas, is shown in Figure 1 below. The project site is zoned general industrial and is generally surrounded by other industrial or agricultural properties. The nearest residential uses, located on agricultural zoned land, are approximately 1650 ft to the north, 2175 ft to the east, 3250 ft to the west, and 3750 ft to the south of the project site.

Figure 1: Zoning Map



The county Industrial District sound standards are more stringent than the general nuisance standards, as they require quieter sound levels from industrial properties to residential properties at all times of day, not only at night. To summarize, we think the following limits are applicable for this project:

- **Chiller & Substation Operations (typical daily use):**
  - 75 dBA at property line
  - 55 dBA at nearest residential sites
- **One Generator Operating per building (testing):**
  - 75 dBA at property line
  - 55 dBA at nearest residential sites
- **All Generators Operating (emergency operations):**
  - Exempt from noise limits (to be confirmed)

WJHW

Noise Modeling Methodology

WJHW's sound modeling was completed using SoundPlan™, an industry standard environmental sound modeling software. This software analyzes environmental sound propagation per ISO 9613 using inputs such as sound sources and locations, exterior barriers (including buildings and walls), ground absorption, and other environmental factors. WJHW modeled the proposed buildings based on the test fit and typical building plans from the architect. Excluded from the sound modeling were ambient sound levels on site, foliage, and atmospheric variation[2].

Model Inputs

The generator(s) modeled were CAT 175 diesel generators; modeling efforts were performed assuming a generator enclosure rated with a sound pressure level of **85 dBA at 10 ft**. We assumed one generator per building would be operating at a time during daytime hours for standard testing/exercising, but also analyzed the impact of no generators and all generators for your information.

The rooftop chillers were modeled as 84 chillers per building for buildings, 1, 2, & 3, and 56 chillers on building 4, with a sound pressure level of **73 dBA at 30 ft.** operating at 100% capacity.

The substation transformers were modeled as 15 - 3000 kVA units with a **NEMA rating of 63 dBA**. Octave band sound data was estimated from typical outdoor transformers, with correction factors applied based on sensitive locations[3]. Corona noise from the transmission lines was not included in the acoustic model.

The data center was modeled as two stories (approximately 50 feet tall) with a 6-foot parapet around the perimeter of the building. The chillers are located on a dunnage platform, with the top of the chillers at 12 feet above the roof level. For the preliminary analysis, the chiller screening was assumed to be standard (non-acoustical) louvers; these were not included in the acoustic model, representing a conservative acoustic approach to the visual barriers around the chillers

The mechanical yard wall around the generators was modeled as 20 feet tall.

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[2] This is consistent with ISO 9613 procedures, which reviews sound propagation from a source as if all receiver positions are downwind

[3] From *An Introduction to Sound Level Data for Mechanical and Electrical Equipment* J Paul Guyer, 2013

WJHW

Results

The following figures present the modeled sound levels under the three operational conditions of the substation and all chillers operating (Figure 2), the substation, all chillers + one generator per building operating (Figure 3), and the substation, all chillers and all generators operating (Figure 4). The results at the property lines are also summarized in Table 3 below.

Table 3: Predicted Sound Levels, dBA

Location	**Equipment Operating**			**Noise Limit**
	Chillers + Substation (Daily Operations)	One Generator (Testing)	All Generators (Emergency)	
North Property Line	62 dBA	62 dBA	64 dBA	75 dBA
East Property Line	60 dBA	60 dBA	65 dBA	75 dBA
South Property Line	59 dBA	59 dBA	62 dBA	75 dBA
West Property Line	65 dBA	65 dBA	66 dBA	75 dBA
North Residence	52 dBA	52 dBA	54 dBA	55 dBA
East Residence	49 dBA	49 dBA	50 dBA	55 dBA
South Residence	46 dBA	46 dBA	49 dBA	55 dBA
West Residence	46 dBA	46 dBA	49 dBA	55 dBA

WJHW

Figure 2: Predicted Sound Levels, Chillers & Substation, dBA

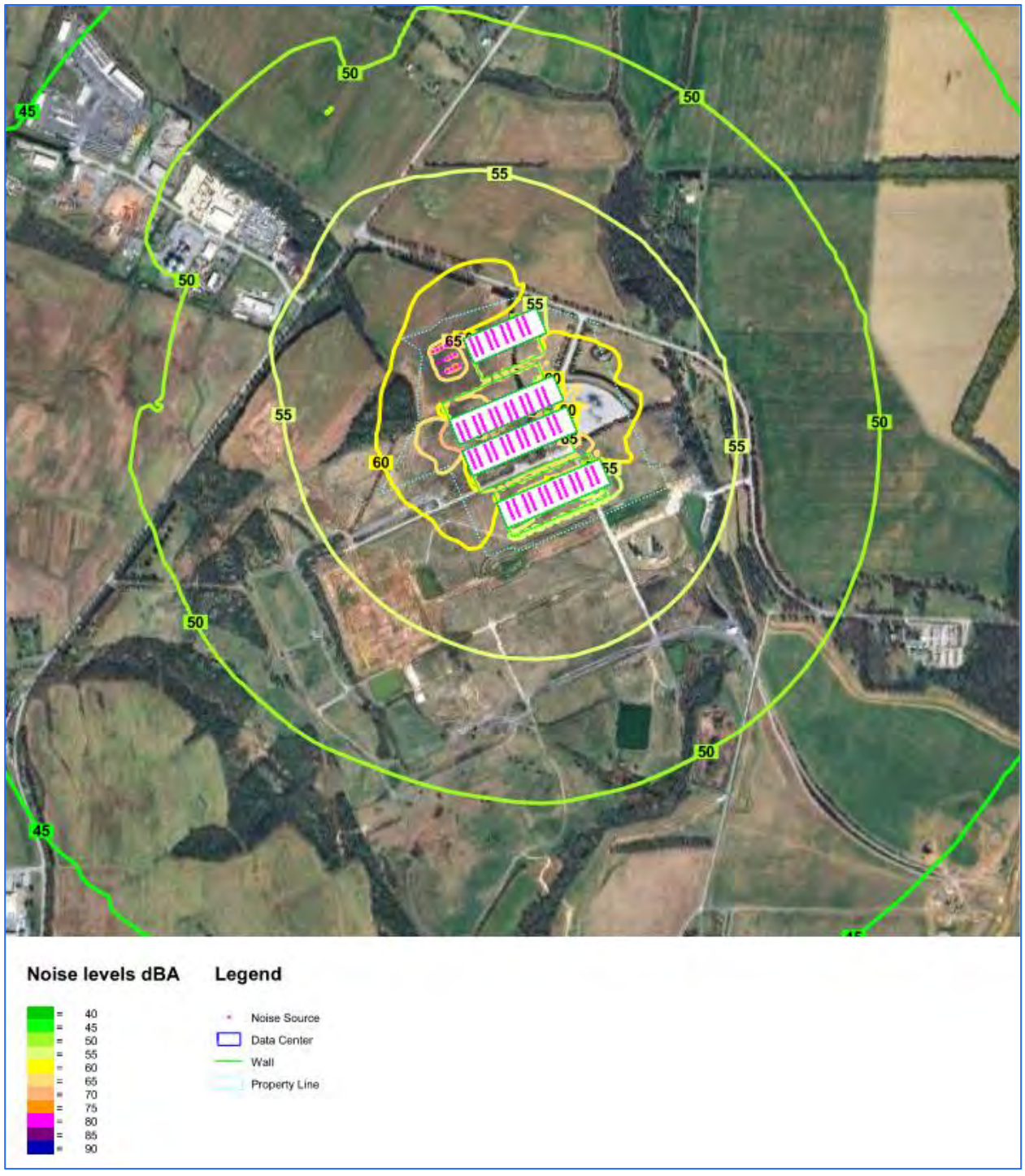


Figure 3: Predicted Sound Levels, One Generator Operating per building, dBA

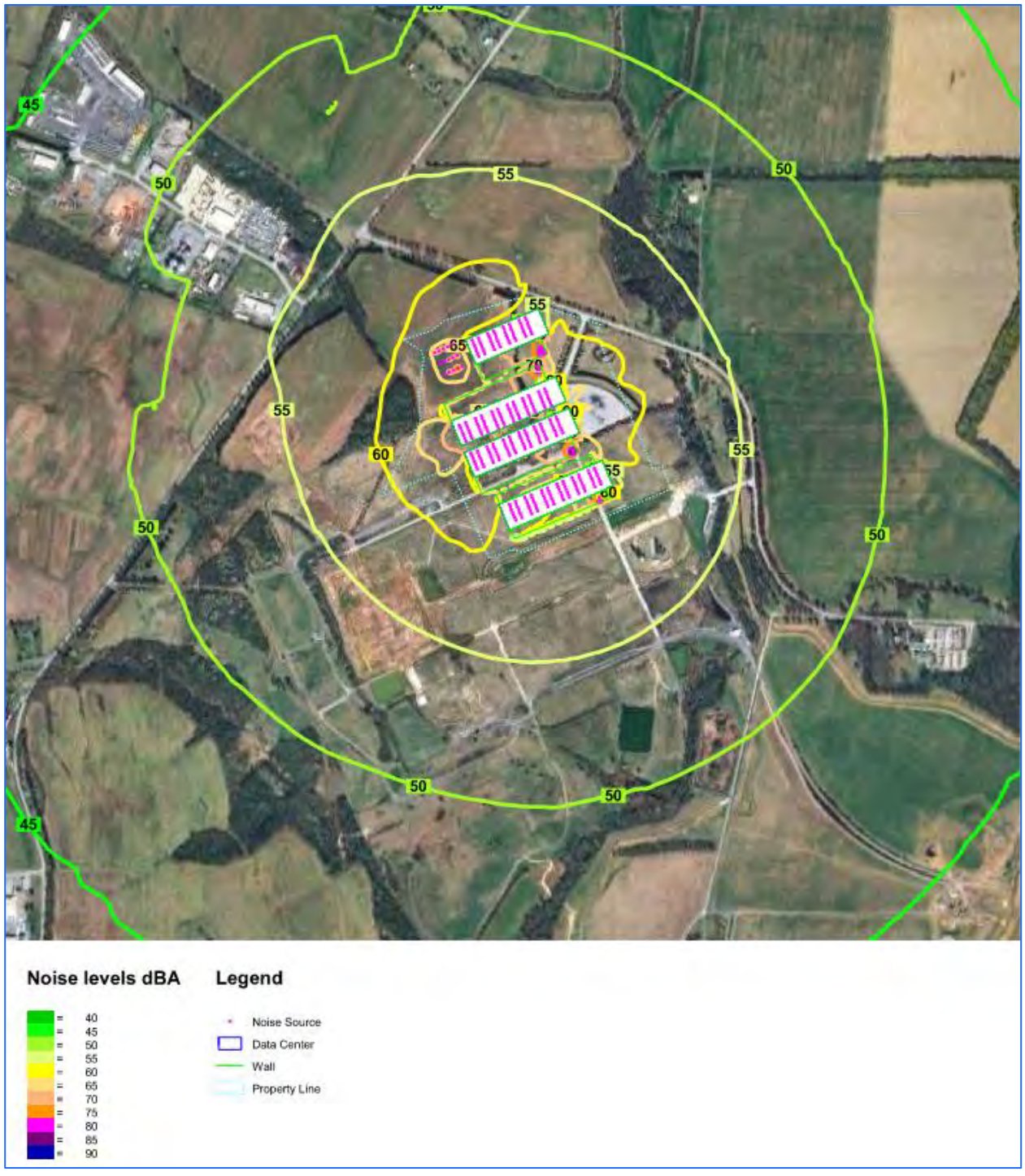
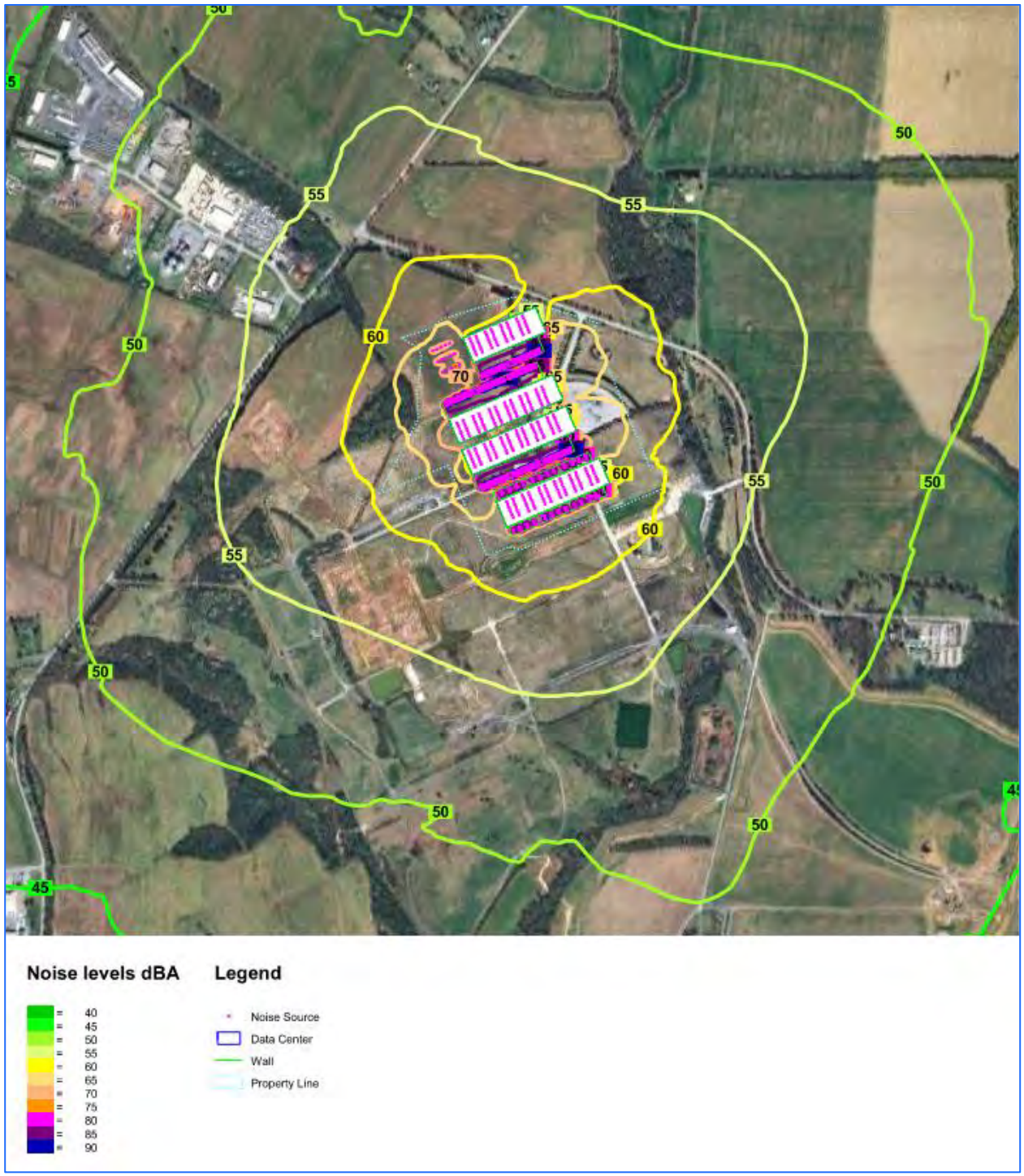


Figure 4: Predicted Sound Levels, All Generators Operating, dBA



WJHW

Discussion

The predicted sound levels from the substation and data center operations in typical use, testing operating conditions, and emergency operating conditions are all below the Frederick County sound limits for general industrial uses to either other industrial properties or residential properties. The selected equipment/enclosures are appropriately quiet and no further mitigation is needed to meet the County noise requirements.

APPENDIX E. ZONING APPROVAL

Jessica Fitzwater
County Executive

FREDERICK COUNTY GOVERNMENT

DIVISION OF PLANNING & PERMITTING *Deborah A. Carpenter, AICP, Division Director*
Department of Development Review *Michael L. Wilkins Director*

October 4, 2023

Aligned Data Centers Propco LLC
2800 Summit Avenue
Plano, Texas 75074

Re: 5601 Manor Woods Rd Tax Map 0094,
Parcel 0071 Size 74 Acres, Tax ID#01005383
Zoned (GI), V**275670**

To Whom It May Concern,

This letter is in response to your zoning verification application dated submitted on 8/2/2023. In your letter you requested that zoning district confirmation for the above referenced property and referenced that you will be applying for a permit to construct generators from the state of Maryland. The Property referenced above is surrounded by General Industrial (GI) under the Frederick County Zoning Code. There is some Limited Industrial (LI) zoning district to the west and south of the subject property. **Critical Digital Infrastructure Facility is an allowed use in the (GI) zone.**
The following definitions are provided in support of your application.

Chapter 1-19-5.250 of the Frederick County Zoning Code, Industrial Zoning District
(A) The purpose of the industrial districts is to provide for the development of varied industrial uses that would supply needed employment opportunities for the county. Industrial development has inherent characteristics that require special attention and protection. Due regard must be given to industrial needs for adequate site locations with concentration on terrain, availability of water and sewer systems, transportation, and compatibility with surrounding development. (C) The General Industrial District (GI) is intended to provide areas for industries involving manufacturing or processing and for those industrial use which cannot meet the performance criteria of the Limited Industrial District.

Chapter 1-19-11.100CRITICAL DIGITAL INFRASTRUCTURE FACILITY. A facility consisting of one or more buildings used primarily for the storage, management, processing, and transmission of digital data, and which houses computer or network equipment, systems, servers, appliances, and other associated components related to digital data operations. The facility may also include customary accessory uses such as an office use, air handlers, **power generators** and storage, water cooling and storage facilities, and associated utility infrastructure needed to support sustained operations of the digital infrastructure.

Critical Digital Infrastructure Facility such as the one you describe in your letter dated August 1, 2023, is an allowed use in the (LI) and (GI) zoning districts, subject to site plan approval. Approval of other permits including both County and State, may be required as part of the permitting process. A review of our files does not indicate any zoning violation on this property currently.

To assist with permitting, we are providing the definitions for ***Structure and Building in accordance with Section 1-19-11.100 Definitions. BUILDING.*** A structure other than a tent or travel trailer, which has 1 or more stories and a roof, and is designed primarily for the permanent shelter, support or enclosure of persons, animals, or property of any kind. ***STRUCTURE.*** A walled and/or roofed building, including but not limited to, a gas or liquid storage tank, a building foundation, platform, deck, swimming pool, bulkhead or greenhouse that is principally above ground and attached to a permanent site or location.

If you have any permitting questions, please contact Megan Libbey at 301-600-6727, for zoning questions please feel free contact me at (301) 6001491.

Sincerely,

Tolson DeSa
Zoning Administrator

Ec: M.Wilkins
T. Sinton
K. Mitchell

APPENDIX F. MDE EJ SCREENING REPORT

MDE Screening Report

Area of Interest (AOI) Information

Jun 14 2024 9:06:34 Eastern Daylight Time

Summary

Name	Count	Area(mi²)	Length(mi)
MDE Final EJ Score (%ile score)	1	N/A	N/A
Overburdened Communities Combined Score	1	N/A	N/A
Overburdened Pollution Environmental Score (%ile score)	1	N/A	N/A
Overburdened Exposure Score (%ile score)	1	N/A	N/A
Overburdened Sensitive Population (%ile score)	1	N/A	N/A
Socioeconomic/Demographic Score 2020 (Percentile score) (Underserved Community)	1	N/A	N/A
Air Emissions Facilities	0	N/A	N/A
Sulfur Dioxide (2010)	0	N/A	N/A
Ozone (2015)	1	N/A	N/A
Fine Particles (2012)	1	N/A	N/A
Biosolids FY 2020 and Current Permit Details	0	N/A	N/A
Biosolids FY2010 - 2014 Permit Details	0	N/A	N/A
Biosolids FY2009 Expired Permit Details	0	N/A	N/A
Biosolids FY 2020 and Current Permits Distribution By Acreage	1	N/A	N/A
Biosolids FY2015 - 2019 Permits Distribution By Acreage	1	N/A	N/A
Biosolids FY2010 - 2014 Permits Distribution By Acreage	1	N/A	N/A
Biosolids FY2009 Permits Expired Distribution By Acreage	1	N/A	N/A
Biosolids FY 2020 and Current Permit Distribution By Percent Coverage	1	N/A	N/A
Biosolids FY2015 - 2019 Permit Distribution By Percent Coverage	1	N/A	N/A
Biosolids FY2010 - 2014 Permit Distribution By Percent Coverage	1	N/A	N/A
Biosolids FY2009 Expired Permit Distribution By Percent Coverage	1	N/A	N/A
Concentrated Animal Feeding Operations (CAFOs)	0	N/A	N/A
Composting Facilities	0	N/A	N/A
Food Scrap Acceptors	0	N/A	N/A
Landfills	0	N/A	N/A

Correctional Facilities	0	N/A	N/A
Industrial Food Suppliers	0	N/A	N/A
Residential Colleges	0	N/A	N/A
Non-Residential Colleges	0	N/A	N/A
Hospitals	0	N/A	N/A
High Schools	0	N/A	N/A
Grocery Stores	0	N/A	N/A
10 Miles from Landfill	7	N/A	N/A
10 Miles from Composting Facility	2	N/A	N/A
General Composting Facilities Tier 2 (MD)	0	N/A	N/A
Commercial Anaerobic Digester (MD)	0	N/A	N/A
Out of State Facilities	0	N/A	N/A
30 mile buffer (Maryland)	1	N/A	N/A
30 Mile Buffer (Out of State)	0	N/A	N/A
Land Restoration Facilities	0	N/A	N/A
Determinations (points)	0	N/A	N/A
Determinations (areas)	0	N/A	N/A
Entities	0	N/A	N/A
Active Coal Mine Sites	0	N/A	N/A
Historic Mine Facilities	0	N/A	N/A
All Permitted Solid Waste Acceptance Facilities	0	N/A	N/A
Municipal Solid Waste Acceptance Facilities	0	N/A	N/A
Maryland Dam Locations	0	N/A	N/A
Maryland Pond Locations	0	N/A	N/A
Surface Water Intakes	0	N/A	N/A
Wastewater Discharge Facilities	0	N/A	N/A
Drinking Water	0	N/A	N/A
Clean Water	0	N/A	N/A

MDE Final EJ Score (%ile score)

#	Census tract identifier	Geographic Area Name	Total Population	Final EJ Score Percent (for this tract)	Final EJ Score Percentile (Distribution across Maryland)	Area(mi²)
1	24021752302	Census Tract 7523.02, Frederick County, Maryland	4216	26.64	31.51	N/A

Overburdened Communities Combined Score

#	GEOID20	Geographic_Area_Name	TotalPop	Overburd_Exposure_Percent	Overburd_Exposure_Percentile	Overburd_Poll_Enviro_Percent	Overburd_Poll_Enviro_Percentile	Sensitive_Population_Percent
1	24021752302	Census Tract 7523.02, Frederick County, Maryland	4,216	45.29	39.64	3.78	23.58	65.60

#	Sensitive_Population_Percentile	OverburdenedAllPercent	OverburdenedAllPercentile	Area(mi²)
1	63.09	55.84	63.91	N/A

Overburdened Pollution Environmental Score (%ile score)

#	GEOID20	Geographic_Area_Name	RentalsOccupiedPre79Percent	Percentile	PercentRMP	PercentRMPEJ	PercentHazWaste	PercentHazWasteEJ
1	24021752302	Census Tract 7523.02, Frederick County, Maryland	5.74	31.10	2.43	5.57	1.54	6.70

#	PercentSuperFundNPL	PercentSuperFundNPLEJ	PercentHazWW	PercentHazWWEJ	BrownFPercent	Percentile_1	PercentPowerPlants	Percentile_12
1	5.23	9.97	16.86	10.91	0.00	0.00	0.00	0.00

#	PercentCAFOS	Percentile_12_13	PercentActiveMines	Percentile_12_13_14	PollutionEnvironmentalPercent	PolInEnvironmentalPercentile	Area(mi²)
1	0.00	0.00	0.00	0.00	3.78	23.58	N/A

Overburdened Exposure Score (%ile score)

#	GEOID20	Geographic_Area_Name	Total_Pop	PercentNATA_Cancer	Percentile_NATA_Cancer	PercentNATA_Resp_HI	Percentile_NATA_Resp_HI	PercentNATA_Diesel
1	24021752302	Census Tract 7523.02, Frederick County, Maryland	4,216.00	60.00	13.82	60.00	9.13	18.90

#	Percentile_NATA_Diesel	PercentNATA_PM25	PercentileNATA_PM25	PercentOzone	PercentileOzone	PercentTraffic	PercentileTraffic	PercentTRI
1	6.88	94.77	11.87	90.85	9.60	0.12	1.35	21.05

#	PercentileTRI	PercentHazWasteLF	Percentile_HazWasteLF	PollutionExposurePercent	PollutionExposurePercentile	Area(mi²)
1	97.20	16.67	95.49	45.29	39.64	N/A

Overburdened Sensitive Population (%ile score)

#	GEOID20	Geographic_Area_Name	PerAstma	PercentileAst	PerMyo	PercentileMyo	PerLow	PercentileLow
1	24021752302	Census Tract 7523.02, Frederick County, Maryland	89.00	83.46	88.80	80.72	0.00	0.00

#	PercentBroad	PercentileBroad	PercentSens	PercentileSens	Area(mi²)
1	14.77	75.60	48.14	59.96	N/A

Socioeconomic/Demographic Score 2020 (Percentile score) (Underserved Community)

#	Census tract identifier	Geographic Area Name	Total Population	Percent Poverty	Percent Minority	Percent Limited English Proficiency	Demographic Score (Percent for this tract)	Demographic Score (Percentile Distribution acoss Maryland)	Area(mi²)
1	24021752302	Census Tract 7523.02, Frederick County, Maryland	4,216	7.75	20.23	0.00	9.33	14.12	N/A

Ozone (2015)

#	STATEFP10	COUNTYFP10	COUNTYNS10	GEOID10	NAME10	Ozone NAA Area	8-Hr Ozone (2015) Designation	8-HR Ozone (2015) Classification	8-Hr Ozone (2015) Status	Area(mi²)
1	24	021	01711211	24021	Frederick	Washington DC-MD-VA	Nonattainment	Moderate	*No Data*	N/A

Fine Particles (2012)

#	STATEFP10	COUNTYFP10	COUNTYNS10	GEOID10	NAME10	PM2.5 (2012) Status	Area(mi²)
1	24	021	01711211	24021	Frederick	Attainment/Unclassifiable	N/A

Biosolids FY 2020 and Current Permits Distribution By Acreage

#	County Name	FY2020andAfter	Area(mi²)
1	Frederick	2,894.50	N/A

Biosolids FY2015 - 2019 Permits Distribution By Acreage

#	County Name	FY2015to2019	Area(mi²)
1	Frederick	2,068.60	N/A

Biosolids FY2010 - 2014 Permits Distribution By Acreage

#	County Name	FY2010to2014	Area(mi²)
1	Frederick	2,639.00	N/A

Biosolids FY2009 Permits Expired Distribution By Acreage

#	County Name	FY2009	Area(mi²)
1	Frederick	152.70	N/A

Biosolids FY 2020 and Current Permit Distribution By Percent Coverage

#	County Name	FY2020andAfter	Area(mi²)
1	Frederick	2,894.50	N/A

Biosolids FY2015 - 2019 Permit Distribution By Percent Coverage

#	County Name	FY2015to2019	Area(mi²)
1	Frederick	2,068.60	N/A

Biosolids FY2010 - 2014 Permit Distribution By Percent Coverage

#	County Name	FY2010to2014	Area(mi²)
1	Frederick	2,639.00	N/A

Biosolids FY2009 Expired Permit Distribution By Percent Coverage

#	County Name	FY2009	Area(mi²)
1	Frederick	152.70	N/A

10 Miles from Landfill

#	County	Type	Facility_N	ADDRESS	FILL	SITE__ACRE	AI_No_	Owner_Type
1	FREDERICK	WIF	EASTALCO Industrial WasteLF	5601 Manor Wood Road, Frederick MD 21703.	10.2	20.00	8,459.00	PRI
2	FREDERICK	WIF	Essroc Industrial WasteLF	4120 Buckeystown Pike, Buckeystown MD 21717	25	50.00	69,053.00	PRI
3	FREDERICK	WIN	Fort Detrick IncineratorComplex	9031 Reichs Ford Road Frederick MD	-	1.00	1,827.00	FED
4	FREDERICK	WMF	Site B Municipal Landfill -VE	9031 Reichs Ford Road, Frederick MD 21704.	58	184.00	37,448.00	CTY
5	FREDERICK	WPT	Site B Solid WastePF&TS	9031 Reichs Ford Road, Frederick MD 21704.	58	184.00	37,448.00	CTY
6	MONTGOMERY	WTE	MCRRF	21204 Martinsburg Road, Dickerson MD 20842.	-	35.00	17,118.00	CTY
7	MONTGOMERY	WMF	Montgomery Co. Site 2LF	3 miles southwest of Dickerson, MD 20842.	125	650.00	37,661.00	CTY

#	MD_GRID__E	PERMITNUMB	EXPIRATION	Area(mi²)
1	650 /535	2014-WIF-0537	11/29/2019, 7:00 PM	N/A
2	672 /547	2010-WIF-0640	1/21/2017, 7:00 PM	N/A
3	678 /582	2010-WIN-0341	11/28/2015, 7:00 PM	N/A
4	702 /561	2013-WMF-0582	6/10/2018, 8:00 PM	N/A
5	702 /561	2011-WPT-0604	7/24/2016, 8:00 PM	N/A
6	671 /501	2013-WTE-0538	12/25/2018, 7:00 PM	N/A
7	680 /490	2014-WMF-0237	5/10/2019, 8:00 PM	N/A

10 Miles from Composting Facility

#	County	Facility	Address	Accepts_Fo	Location_o	Area(mi²)
1	*No Data*	Frederick County Department of Solid Waste Management	9031 Reichs Ford Rd, Frederick, MD 21704	No	9031 Reichs Ford Rd, Frederick, MD 21704	N/A
2	*No Data*	Montgomery County Yard Trim Composting Facility	21210 Martinsburg Road, Dickerson, MD 20842	No	21210 Martinsburg Rd, Dickerson, MD 20842	N/A

30 mile buffer (Maryland)

#	Facility_Name_1	Facility_Contact_1	Contact_Phone	Contact_Email_1	Contact_2	Contact_2_Phone	Contact_2_Email	URL	Area(mi²)
1	Key City Compost at Utica Bridge Farm	Phil Westcott	(240) 608-0283	info@keycompost.com	*No Data*	*No Data*	*No Data*	https://www.keycompost.com/	N/A

APPENDIX G. EVIDENCE OF WORKMEN'S COMPENSATION INSURANCE

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY)
06/18/2024

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must have ADDITIONAL INSURED provisions or be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER	CONTACT NAME: Marsh Affinity	
Marsh Affinity a division of Marsh USA LLC. PO BOX 14404 Des Moines, IA 50306-9686	PHONE (A/C, No, Ext): 800-743-8130	FAX (A/C, No):
	E-MAIL ADDRESS: ADPTotalSource@marsh.com	
	INSURER(S) AFFORDING COVERAGE	NAIC #
	INSURER A : New Hampshire Insurance Co.	23841
INSURED	INSURER B :	
ADP TotalSource FL XVI, Inc. 5800 Windward Parkway Alpharetta, GA 30005 Alternate Employer: Aligned Data Centers, LLC 2800 Summit Avenue Plano, TX 75074	INSURER C :	
	INSURER D :	
	INSURER E :	
	INSURER F :	

COVERAGES **CERTIFICATE NUMBER:** **REVISION NUMBER:**

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSD	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
	COMMERCIAL GENERAL LIABILITY						EACH OCCURRENCE	$
	☐ CLAIMS-MADE ☐ OCCUR						DAMAGE TO RENTED PREMISES (Ea occurrence)	$
							MED EXP (Any one person)	$
							PERSONAL & ADV INJURY	$
	GEN'L AGGREGATE LIMIT APPLIES PER:						GENERAL AGGREGATE	$
	☐ POLICY ☐ PRO JECT ☐ LOC						PRODUCTS - COMP/OP AGG	$
	☐ OTHER:							$
	AUTOMOBILE LIABILITY						COMBINED SINGLE LIMIT (Ea accident)	$
	☐ ANY AUTO						BODILY INJURY (Per person)	$
	☐ OWNED AUTOS ONLY ☐ SCHEDULED AUTOS						BODILY INJURY (Per accident)	$
	☐ HIRED AUTOS ONLY ☐ NON-OWNED AUTOS ONLY						PROPERTY DAMAGE (Per accident)	$
								$
	☐ UMBRELLA LIAB ☐ OCCUR						EACH OCCURRENCE	$
	☐ EXCESS LIAB ☐ CLAIMS-MADE						AGGREGATE	$
	☐ DED ☐ RETENTION $							$
A	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY Y / N ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? ☐ (Mandatory in NH) If yes, describe under DESCRIPTION OF OPERATIONS below	N/A		WC 088407056 MD	07/01/2024	07/01/2025	X PER STATUTE ☐ OTH-ER	
							E.L. EACH ACCIDENT	$ 2,000,000
							E.L. DISEASE - EA EMPLOYEE	$ 2,000,000
							E.L. DISEASE - POLICY LIMIT	$ 2,000,000

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (ACORD 101, Additional Remarks Schedule, may be attached if more space is required)
All worksite employees working for Aligned Data Centers, LLC paid under ADP TOTALSOURCE, INC.'s payroll, are covered under the above stated policy. Aligned Data Centers, LLC is an alternate employer under this policy.

CERTIFICATE HOLDER

Aligned Data Centers, LLC
2800 Summit Avenue
Plano, TX 75074

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE Jo Phillips

August 1, 2024

Ms. Suna Yi Sariscak
Manager, Air Quality Permits Program
Air and Radiation Administration
Maryland Department of the Environment (MDE)
1800 Washington Boulevard, Suite 720
Baltimore, MD 21230

RE: Permit to Construct Application Additional Information
Aligned Data Centers (MD) PropCo, LLC – Frederick Data Center

Dear Ms. Sariscak:

Aligned Data Centers (MD) PropCo, LLC (Aligned) is submitting additional information pertaining to our July 1, 2024 Permit to Construct application for the Frederick data center campus in response to the Maryland Department of the Environment's (MDE's) letter dated July 19, 2024.

1. Documentation from the engine manufacturer is attached confirming the proposed maintenance and testing schedule (Table 3-1 of permit application) meets the manufacturer's recommendations is provided in Attachment A to this letter.

2. Stack testing will be conducted as required by MDE. Stack testing is typically conducted at or close to full load and can be combined with the annual load test. For a test consisting of three one-hour test runs, the additional two hours of testing can be accommodated under the buffer included in Table 3-1. It is also not expected that all engines at the data center will be required to be tested in a given 12-month period. As such, it is expected that stack testing could be accommodated under the 10 hours per year of expected maintenance and testing on average across all generators at the site. However, even if maintenance hours exceed the projected 10 hours per year, as shown in Table 3-2 of the application, the proposed fuel usage limits allow for over five hours per year of additional runtime per generator which is well above the expected amount needed for emergencies. Accordingly, Aligned believes that the proposed fuel usage limits will not be a constraint in planning or conducting any required stack testing.

3. O&M manuals for generators and emissions controls are provided as Attachment B.

4. A preliminary site plan of the Frederick data center campus is provided as Attachment C.

2800 Summit Ave.
Plano, TX 75074
alignedenergy.com

5. The table below provides a preliminary construction and operating schedule for the Frederick data center. Each building is expected to be be a two-story data center with two-story office space and a mezzanine. Buildings 1, 2, and 3 are expected to be approximately 435,000 square feet each and 60 feet tall, and Building 4 may be up to the same size and also 60 feet tall. The actual schedule, building size and capacity will be driven by market conditions and customer demand.

Building No.	Targeted Construction Start	Targeted First Turnover Completion	Construction Completion / Fully Operational	# of 3MW Generators	# of 1MW House Generators
1	Q3 2024	Q1 2026	Q4 2026	42	1
2	Q2 2025	Q3 2026	Q2 2027	42	1
3	Q1 2026	Q2 2027	Q1 2028	42	1
4	Q1 2027	Q2 2028	Q1 2029	Up to 42	1

If you have any questions, please do not hesitate to contact Michael Welch at 203.981.6922 or Michael.Welch@aligneddc.com.

Sincerely,

DocuSigned by:
Michael Welch
F9EADA3FAF3543E...

Michael Welch
VP, Design and Procurement
Aligned Data Centers

Attachment A – Letter from Caterpillar

Caterpillar Electric Power Division
5212 N O'Connor Blvd Ste 1100
Irving, TX 75039

To: Aligned Data Centers
Re: Cat 3516/C175 Maintenance Program
July 30, 2024

To whom it may concern:

The testing and maintenance schedule for the Caterpillar C175-16 and 3516E generator sets being applied at Aligned Data Center locations is as follows:

Description	Frequency	Load	Duration per Event	Hours per Year per Generator
Readiness Test	Monthly	0%	15 Minutes	3
PM Checks	Quarterly	75%	30 Minutes	2
Load Test	Annual	100%	1 Hour	1

The planned maintenance program outlined above has been verified by Caterpillar and aligns with Caterpillar's maintenance guidelines and intervals for loaded and unloaded operation.

Sincerely,

Laura Maciosek

Laura Maciosek
Global Account Manager
Large Electric Power Solutions
Caterpillar Inc.
Maciosek_Laura_L@cat.com

Attachment B – O&M Manuals

SEBU8100-38 (en-us)
January 2021

Operation and Maintenance Manual

C175 Generator Sets

WYB 1-UP (Generator Set)
BXR 1-UP (Generator Set)
TB8 1-UP (Generator Set)
TZ8 1-UP (Generator Set)

Language: Original Instructions

Important Safety Information

Most accidents that involve product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards, including human factors that can affect safety. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you verify that you are authorized to perform this work, and have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or to other persons.

The hazards are identified by the “Safety Alert Symbol” and followed by a “Signal Word” such as “DANGER”, “WARNING” or “CAUTION”. The Safety Alert “WARNING” label is shown below.

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning explains the hazard and can be either written or pictorially presented.

A non-exhaustive list of operations that may cause product damage are identified by “NOTICE” labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. You must not use this product in any manner different from that considered by this manual without first satisfying yourself that you have considered all safety rules and precautions applicable to the operation of the product in the location of use, including site-specific rules and precautions applicable to the worksite. If a tool, procedure, work method or operating technique that is not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that you are authorized to perform this work, and that the product will not be damaged or become unsafe by the operation, lubrication, maintenance or repair procedures that you intend to use.

The information, specifications, and illustrations in this publication are on the basis of information that was available at the time that the publication was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service that is given to the product. Obtain the complete and most current information before you start any job. Cat dealers have the most current information available.

NOTICE

When replacement parts are required for this product Caterpillar recommends using original Caterpillar® replacement parts.

Other parts may not meet certain original equipment specifications.

When replacement parts are installed, the machine owner/user should ensure that the machine remains in compliance with all applicable requirements.

In the United States, the maintenance, replacement, or repair of the emission control devices and systems may be performed by any repair establishment or individual of the owner's choosing.

Table of Contents

Foreword

California Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

WARNING – This product can expose you to chemicals including ethylene glycol, which is known to the State of California to cause birth defects or other reproductive harm. For more information go to:

www.P65Warnings.ca.gov

Do not ingest this chemical. Wash hands after handling to avoid incidental ingestion.

WARNING – This product can expose you to chemicals including lead and lead compounds, which are known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information go to:

www.P65Warnings.ca.gov

Wash hands after handling components that may contain lead.

Literature Information

This manual contains safety, operation instructions, lubrication, and maintenance information. This manual should be stored in or near the engine area in a literature holder or literature storage area. Read, study, and keep it with the literature and engine information.

English is the primary language for all Cat publications. The English used facilitates translation and consistency in electronic media delivery.

Some photographs or illustrations in this manual show details or attachments that may be different from your engine. Guards and covers may have been removed for illustrative purposes. Continuing improvement and advancement of product design may have caused changes to your engine which are not included in this manual Whenever a question arises regarding your engine, or this manual, please consult with your Cat dealer for the latest available information.

Safety

This safety section lists basic safety precautions. In addition, this section identifies hazardous, warning situations. Read and understand the basic precautions listed in the safety section before operating or performing lubrication, maintenance, and repair on this product.

Operation

Operating techniques outlined in this manual are basic. They assist with developing the skills and techniques required to operate the engine more efficiently and economically. Skill and techniques develop as the operator gains knowledge of the engine and its capabilities.

The operation section is a reference for operators. Photographs and illustrations guide the operator through procedures of inspecting, starting, operating, and stopping the engine. This section also includes a discussion of electronic diagnostic information.

Maintenance

The maintenance section is a guide to engine care. The illustrated, step-by-step instructions are grouped by fuel consumption, service hours and/or calendar time maintenance intervals. Items in the maintenance schedule are referenced to detailed instructions that follow.

Use fuel consumption or service hours to determine intervals. Calendar intervals shown (daily, annually, etc.) may be used instead of service meter intervals if they provide more convenient schedules and approximate the indicated service meter reading.

Recommended service should be performed at the appropriate intervals as indicated in the Maintenance Interval Schedule. The actual operating environment of the engine also governs the Maintenance Interval Schedule. Therefore, under severe, dusty, wet, or freezing cold operating conditions, more frequent lubrication, and maintenance than is specified in the Maintenance Interval Schedule may be necessary.

The maintenance schedule items are organized for a preventive maintenance management program. If the preventive maintenance program is followed, a periodic tune-up is not required. The implementation of a preventive maintenance management program should minimize operating costs through cost avoidances resulting from reductions in unscheduled downtime and failures.

Maintenance Intervals

Perform maintenance on items at multiples of the original requirement. Each level and/or individual items in each level should be shifted ahead or back depending upon your specific maintenance practices, operation, and application. We recommend that the maintenance schedules be reproduced and displayed near the engine as a convenient reminder. We also recommend that a maintenance record be maintained as part of the engine's permanent record.

See the section in the Operation and Maintenance Manual, “Maintenance Records” for information regarding documents that are accepted as proof of maintenance or repair. Your authorized Cat dealer can assist you in adjusting your maintenance schedule to meet the needs of your operating environment.

Overhaul

Major engine overhaul details are not covered in the Operation and Maintenance Manual except for the interval and the maintenance items in that interval. Major repairs are best left to trained personnel or an authorized Cat dealer. Your Cat dealer offers various options regarding overhaul programs. If you experience a major engine failure, there are also numerous after failure overhaul options available from your Cat dealer. Consult with your dealer for information regarding these options.

Safety Section

i04907136

Safety Messages

SMCS Code: 1000; 7405

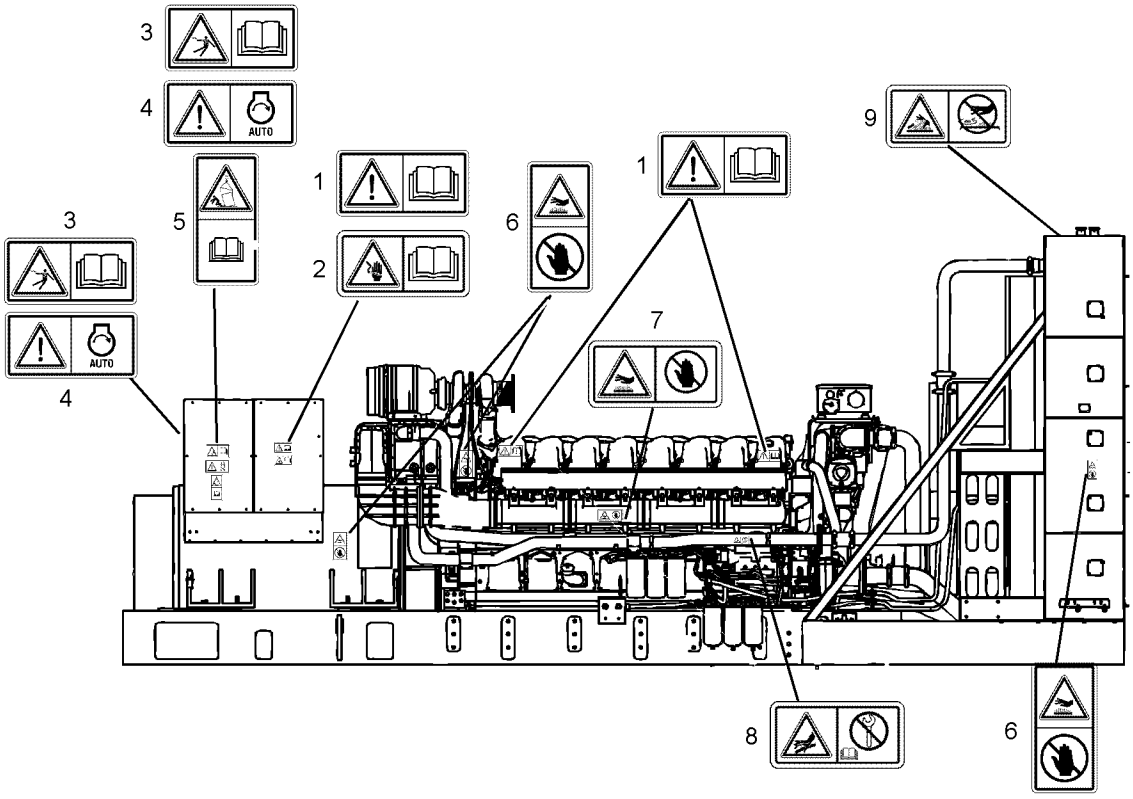


Illustration 1 g02147469

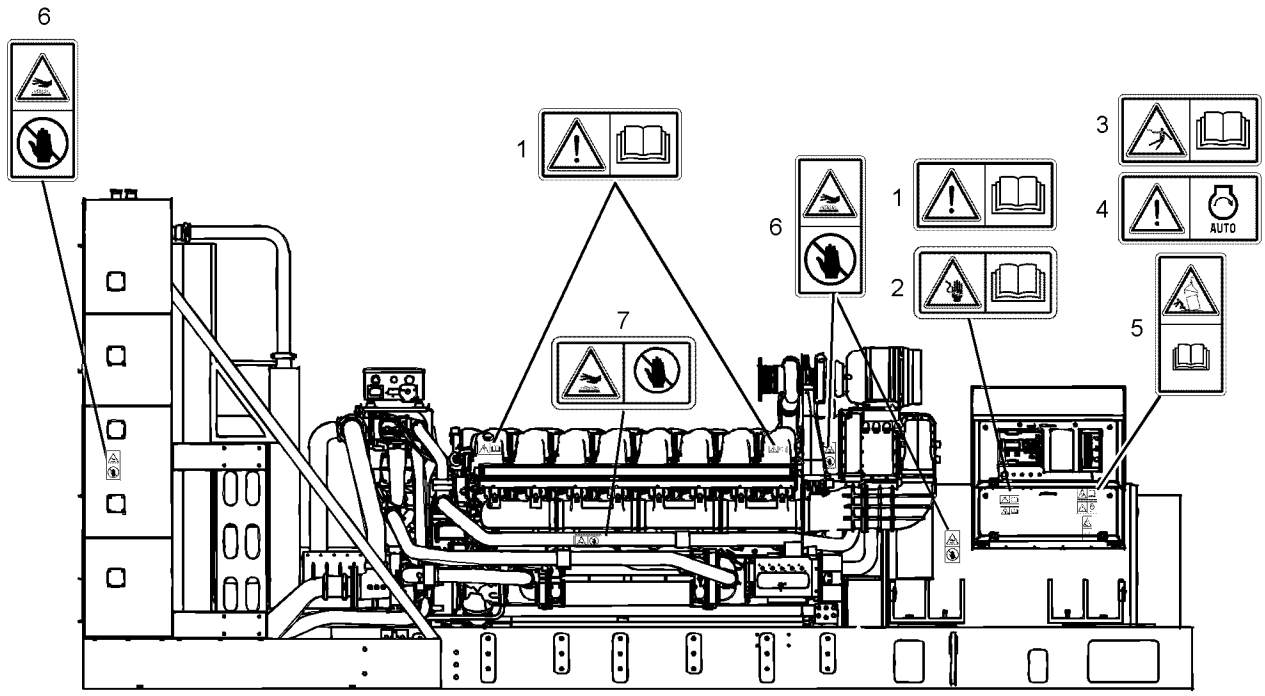


Illustration 2 g02147471

There may be several specific safety messages on your generator set. The exact location and a description of the safety messages are reviewed in this section. Become familiar with all safety messages.

Ensure that all of the safety messages are legible. Clean the safety messages or replace the safety messages if the words cannot be read or if the illustrations are not visible. Use a cloth, water, and soap to clean the safety messages. Do not use solvents, gasoline, or other harsh chemicals. Solvents, gasoline, or harsh chemicals could loosen the adhesive that secures the safety messages. The safety messages that are loosened could drop off the engine.

Replace any safety message that is damaged or missing. If a safety message is attached to a part of the engine that is replaced, install a new safety message on the replacement part. Your Caterpillar dealer can provide new safety messages.

⚠ WARNING

Do not operate or work on this engine unless you have read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings could result in injury or death. Contact any Caterpillar dealer for replacement manuals. Proper care is your responsibility.

Universal Warning (1)

One of these safety messages is located on each side of the terminal box.

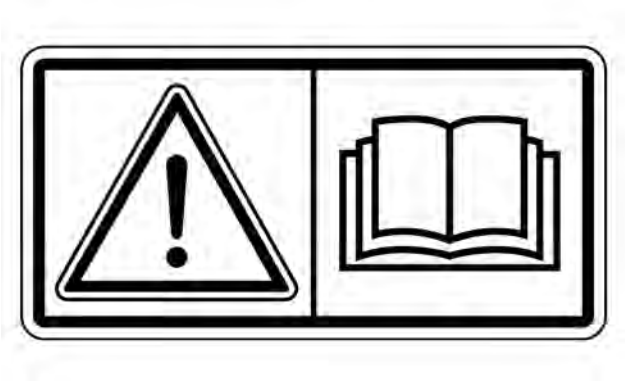


Illustration 3 g01370904

WARNING

Do not operate or work on this engine unless you have read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings could result in injury or death. Contact any Caperpillar dealer for replacement manuals. Proper care is your responsibility.

Electrical Shock (2)

The safety message for electrical shock is located on the rear of the generator.

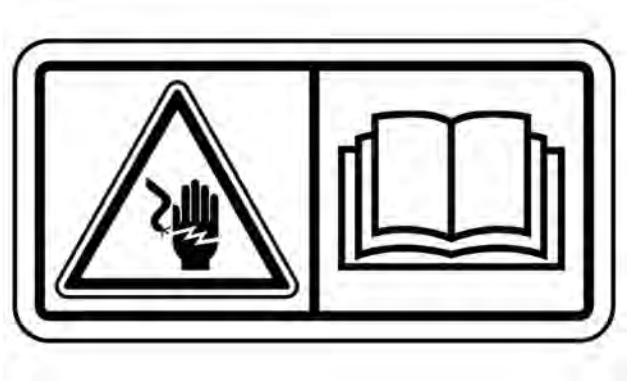


Illustration 4 g01372247

WARNING

WARNING! Shock/Electrocution Hazard! Read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings could cause serious injury or death.

Electrocution (3)

The safety message for electrocution is located on the sides and the rear of the generator and on the control panel.

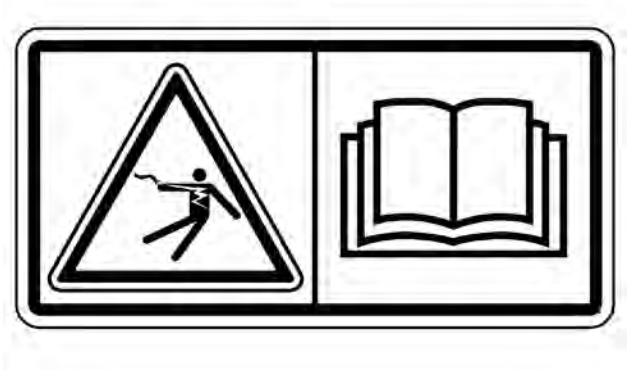


Illustration 5 g01392482

DANGER

Do not connect the generator to a utility electrical distribution system unless it is isolated from the system. Electrical feedback into the distribution system can occur and could cause personal injury or death.

Open and secure the main distribution switch, or if the connection is permanent, install a double throw switch to prevent electrical feedback. Some generators are specifically approved by a utility to run in parallel with the distribution system and isolation may not be required. Always check with your utility for the applicable circumstances.

Automatic Starting (4)

The safety message for automatic starting is located on the sides of the terminal box.

Illustration 6 g01392484

⚠ WARNING

When the engine is in the AUTOMATIC mode, the engine can start at any moment. To avoid personal injury, always remain clear of the the engine when the engine is in the AUTOMATIC mode.

Lifting the Genset (5)

This safety message for lifting the genset is located on the side panels of the generator.

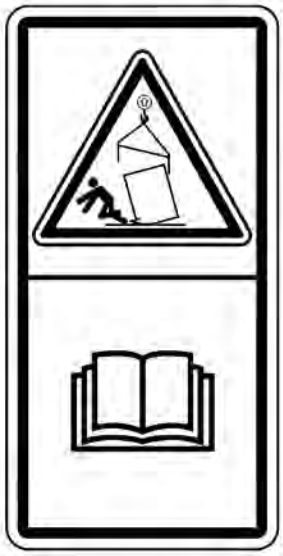


Illustration 7 g01433231

⚠ WARNING

Crushing Hazard! Improper lifting could cause serious injury or death. Follow the lifting instructions in the Operation and Maintenance Manual for safe lifting procedures.

Hot Surface (6)

One of these messages is located on each side of the barrel of the generator. This message is also located on both sides of the radiator.

Illustration 8 g01384734

WARNING

Hot parts or hot components can cause burns or personal injury. Do not allow hot parts or components to contact your skin. Use protective clothing or protective equipment to protect your skin.

Hot Surface (7)

One of these safety messages is located on each side of the engine.

Illustration 9 g01372256

WARNING

Hot surface! Do not touch!

High Pressure (8)

This warning message is typically located on the high-pressure fuel pump.

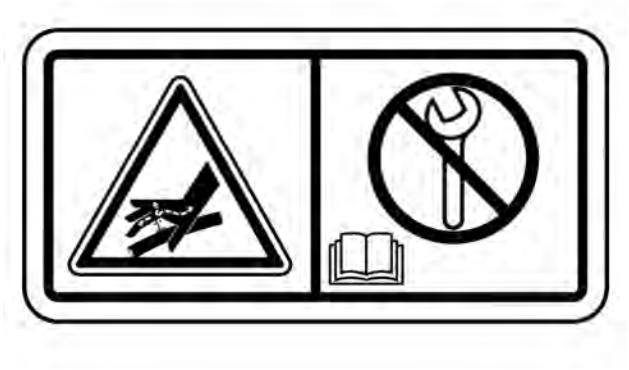


Illustration 10 g01381180

WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

Hot Fluid Under Pressure (9)

This safety message is located on top of the radiator near the radiator cap.

Illustration 11 g01371640

⚠ WARNING

Pressurized system! Hot coolant can cause serious burns, injury or death. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure. Read and understand the Operation and Maintenance Manual before performing any cooling system maintenance.

i03649637

General Hazard Information

SMCS Code: 1000; 4450; 7405

Attach a “Do Not Operate” warning tag or a similar warning tag to the start switch or to the controls before the engine is serviced or before the engine is repaired. These warning tags (Special Instruction, SEHS7332) are available from your Caterpillar dealer. Attach the warning tags to the engine and to each operator control station. When it is appropriate, disconnect the starting controls.

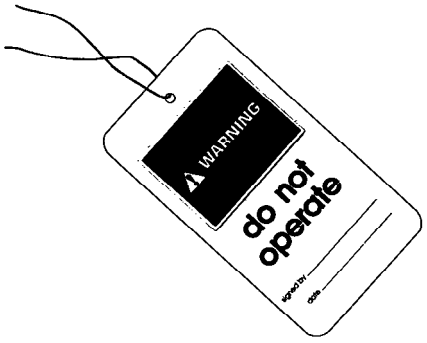


Illustration 12 g00104545

Do not allow unauthorized personnel on the engine or around the engine when the engine is serviced.

NOTICE
Hearing protection may be needed when working near an operating generator set.

Engine exhaust contains products of combustion which may be harmful to your health. Always start the engine and operate the engine in a well ventilated area. If the engine is in an enclosed area, vent the engine exhaust to the outside.

Cautiously remove the following parts:

Note: To help prevent spraying or splashing of pressurized fluids, hold a rag over the part that is being removed.

- Filler caps
- Grease fittings
- Pressure taps
- Breathers
- Drain plugs

Use caution when cover plates are removed. Gradually loosen but do not remove the last two bolts or nuts that are located at opposite ends of the cover plate or the device. Before removing the last two bolts or nuts, pry the cover loose in order to relieve any spring pressure or other pressure.

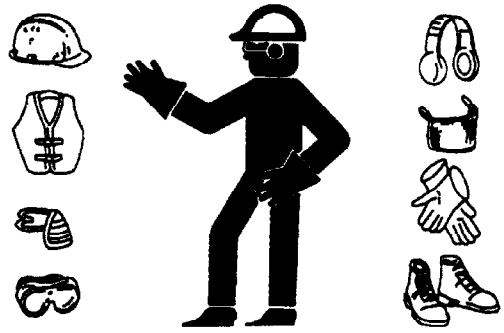


Illustration 13 g00702020

- Wear a hard hat, protective glasses, hearing protection and other protective equipment, as required.
- When work is performed around an engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.
- Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.
- Ensure that all protective guards and all covers are secured in place on the engine.

- Never put maintenance fluids into glass containers. Glass containers can break.
- Use all cleaning solutions with care.
- Report all necessary repairs.

Unless other instructions are provided, perform the maintenance under the following conditions:

- The engine is stopped. Ensure that the engine cannot be started.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.

Pressurized Air and Water

Pressurized air and/or water can cause debris and/or hot water to be blown out. This could result in personal injury.

When pressurized air and/or pressurized water is used for cleaning, wear protective clothing, protective shoes, and eye protection. Eye protection includes goggles or a protective face shield.

The maximum air pressure for cleaning purposes must be below 205 kPa (30 psi). The maximum water pressure for cleaning purposes must be below 275 kPa (40 psi).

Fluid Penetration

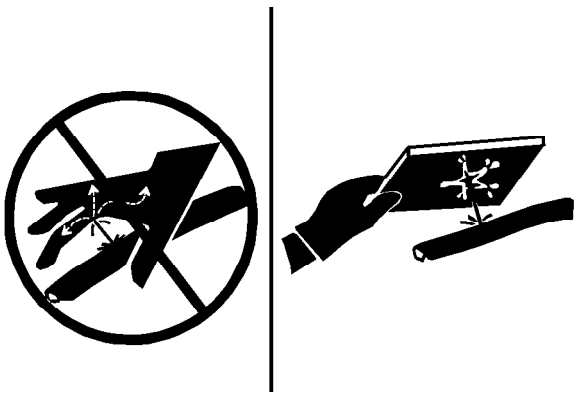


Illustration 14 g00687600

Always use a board or cardboard when the engine components are checked for leaks. Leaking fluid that is under pressure can cause serious injury or possible death. This includes leaks that are the size of a pin hole.

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

If fluid is injected into the skin, seek treatment immediately. Seek treatment from a doctor that is familiar with this type of injury.

Containing Fluid Spillage

Care must be used in order to ensure that the fluids are contained during the inspection, the maintenance, the testing, the adjusting, and the repair of the engine. Prepare to collect the fluid with suitable containers before any compartment is opened or before any component is disassembled.

Refer to Catalog, NENG2500, “Caterpillar Dealer Service Tool Catalog” for the following items:

- Tools that are suitable for collecting fluids and equipment that is suitable for collecting fluids
- Tools that are suitable for containing fluids and equipment that is suitable for containing fluids

Obey all local regulations for the disposal of liquids.

Asbestos Information

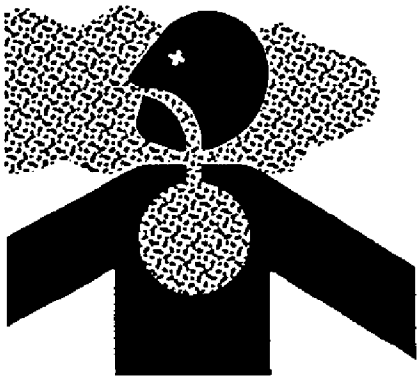


Illustration 15 g00702022

Caterpillar equipment and replacement parts that are shipped from Caterpillar are asbestos free. Caterpillar recommends the use of only genuine Caterpillar replacement parts. Use the following guidelines when you handle any replacement parts that contain asbestos or when you handle asbestos debris.

Use caution. Avoid inhaling dust that might be generated when you handle components that contain asbestos fibers. Inhaling this dust can be hazardous to your health. The components that may contain asbestos fibers are brake pads, brake bands, lining material, clutch plates, and some gaskets. The asbestos that is used in these components is usually bound in a resin or sealed in some way. Normal handling is not hazardous unless airborne dust that contains asbestos is generated.

If dust that may contain asbestos is present, there are several guidelines that should be followed:

- Never use compressed air for cleaning.
- Avoid brushing materials that contain asbestos.
- Avoid grinding materials that contain asbestos.
- Use a wet method in order to clean up asbestos materials.
- A vacuum cleaner that is equipped with a high efficiency particulate air filter (HEPA) can also be used.
- Use exhaust ventilation on permanent machining jobs.
- Wear an approved respirator if there is no other way to control the dust.
- Comply with applicable rules and regulations for the work place. In the United States, use Occupational Safety and Health Administration (OSHA) requirements. These OSHA requirements can be found in “29 CFR 1910.1001”.
- Obey environmental regulations for the disposal of asbestos.
- Stay away from areas that might have asbestos particles in the air.

Lines, Tubes, and Hoses

Do not bend or strike high pressure lines. Do not install lines, tubes, or hoses that are damaged.

Repair any fuel lines, oil lines, tubes, or hoses that are loose or damaged. Leaks can cause fires.

Inspect all lines, tubes and hoses carefully. Do not use bare hands to check for leaks. Always use a board or cardboard for checking engine components for leaks. Tighten all connections to the recommended torque.

Check for the following conditions:

- End fittings that are damaged or leaking
- Outer covering that is chafed or cut
- Wire that is exposed in reinforced hose
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering

Ensure that all of the clamps, the guards, and the heat shields are installed correctly. This will help to prevent these effects: vibration, rubbing against other parts and excessive heat during operation.

Dispose of Waste Properly

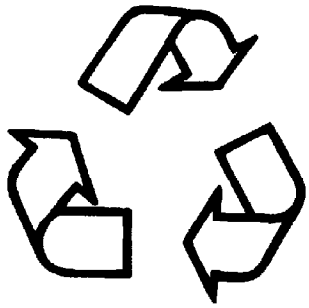


Illustration 16 g00706404

Improperly disposing of waste can threaten the environment. Potentially harmful fluids should be disposed of according to local regulations.

Always use leakproof containers when you drain fluids. Do not pour waste onto the ground, down a drain, or into any source of water.

i08162288

Burn Prevention

SMCS Code: 1000; 4450; 7405

Do not touch any part of an operating engine. Allow the engine to cool before any maintenance is performed on the engine. Relieve all pressure in the air system, hydraulic system, lubrication system, fuel system, and cooling system before any lines, fittings, or related items are disconnected.

Coolant

When the engine is at operating temperature, the engine coolant is hot. The coolant is also under pressure. The radiator and all lines to the heaters or to the engine contain hot coolant.

Any contact with hot coolant or with steam can cause severe burns. Allow cooling system components to cool before the cooling system is drained.

Check that the coolant level after the engine has stopped and the engine has been allowed to cool.

Ensure that the filler cap is cool before removing the filler cap. The filler cap must be cool enough to touch with a bare hand. Remove the filler cap slowly to relieve pressure.

Cooling system conditioner contains alkali. Alkali can cause personal injury. Do not allow alkali to contact the skin, the eyes, or the mouth.

Oils

Hot oil and hot lubricating components can cause personal injury. Do not allow hot oil to contact the skin. Also, do not allow hot components to contact the skin.

Batteries

Electrolyte is an acid. Electrolyte can cause personal injury. Do not allow electrolyte to contact the skin or the eyes. Always wear protective glasses for servicing batteries. Wash hands after touching the batteries and connectors. Use of gloves is recommended.

i08302987

Fire Prevention and Explosion Prevention

SMCS Code: 1000; 4450; 7405

Illustration 17 g00704000

Use of personal protection equipment (PPE) may be needed.

All fuels, most lubricants, and some coolant mixtures are flammable.

Always perform a Walk-Around Inspection, which may help you identify a fire hazard. Do not operate a product when a fire hazard exists. Contact your Cat dealer for service.

Flammable fluids that are leaking or spilled onto hot surfaces or onto electrical components can cause a fire. Fire may cause personal injury and property damage.

Flash fires may result if the covers for the engine crankcase are removed within 15 minutes after an emergency shutdown.

Determine whether the engine will be operated in an environment that allows combustible gases to be drawn into the air inlet system. These gases could cause the engine to overspeed. Personal injury, property damage, or engine damage could result.

If the application involves the presence of combustible gases, consult your Cat dealer for additional information about suitable protection devices.

Remove all flammable materials such as fuel, oil, and debris from the engine. Do not allow any flammable materials to accumulate on the engine.

All fluids that are captured in the fluid spill containment basin should be cleaned up immediately. Failure to clean up spilled fluids can cause a fire. Fire may cause personal injury and property damage.

Store fuels and lubricants in properly marked containers away from unauthorized persons. Store oily rags and any flammable materials in protective containers. Do not smoke in areas that are used for storing flammable materials.

Do not expose the engine to any flame.

Exhaust shields (if equipped) protect hot exhaust components from oil or fuel spray in a line, a tube, or a seal failure. Exhaust shields must be installed correctly.

Do not weld on lines or tanks that contain flammable fluids. Do not use flame to cut lines or tanks that contain flammable fluid. Clean any such lines or tanks thoroughly with a nonflammable solvent prior to welding or flame cutting.

Wiring must be kept in good condition. Properly route and attach all electrical wires. Check all electrical wires daily. Repair any wires that are loose or frayed before you operate the engine. Clean all electrical connections and tighten all electrical connections.

Eliminate all wiring that is unattached or unnecessary. Do not use any wires or cables that are smaller than the recommended gauge. Do not bypass any fuses and/or circuit breakers.

Arcing or sparking could cause a fire. Secure connections, recommended wiring, and properly maintained battery cables will help to prevent arcing or sparking.

Inspect all lines and hoses for wear or for deterioration. Properly route all hoses. The lines and hoses must have adequate support and secure clamps. Tighten all connections to the recommended torque. Leaks can cause fires.

Properly install all oil filters and fuel filters. The filter housings must be tightened to the proper torque.

Illustration 18 g00704059

Use caution when you are refueling an engine. Do not smoke while you are refueling an engine. Do not refuel an engine near open flames or sparks. Always stop the engine before refueling.

Avoid static electricity risk when fueling. Ultra Low Sulfur Diesel (ULSD) poses a greater static ignition hazard than earlier diesel formulations with a higher Sulfur content. Avoid death or serious injury from fire or explosion. Consult with your fuel or fuel system supplier to ensure that the delivery system is in compliance with fueling standards for proper grounding and bonding practices.

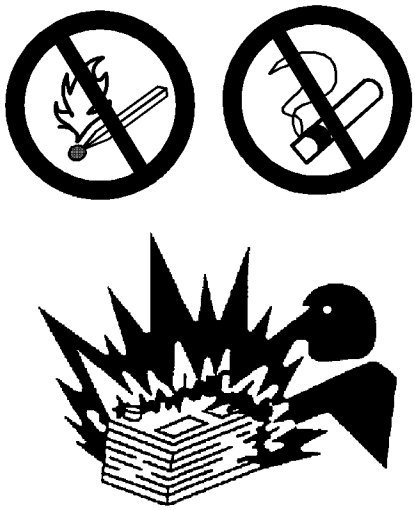


Illustration 19 g02298225

Gases from a battery can explode. Keep any open flames or sparks away from the top of a battery. Do not smoke in battery charging areas.

Never check the battery charge by placing a metal object across the terminal posts. Use a voltmeter or a hydrometer.

Improper jumper cable connections can cause an explosion that can result in injury. Refer to the Operation Section of this manual for specific instructions.

Do not charge a frozen battery. Charging a frozen battery may result in an explosion.

The batteries must be kept clean. The covers (if equipped) must be kept on the cells. Use the recommended cables, connections, and battery box covers when the engine is operated.

Fire Extinguisher

Make sure that a fire extinguisher is available. Be familiar with the operation of the fire extinguisher. Inspect the fire extinguisher and service the fire extinguisher regularly. Obey the recommendations on the instruction plate.

Ether

Ether is flammable and poisonous.

Use ether in ventilated areas. Do not smoke while you are replacing an ether cylinder or while you are using an ether spray.

Do not store ether cylinders in living areas or in the engine compartment. Do not store ether cylinders in direct sunlight or in temperatures above 49 °C (120 °F). Keep ether cylinders away from open flames or sparks.

Dispose of used ether cylinders properly. Do not puncture an ether cylinder. Keep ether cylinders away from unauthorized personnel.

Do not spray ether into an engine if the engine is equipped with a thermal starting aid for cold weather starting.

Lines, Tubes, and Hoses

Do not bend high-pressure lines. Do not strike high-pressure lines. Do not install any lines that are bent or damaged.

Repair any lines that are loose or damaged. Leaks can cause fires. Consult your Cat dealer for repair or for replacement parts.

Check lines, tubes, and hoses carefully. Do not use your bare hand to check for leaks. Use a board or cardboard to check for leaks. Tighten all connections to the recommended torque.

Replace the parts if any of the following conditions are present:

- End fittings are damaged or leaking.
- Outer coverings are chafed or cut.
- Wires are exposed.
- Outer coverings are ballooning.
- Flexible parts of the hoses are kinked.
- Outer covers have embedded armoring.
- End fittings are displaced.

Make sure that all clamps, guards, and heat shields are installed correctly to prevent vibration, rubbing against other parts, and excessive heat.

i08162291

Crushing Prevention and Cutting Prevention

SMCS Code: 1000; 4450; 7405

Support the component properly when work beneath the component is performed.

Unless other maintenance instructions are provided, never attempt adjustments while the engine is running.

Stay clear of all rotating parts and of all moving parts. Leave the guards in place until maintenance is performed. After the maintenance is performed, reinstall the guards.

Keep objects away from moving fan blades. The fan blades will throw objects or cut objects.

When objects are struck, wear protective glasses to avoid injury to the eyes.

Chips or other debris may fly off objects when objects are struck. Before objects are struck, ensure that no one will be injured by flying debris.

i08159517

Mounting and Dismounting

SMCS Code: 1000; 4450; 7405

Inspect the steps, the handholds, and the work area before mounting the engine. Keep these items clean and keep these items in good repair.

Mount the engine and dismount the engine only at locations that have steps and/or handholds. Do not climb on the engine, and do not jump off the engine.

Face the engine to mount the engine or dismount the engine. With your feet and hands, always maintain a three-point contact with the steps and designated handholds. Do not use any controls as handholds.

Do not stand on components which cannot support your weight. Use an adequate ladder or use a work platform. Secure the climbing equipment so that the equipment will not move.

Do not carry tools or supplies when you mount the engine or when you dismount the engine. Use a hand line to raise and lower tools or supplies.

i08287073

Sound Information

SMCS Code: 1000

Note: Information of the sound level is for machines in European Union countries and in countries that adopt the directives of the European Union.

NOTICE
Hearing protection may be needed when working near an operating generator set.

Sound levels will vary depending on the configuration of the generator set and the final installation of the generator set.

Refer to the following for sound levels:

- The sound pressure level of a complete generator set (including the radiator) at 1 m is 107 dB(A) for the noisiest configuration when “ISO 8528-10:1998(E) clause 14” is used at 75 percent of the rated power.
- The sound power level of a complete generator set (including the radiator) that is not covered by the “European Union Directive 2000/14/EC” is 118 dB(A) for the noisiest configuration when “ISO 8528-10:1998(E) clause 13” is used at 75 per cent of the rated power.
- The sound pressure level of a partly completed generator set (excluding the radiator) at 1 m is 104 dB(A) for the noisiest configuration when “ISO 8528-10:1998(E) clause 14” is used at 75 percent of the rated power.
- The sound power level of a partly completed generator set (excluding the radiator) is 114 dB(A) for the noisiest configuration when “ISO 8528-10:1998(E) clause 13” is used at 75 percent of the rated power.

Note: The preceding sound levels are emission levels. The preceding sound levels are not necessarily safe sound levels. There is a correlation between the emission levels and the level of exposure. The correlation between emission levels and the level of exposure cannot be used to determine if further precautions are required.

Refer to the following for factors that influence the level of exposure:

- The characteristics of the area around the generator set
- Other sources of noise
- The number of machines and other adjacent processes
- The length of time of exposure to the noise

This information will enable the user of the machine to evaluate the hazard and the risk.

i08232575

High Pressure Fuel Lines

SMCS Code: 1274

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

The high-pressure fuel lines are the fuel lines that are between the high-pressure fuel pump and the high-pressure fuel manifold. High-pressure fuel lines are also the fuel lines that are between the fuel manifold and cylinder head. These fuel lines are different from fuel lines on other fuel systems.

The differences are because of the following:

The high-pressure fuel lines are constantly charged with high pressure.

The internal pressures of the high-pressure fuel lines are higher than other types of fuel system.

The high-pressure fuel lines are formed to shape and then strengthened by a special process.

Do not step on the high-pressure fuel lines. Do not deflect the high-pressure fuel lines. Do not bend or strike the high-pressure fuel lines. Deformation or damage of the high-pressure fuel lines may cause a point of weakness and potential failure.

Do not check the high-pressure fuel lines with the engine or the starting motor in operation. Stop the engine. Wait for 5 minutes to allow the pressure to be purged before any service or repair is performed on the engine fuel lines.

Do not loosen the high-pressure fuel lines to remove air from the fuel system. This procedure is not required.

Visually inspect the high-pressure fuel lines before the engine is started. This inspection should be each day.

If you inspect the engine in operation, always use the proper inspection procedure to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, “General hazard Information”.

Inspect the high-pressure fuel lines for damage, deformation, a nick, a cut, a crease, or a dent.

Do not operate the engine with a fuel leak. If there is a leak, do not tighten the connection to stop the leak. The connection must be tightened to the recommended torque. Refer to Disassembly and Assembly for your engine.

If the high-pressure fuel lines are torqued correctly and the fuel lines are leaking, then high-pressure fuel lines must be replaced.

Ensure that all clips on the high-pressure fuel lines are in place. Do not operate the engine with clips that are damaged, missing, or loose.

Do not attach any other item to the high-pressure fuel lines.

i08258438

Before Starting Engine

SMCS Code: 1000

NOTICE
For initial start-up of a new or rebuilt engine, and for start-up of an engine that has been serviced, make provision to shut the engine off should an overspeed occur. This may be accomplished by shutting off the air and/or fuel supply to the engine.

⚠ WARNING

Engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.

Inspect the engine for potential hazards.

Do not start the engine if there is a “DO NOT OPERATE” warning tag or similar warning tag attached to the start switch. Do not move any of the controls if there is a “DO NOT OPERATE” warning tag or similar warning tag attached to the controls.

Before starting the engine, ensure that no one is on, underneath, or close to the engine. Ensure that the area is free of personnel.

If equipped, ensure that the lighting system for the engine is suitable for the conditions. Ensure that all lights work properly, if equipped.

All protective guards and all protective covers must be installed if the engine must be started to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Do not bypass the automatic shutoff circuits. Do not disable the automatic shutoff circuits. The circuits are provided to help prevent personal injury. The circuits are also provided to help prevent engine damage.

See the Service Manual for repairs and for adjustments.

i08193936

Engine Starting

SMCS Code: 1000

If a warning tag is attached to the engine start switch, DO NOT start the engine. If a warning tag is attached to the controls, DO NOT move the controls. Consult with the person that attached the warning tag before the engine is started.

All protective guards and all protective covers must be installed if the engine must be started to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Start the engine from the operator compartment or from the engine start switch.

Always start the engine according to the procedure that is described in this Operation and Maintenance Manual, “Engine Starting” topic (Operation Section). Knowing the correct procedure will help to prevent major damage to the engine components. Knowing the procedure will also help to prevent personal injury.

To ensure that the jacket water heater (if equipped) and/or the lube oil heater (if equipped) is working properly, check the water temperature gauge and the oil temperature gauge during the heater operation.

Engine exhaust contains products of combustion that can be harmful to your health. Always start the engine and operate the engine in a well-ventilated area. If the engine is started in an enclosed area, vent the engine exhaust to the outside.

Ether

Ether is poisonous and flammable.

Do not inhale ether, and do not allow ether to contact the skin. Personal injury could result.

Do not smoke while ether cylinders are changed.

Use ether in well-ventilated areas.

Use ether with care to avoid fires.

Keep ether cylinders out of the reach of unauthorized persons.

Store ether cylinders in authorized storage areas only.

Do not store ether cylinders in direct sunlight or at temperatures above 49 °C (120 °F).

Discard the ether cylinders in a safe place. Do not puncture the ether cylinders. Do not burn the ether cylinders.

i08232573

Engine Stopping

SMCS Code: 1000

Overheating and accelerated wear of engine components may result from stopping the engine immediately after the engine has been operated under load. A cooldown period can be programmed to happen automatically. For information about programming the cooldown period, see System Operation, Troubleshooting, Testing and Adjusting, RENR7902, “Electronic Control Module (Generator Set) - Configure”.

To avoid problems that are associated with improper engine cooling, a period of 5 minutes is recommended for the cooldown period. This cooldown period allows hot areas of the engine to cool gradually.

i08197790

Electrical System

SMCS Code: 1000; 1400

Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operating. A spark can cause the combustible gases that are produced by some batteries to ignite.

When the engine is started from an external source, follow this procedure: first, connect the positive “+” jump-start cable from the external power source to the positive “+” battery terminal of the engine that is being started. Then connect the negative “−” jump-start cable from the external power source to the negative “−” terminal of the starting motor. This procedure will help to prevent sparks from igniting combustible gases that are produced by some batteries.

Check the electrical wires daily for wires that are loose or frayed. Tighten all loose electrical wires before the engine is operated. Repair all frayed electrical wires before the engine is started.

Grounding Practices

The electrical systems for the generator, the engine, and the control systems must be properly grounded. Proper grounding is necessary for optimum performance and reliability. Improper grounding will result in uncontrolled electrical circuit paths and in unreliable electrical circuit paths.

Uncontrolled electrical circuit paths can result in damage to main bearings, to the surface of crankshaft journals, and to aluminum components. Uncontrolled electrical circuit paths can also cause electrical activity that may degrade the performance of the generator set electronics.

The alternator and the starting motor must be grounded to the negative “−” battery terminal.

A ground plate with a direct path to the negative “−” battery terminal may be used as a common ground for the components of one engine system.

For engines with an alternator that is grounded to an engine component, a ground strap must connect that component to the negative “−” battery terminal. Also, that component must be electrically isolated from the engine.

The ground strap for the alternator must be of a size that is adequate for carrying the full charging current of the alternator.

i08197795

Generator Isolating for Maintenance

SMCS Code: 4450

Note: If the rated output voltage of the generator is greater than 600 volts, the generator and connected load cable capacitances must be discharged prior to servicing the generator.

When you service an electric power generation set or when you repair an electric power generation set, follow the procedure below:

1. Stop the engine.

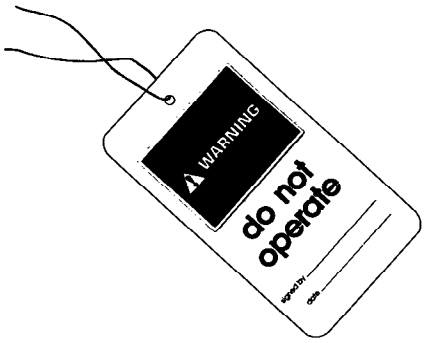


Illustration 20 g00104545

2. Attach a “DO NOT OPERATE” or similar warning tag to the engine prime mover starting circuit. Disconnect the engine starting circuit.

3. Disconnect the generator from the distribution system.

4. Lock out the circuit breaker. Attach a “DO NOT OPERATE” or similar warning tag to the circuit breaker. Refer to the electrical diagram. Verify that all points of possible reverse power flow have been locked out.

5. For the following circuitry, remove the transformer fuses:

- Power
- Sensing
- Control

6. Attach a “DO NOT OPERATE” or similar warning tag to the generator excitation controls.

7. Remove the cover of the generator terminal box.

8. Use an audio/visual proximity tester to verify that the generator is de-energized. This tester must be insulated for the proper voltage rating. Follow all guidelines to verify that the tester is operational.

9. Determine that the generator is in a de-energized condition. Ensure that any power source is in this condition: removed, disabled, locked state, tagged out and tested out. Add ground straps to the conductors or terminals. Connect the ground straps to the electrical distribution system common grounding location or to the ground system. During the entire work period, these ground straps must remain connected to the conductors and generator terminals.

Product Information Section

General Information

i04964931

Model View Illustrations

SMCS Code: 1000

The illustrations show typical features of the C175 Series Generator Sets. The illustrations do not show all of the options that are available.

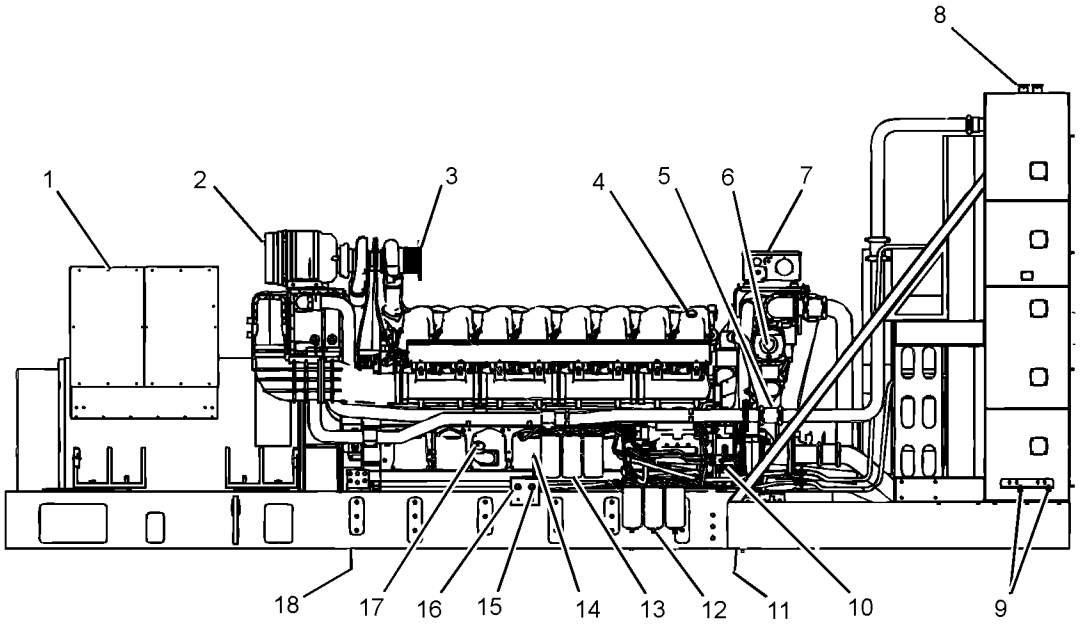


Illustration 21 g03155562

C175-16 right side view

(1) Terminal box
(2) Air cleaner
(3) Exhaust
(4) Oil filler
(5) Coolant sampling port
(6) Oil filter
(7) Control box
(8) Radiator caps
(9) Radiator drain plugs
(10) Fuel priming pump
(11) Oil drain valve
(12) Primary fuel filters
(13) Secondary fuel filters
(14) Oil level gauge
(15) Fuel inlet
(16) Excess fuel return
(17) Oil filler
(18) Oil drain

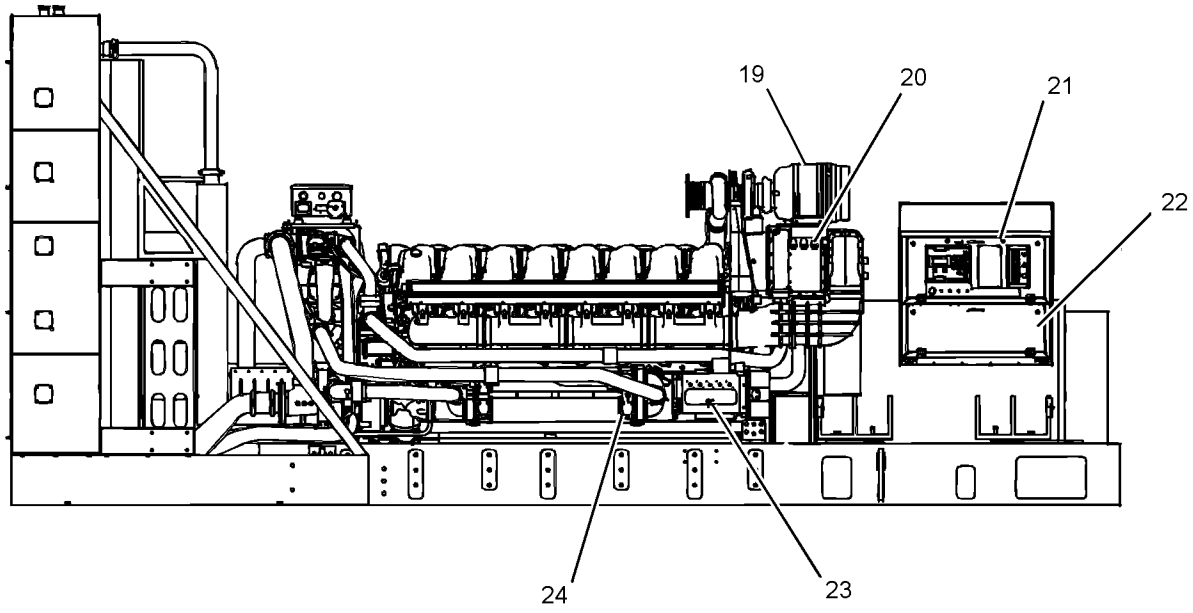


Illustration 22 g03155563

C175-16 left side view

(19) Air cleaner
(20) Indicators
(21) Control and power panel
(22) Customer wiring box
(23) Electric start switch
(24) Engine oil sampling port

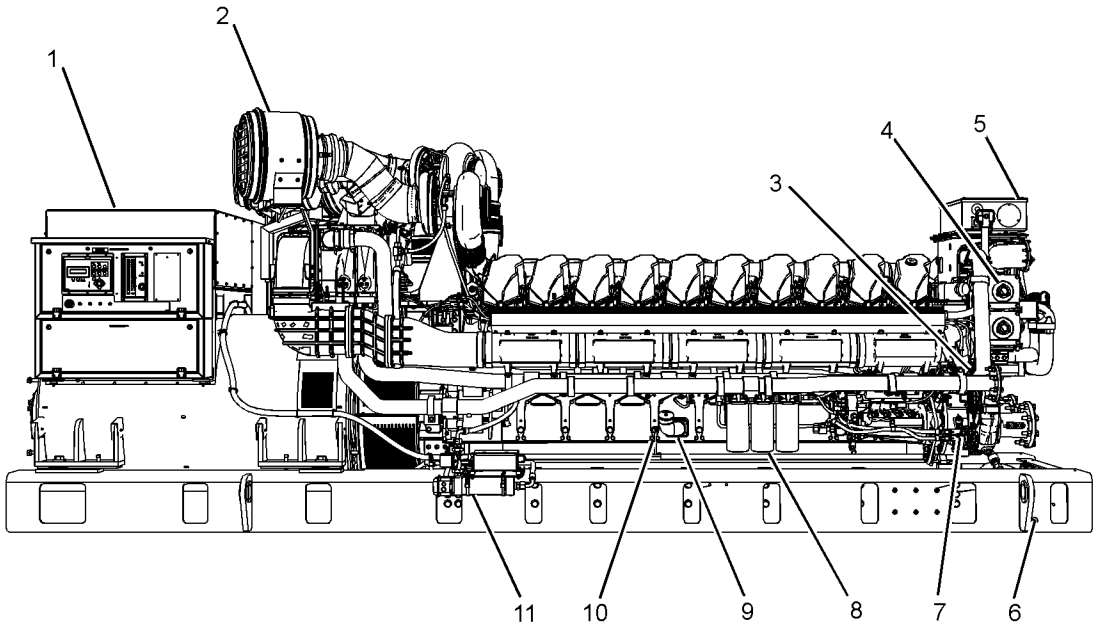


Illustration 23 g03148977

C175-20 right side view

(1) Terminal box
(2) Air cleaner
(3) Coolant sampling port
(4) Engine oil filters
(5) Control Box
(6) Engine oil drain
(7) Fuel priming pump
(8) Fuel filters
(9) Oil filler
(10) Oil level gauge
(11) Jacket water heater

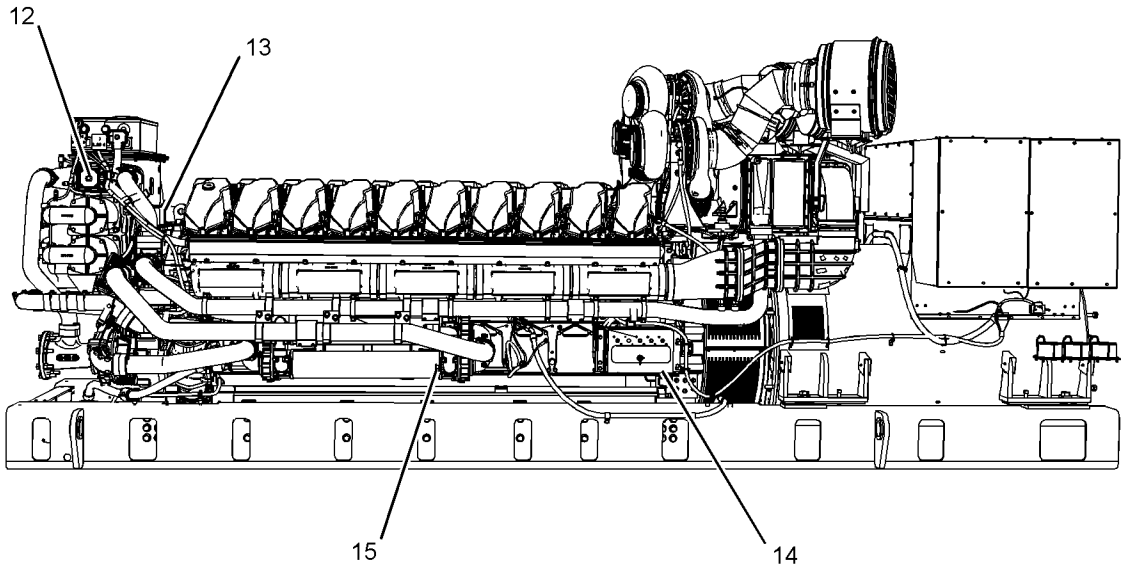


Illustration 24 g03148979

C175-20 left side view

(12) Thermostatic valve
(13) Crankcase breathers
(14) Circuit breakers
(15) Engine oil sampling port

i08331013

Product Description

SMCS Code: 1000; 4450; 4491

Cat C175 Generator Sets consist of an engine, a generator, and control systems.

Intended Use

This generator is used to generate electrical power.

Engine Description

C175 Generator Set Engines are electronically controlled diesel engines. The engines have electronic fuel injectors. The engines can be equipped with either two-stage aftercooling or air-to-air aftercooling.

Engine efficiency and engine performance depend on adherence to proper operation and maintenance recommendations. Use the recommended fuels, lubrication oils, and coolant. Pay special attention to the air cleaner, to the fuel system, to the lubrication system, and to the cooling system maintenance. Refer to the Operation and Maintenance Manual, “Maintenance Interval Schedule” for more information on maintenance items.

Generator Description

The generator can be used with the following loads: mixed loads of motors and lights, SCR-controlled equipment, computer centers, installations of communications and petroleum drilling applications.

The generator set packages can be utilized for prime power generation or standby power generation.

The generators are utilized in three-phase full-wave excitation and regulation. The generators are either four pole or six pole design. The frame size will determine if the generator has six leads or 12. The generators can produce electrical power in either 50 Hz or 60 Hz applications.

Product Identification Information

i08286748

Plate Locations and Film Locations

SMCS Code: 1000; 4450

Engine Identification

Cat engines are identified with serial numbers, with performance specification numbers, and with arrangement numbers. In some of the cases, modification numbers are used. These numbers are shown on the Serial Number Plate and the Information Plate that are mounted on the engine.

Cat dealers need these numbers to determine the components that were included with the engine. This information permits accurate identification of replacement part numbers.

Serial Number Plate

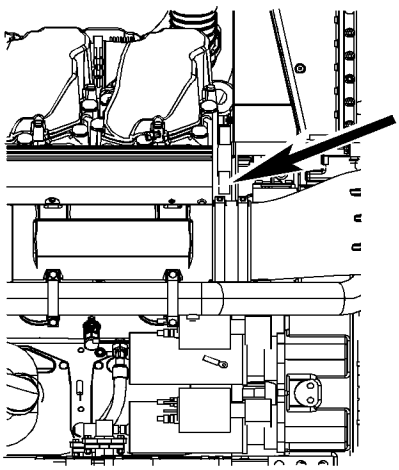


Illustration 25 g01944034

The Serial Number Plate is on the left side of the cylinder block. The Serial Number Plate is located above the starters, and near the rear of the engine.

The following information is stamped on the Serial Number Plate: engine serial number, model, and arrangement number.

Generator Identification

The generator identification plate is on the top of the barrel of the generator.

When service is required, the information that is given on this plate should be used. The generator identification and information plate include the following information: serial number, model number, and the rating of the generator set. The generator set consists of the engine and the generator. All pertinent generator data is also included on the plate to provide the information that is necessary to order parts.

Output Lead Wiring

All generator lead wiring information can be found on a decal that is on the side panel of the generator terminal box. If the generator is equipped with a circuit breaker, the decal may be found on the sheet metal of the circuit breaker panel.

European Union

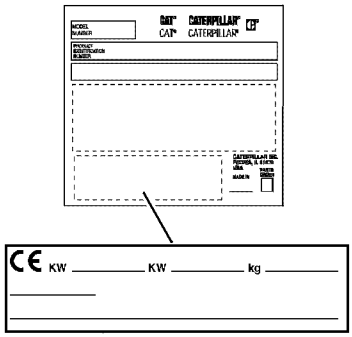


Illustration 26 g01880193

This plate is positioned on the bottom-left side of the plate for the PIN.

Note: The CE plate is on machines that are certified to the European Union requirements that were effective then.

For machines compliant to 2006/42/EC, the following information is stamped onto the CE plate. For quick reference, record this information in the spaces that are provided below.

- Engine Power Primary Engine (kW)_____
- Engine Power for an extra Engine (If Equipped)

- Typical Machine Operating Weight for European Market (kg)_____
- Year of Construction_____
- Machine Type _____

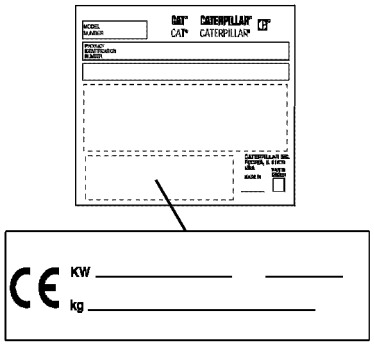


Illustration 27 g01120192

This plate is positioned on the bottom-left side of the plate for the PIN.

Note: The CE plate is on machines that are certified to the European Union requirements that were effective then.

For machines compliant to 1998/42/EC, the following information is stamped onto the CE plate. For quick reference, record this information in the spaces that are provided below.

- Engine Power Primary Engine (kW)_____
- Typical Machine Operating Weight for European Market (kg)_____
- Year_____

For the name and address of the manufacturer, and the country of origin of the machine, refer to the PIN plate.

For manufacturer name and address and the country of origin, see the PIN plate.

Rating Plate

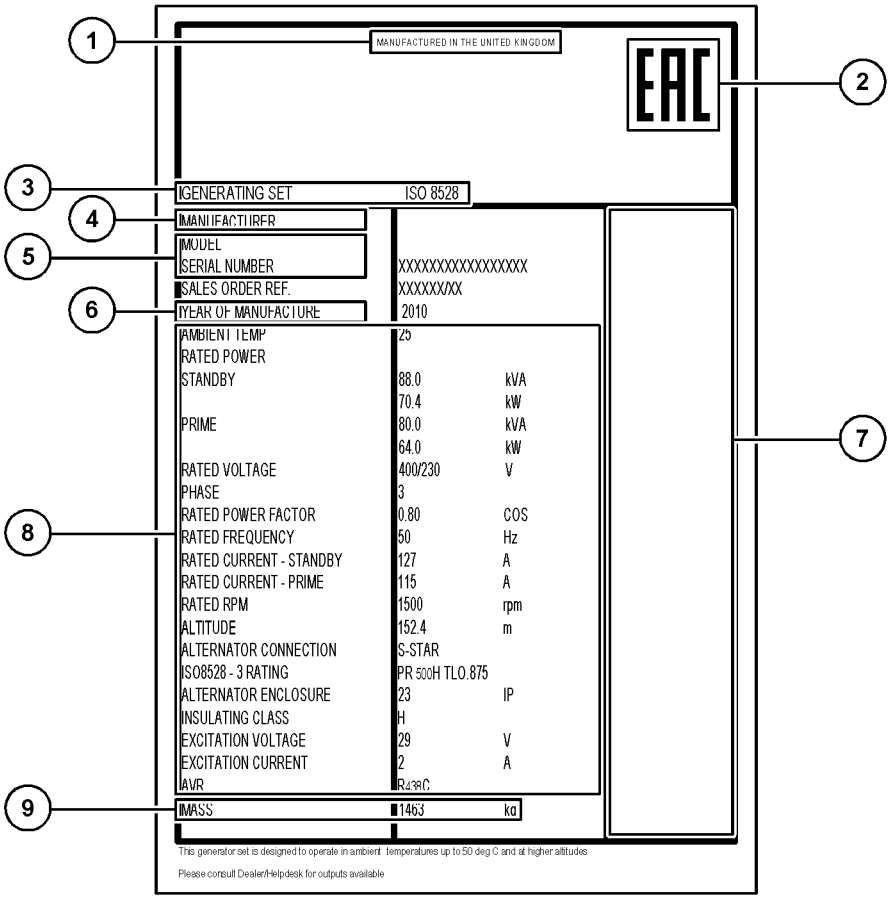


Illustration 28 g06435333

(1) Country of Origin
(2) EAC mark of conformity
(3) Name/designation
(4) Manufacturer name
(5) Model and serial number
(6) Month and Year of Manufacture
(7) Eurasian Economic Union Member national language
(8) Basic parameters/features
(9) Mass

Eurasian Economic Union

For generator sets compliant to the Eurasian Economic Union requirements, the EAC mark plate is positioned in the upper right corner of the rating plate. The EAC mark plate is placed on generator sets certified to the Eurasian Economic Union requirements effective at the time of market entry.

Illustration 29 g06094564

The Month and Year of Manufacture are on the rating plate.

Manufacturer Information

Manufacturer:

Caterpillar Inc.,
100 N.E. Adams Street
Peoria, Illinois 61629, USA

Entity authorized by the manufacturer at the territory of Eurasian Economic Union:

Caterpillar Eurasia LLC
75, Sadovnicheskaya Emb.
Moscow 115035, Russia

Declaration of Conformity

SMCS Code: 1000

Table 1

An EU Declaration of Conformity document was provided with the product, if product was manufactured to comply with specific requirements for the European Union. To determine the details of the applicable Directives, review the complete EU Declaration of Conformity provided with the product. The excerpt below from an EU Declaration of Conformity for products that are declared compliant to “2006/42/EC” applies only to those product originally “CE” marked by the manufacturer listed and which have not since been modified.

ORIGINAL EU DECLARATION OF CONFORMITY

Manufacturer:CATERPILLAR INC. 100 N.E. ADAMS STREET PEORIA, IL 61629 USA

Person authorized to compile the Technical File and to communicate relevant part or parts of the Technical File to the Authorities of European Union Member States on request:

Standards & Regulations Manager,Caterpillar France S.A.S,
40 Avenue Leon-Blum, 38000 Grenoble, France

I, the undersigned, _____, hereby certify that the construction equipment specified hereunder

Description:	Generic Denomination:	Power Generation Equipment
	Function:	Power Generator
	Model/Type:	C175
	Serial Number:	
	Commercial Name:	Caterpillar

Fulfills all the relevant provisions of the following Directives

Directives	Notified Body	Document No.
2006/42/EC	N/A	
2006/95/EC	N/A	
2004/108/EC	N/A	
2000/14/EC amended by 2005/88/EC, Note (1)	Note (2)	

Note (1) Annex -_____ Guaranteed Sound Power Level -_____dB (A)
Representative Equipment Type Sound Power Level - _____dB (A)
Engine Power per ____-____ kW Rated engine speed - _____ rpm
Technical Documentation accessible through person listed above authorized to compile the Technical File

Note (2) Notified body name and address

Done at: **Signature**

Date: **Name/Position**

Note: The above information was correct as of October, 2009, but may be subject to change. Refer to the individual declaration of conformity issued with the machine for exact details.

i08085827

Emissions Certification Film

SMCS Code: 1000; 7405

Consult your Cat dealer for an Emission Control Warranty Statement.

The emission certification film is on the engine.

i08186130

Reference Information

SMCS Code: 1000; 4450

Identification of the items in Table 2 may be needed to obtain parts and service. Some of the information is on the engine Serial Number Plate and/or Information Plate. Locate the information for your engine. Record the information on the appropriate space in Table 2 . Make a copy of this list for a record. Retain the information for future reference.

The top-level part numbers in the Parts Manual for the engine are listed with the engine arrangement number. Occasionally, an arrangement may be slightly modified before the product is shipped from the factory. In these cases, a modification number indicates that the arrangement has been modified.

The packaging arrangement may also be called a pricing arrangement or a customer arrangement. This arrangement is the total package with attachments and options that are not included in the engine arrangement.

The performance specification can be used by your Cat dealer with the Technical Marketing Information system. Before the engine leaves the factory, the engine performance is tested. Detailed performance data is recorded. The performance specification number can be used for obtaining the data.

Table 2

Reference Information	
Engine Model	
Serial Number	
Arrangement Number	
Modification Number	
Packaging Arrangement	
Turbocharger	
Fuel Filter Element	
Lubrication Oil Filter Element	
Auxiliary Oil Filter Element	

(continued)

(Table 2, contd)

Air Cleaner Element	
Fan Drive Belt	
Alternator Belt	
Capacity of the Lubrication System	
Capacity of the Cooling System	
Performance Specification Number	
Personality Module	
Low Idle rpm	
High Idle rpm	
Full Load rpm	
Power Rating	

Operation Section

Lifting and Storage

i08335377

Product Lifting

SMCS Code: 7000; 7002

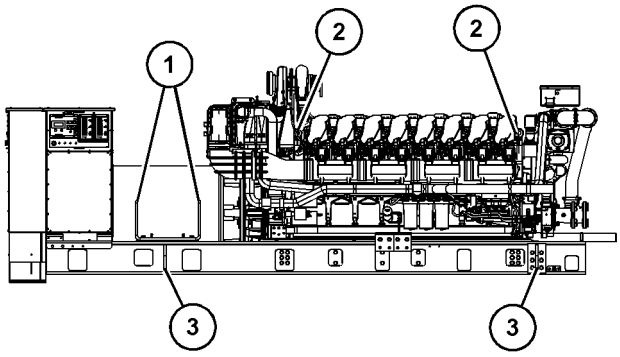


Illustration 30 g06632074

NOTICE
Never bend the eyebolts and the brackets. Only load the eyebolts and the brackets under tension. Remember that the capacity of an eyebolt is less as the angle between the supporting members and the object becomes less than 90 degrees.

When it is necessary to remove a component at an angle, only use a link bracket that is properly rated for the weight.

Use a hoist to remove heavy components. Use spreader bars to lift entire package. Use an adjustable lifting beam or spreader bars to lift the engine. All supporting members (chains and cables) should be parallel to each other. The chains and cables should be perpendicular to the top of the object that is being lifted.

Some removals require lifting fixtures to obtain proper balance. Lifting fixtures also help to provide safety.

Lifting eyes are designed and installed for each package. Alterations to the lifting eyes and/or the package make the lifting eyes and the lifting fixtures obsolete. If alterations are made, ensure that proper lifting devices are provided. Consult your Cat dealer for information regarding fixtures for proper lifting.

Lifting the Generator Set Package

Note: Two 2320 mm (91.3 inch) spreader bars are required to lift the generator set safely.

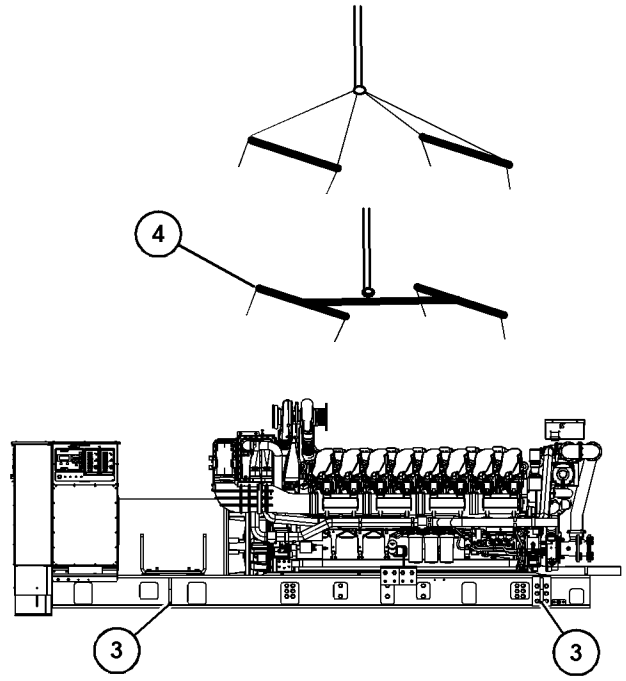


Illustration 31 g06632168

Lift rigging configurations

(4) Rigging configurations

Use lifting fixtures that are joined at a single rigging point. Select lifting equipment that is rated for the weight of the generator set package.

Do NOT use the engine lifting eyes or the generator lifting eyes to lift the entire package. Lifting points (3) have been provided on the base rails of the generator set for lifting the generator set package. However, lifting the engine and the generator together requires special equipment and procedures. Consult your Cat dealer for additional information regarding fixtures for proper lifting of your complete package.

Lifting the Engine Only

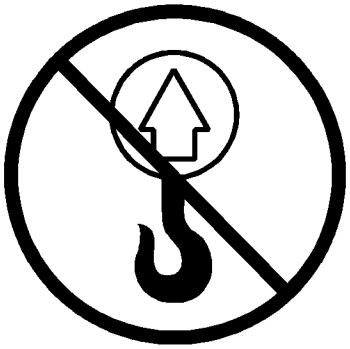


Illustration 32 g01231042

Engine lifting groups (2) are not meant to lift the engine without the installation of the lifting shackles that are shipped with the engine. The lifting groups have a protective cover that prevents using the lifting groups for lifting the package. Follow these steps to lift the engine ONLY:

1. Remove the protective covers.

2. Install the shackles onto the lifting groups.

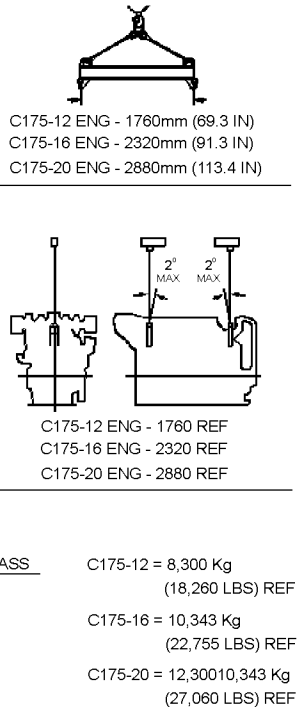


Illustration 33 g01948465

3. Use a properly rated spreader bar with the shackles to lift the engine ONLY.

When you are through lifting the engine, reverse the above procedure to return the engine to the original condition.

Lifting the Generator Only

Note: The control panel and the terminal box will need to be removed before attempting to lift the generator.

To remove the generator ONLY, use lifting eyes (1) that are on the generator.

i08232567

Product Storage

SMCS Code: 7002

Short Time Storage

If the generator is not installed immediately, store the generator in a clean area. This area should also have the following conditions: low humidity, stable humidity, and stable temperature. Space heaters must be energized to keep condensation from the windings. All accessory equipment that is supplied with the unit should be stored with the generator. The combined unit should be covered with a durable cover to protect against the following contaminants:

- Dust
- Dirt
- Moisture
- Other airborne abrasive substances

Long Time Storage

Engine Storage

If the engine will not be started for several weeks, the lubricating oil will drain from the cylinder walls and from the piston rings. Rust can form on the cylinder liner surface, which will increase engine wear which can reduce engine service life.

To help prevent excessive engine wear, use the following guidelines:

- Complete all lubrication recommendations that are listed in this Operation and Maintenance Manual, “Maintenance Interval Schedule” (Maintenance Section).
- If freezing temperatures are expected, check the cooling system for adequate protection against freezing. See this Operation and Maintenance Manual, “Refill Capacities and Recommendations” (Maintenance Section).

If an engine is out of operation and if use of the engine is not planned, special precautions should be made. If the engine will be stored for more than 1 month, a complete protection procedure is recommended.

Your Cat dealer will have instructions for preparing the engine for extended storage periods.

For more detailed information on engine storage, see Special Instruction, SEHS9031, “Storage Procedure for Caterpillar Products”.

Generator Storage

A storage period more than 6 months should be preceded by the following preparation:

1. Install desiccant bags inside the exciter cover and install desiccant bags inside the screen of the fan.
2. Seal the unit in a covering of plastic or other material that has been designed for that purpose.
3. Adequately tag the generator. This tag will ensure that preservative greases and desiccant bags are removed before the generator is placed in operation.

Bearing Inspection

Ball bearing generators use grease. This grease is subject to deterioration. If the generator is stored for more than 1 year, new ball bearings may be required. These bearings should be greased prior to being put into operation. If inspection indicates that bearings are free of rust or corrosion, and no noise or excessive vibration appear on start-up, replacement is not necessary.

Electrical Measurements

Measure the insulation resistance of each winding if the generator was exposed to the following conditions:

- Rapid changes in temperature
- Freezing
- Wet climate during storage

Note: These tests should be conducted prior to any power connections that are being made. These tests should be conducted prior to any control connections that are made.

Refer to the Generator Maintenance section of this manual to measure the following items:

- Exciter Field (Stator)
- Exciter Armature (Rotor)
- Generator Field (Rotor)
- Generator Armature (Stator)

For additional information on generator storage, consult your Cat dealer for assistance.

Installation

i08194353

Product Installation

SMCS Code: 1000; 1404; 4450; 7002

Receiving Inspection

If the generator is received during cold weather, allow the unit to reach room temperature before you remove the protective packing material. Warming the generator to room temperature will prevent the following problems:

- Water condensation on cold surfaces
- Early failures due to wet windings
- Early failures due to wet insulating materials

Unpacking

Moving the Generator

⚠ WARNING

Improper lift rigging can allow unit to tumble causing injury and damage.

NOTICE
Do not use the engine lifting eyes to remove the engine and generator together.

Unpack the equipment with care to avoid scratching painted surfaces. Move the unit to the mounting location. Follow the instructions under the “Product Lifting” topic. The hoist and the hoist cables should have a rating that is greater than the weight of the generator.

Location

The location of the generator must comply with all local regulations. The location of the generator must also comply with all special industrial regulations. Locate the generator in an area that meets the following requirements:

- Clean
- Dry
- Well ventilated
- Easily accessible for inspection and maintenance

Do not obstruct air inlet openings. Do not obstruct discharge openings. Air flow must reach these openings. If the generator is exposed to harsh environmental conditions, the generator can be modified in the field to add filters and space heaters. In addition, a more rigid periodic maintenance schedule should be established.

Note: For further information concerning the installation of this generator set, see the appropriate Application and Installation Guide.

Protective Devices

The output to the load of the generator should always be protected with an overload protection device such as a circuit breaker or fuses. Fuses should be sized by using the lowest possible current rating. However, this rating must be above the current rating for full load. A common recommendation is 115 percent of rated current. Determine the size of fuses or determine the size of circuit breakers in accordance with NEMA, IEC, and Local Electrical Codes.

Storage

If the generator is not installed immediately, refer to the “Product Storage” topic for the proper considerations for storing the unit.

Features and Controls

i08193968

Alarms and Shutoffs

SMCS Code: 7400

This section contains some general information about the function of typical engine protective devices.

Alarms and shutoffs are electronically controlled. The operation of all alarms and shutoffs utilizes components which are actuated by a sensing unit. The alarms and shutoffs are set at critical operating temperatures, pressures, or speed to protect the engine from damage.

The alarms function to warn the operator when an abnormal operating condition occurs. The shutoffs function to shut down the engine when a more critical abnormal operating condition occurs. The shutoffs help to prevent damage to the equipment.

If an engine protective device shuts off the engine, always determine the cause of the shutoff. Make the necessary repairs before attempting to start the engine.

Become familiar with the following information:

- Types of the alarm and shutoff controls
- Locations of the alarm and shutoff controls
- Conditions which cause each control to function
- Resetting procedure that is required before starting the engine

i03323423

Electronic Modular Control Panel 3 (EMCP 3)

SMCS Code: 4490

Electronic Control Module (Generator Set)

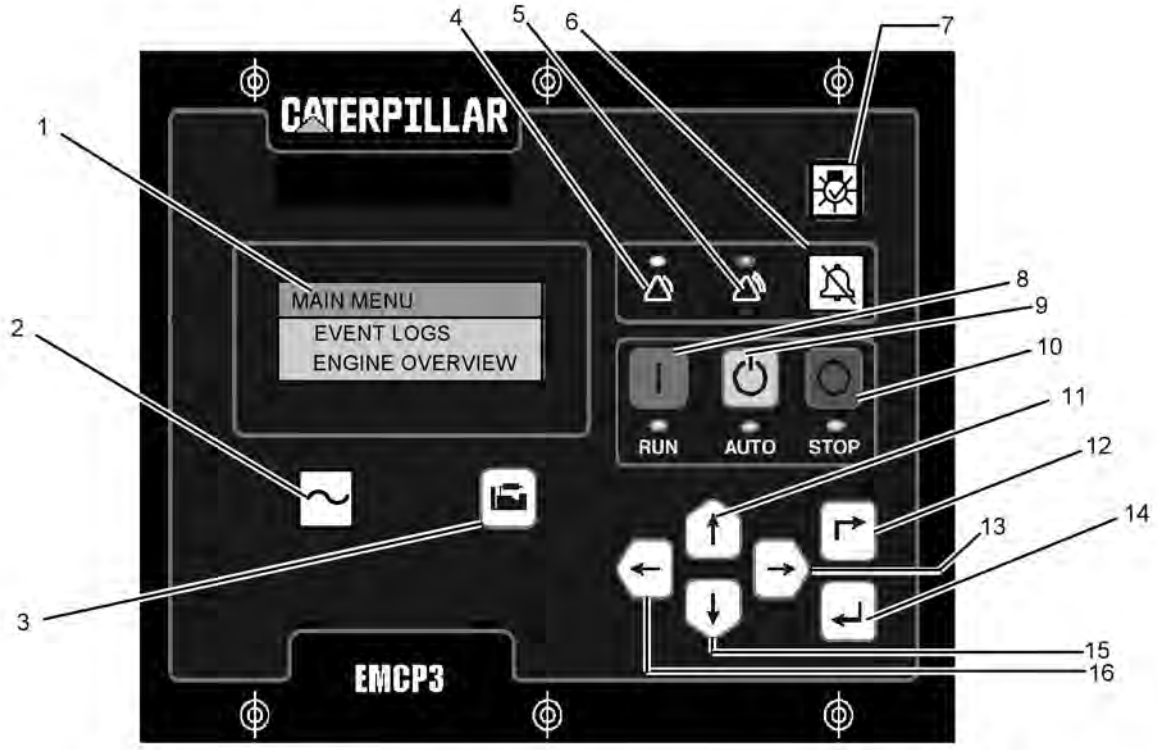


Illustration 34 g01045431

(1) Display screen
(2) AC overview key
(3) Engine overview key
(4) Yellow warning lamp
(5) Red shutdown lamp
(6) Alarm acknowledge key
(7) Lamp test key
(8) Run key
(9) Auto key
(10) Stop key
(11) Up key
(12) Escape key
(13) Right key
(14) Enter key
(15) Down key
(16) Left key

Navigation Keys

AC Overview (2) – The “AC OVERVIEW” key will navigate the display to the first screen of AC information. The “AC OVERVIEW” information contains various AC parameters that summarize the electrical operation of the generator set.

Engine Overview (3) – The “ENGINE OVERVIEW” key will navigate the display to the first screen of engine information. The “ENGINE OVERVIEW” information contains various engine parameters that summarize the operation of the generator set.

Acknowledge Key (6) – Pressing the “ACKNOWLEDGE” key will cause the horn relay to turn off. This will silence the horn. Pressing this key will also cause any red or yellow flashing lights to either turn off or to come on continuously, depending on the active status of the alarms. The “ACKNOWLEDGE” key may also be configured to send out a global alarm silence signal on the J1939 Data Link, which will silence the horns on the annunciators.

Lamp Test Key (7) – Pressing and holding the “LAMP TEST” key will cause each LED and the display screen pixels to turn on continuously until the key is released.

RUN Key (8) – Pressing the “RUN” key will start the engine.

AUTO Key (9) – Pressing the “AUTO” key will cause the engine to enter the “AUTO” mode. The engine will start if the module receives a start command from a remote source.

STOP Key (10) – Pressing the “STOP” key will stop the engine.

Up Key (11) – The “UP” key is used to navigate through the various menus and monitoring screens. The “UP” key is also used when a setpoint is entered. When entering numeric data, the “UP” key is used in order to increment the digits (0-9). If the setpoint requires selection from a list, the “UP” key is used to navigate UP through the list.

Escape Key (12) – The “ESCAPE” key is used in order to navigate through the menus. When the key is pressed, the user moves backward or the user moves upward through the menus. The “ESCAPE” key is also used to exit out of entering data when the user is programming the setpoints. If the “ESCAPE” key is pressed while the user is programming the setpoints, none of the changes made on the screen will be saved to memory.

Right Key (13) – The “RIGHT” key is used during setpoint adjustment. The “RIGHT” key is used to select which digit is edited while entering numeric data. The “RIGHT” key is also used during some setpoint adjustments in order to select or to unselect a check box. If a check box has a check mark, the function has been enabled. Pressing the “RIGHT” key will disable the function. Pressing the “RIGHT” key will also cause the check mark to disappear. If the check box does not have a check mark, the function is disabled. Pressing the “RIGHT” key will enable the function. Pressing the “RIGHT” key will also cause a check mark to appear.

Enter Key (14) – The “ENTER” key is used in order to navigate through the menus. When the key is pressed, the user moves forward or the user moves downward through the menus. The “ENTER” key is also used to save any changes while the setpoints are being programmed. Pressing the “ENTER” key during programming the setpoints causes the changes to be saved to memory.

Down Key (15) – The “DOWN” key is used to navigate downward through the various menus or screens. The “DOWN” key is also used to program the setpoints. The “DOWN” key is used to decrease the digits when entering numeric data. If the setpoint requires selection from a list, the “DOWN” key is used to navigate DOWN through the list.

Left Key (16) – The “LEFT” key is used during setpoint adjustment. The “LEFT” key is used to select the digit that is edited during the entry of numeric data. The “LEFT” key is also used during some of the setpoint adjustments to select a check box. The key is also used to unselect a check box. If a check box has a check mark, pressing the “LEFT” key will disable the function. Pressing the key will also remove the check mark. Pressing the “LEFT” key will also cause the check mark to disappear. If the check box does not have a check mark, pressing the “LEFT” key will enable the function. Pressing the “LEFT” key will also cause a check mark to appear.

Alarm Indicators

Yellow Warning Lamp (4) – A flashing yellow light indicates that there are active warnings that have not been acknowledged. A continuous yellow light indicates that there are acknowledged warnings that are active. If there are any active warnings, the yellow light will change from flashing yellow to continuous yellow after the “ACKNOWLEDGE” key is pressed. If there are no longer any active warnings, the yellow light will turn off after the “ACKNOWLEDGE” key is pressed.

Red Shutdown Lamp (5) – A flashing red light indicates that there are active shutdowns that have not been acknowledged. A continuous red light indicates that there are active shutdowns that have been acknowledged. If there are any active shutdowns the red light will change from flashing red to continuous red after the “ACKNOWLEDGE” key is pressed. Any condition that has caused a shutdown must be manually reset. If there are no longer any active shutdowns, the red light will turn off.

Digital Inputs

Note: There are 8 digital inputs on “EMCP 3.2” and “EMCP 3.3” . There are 6 digital inputs on “EMCP 3.1” .

Digital Input 1 – Digital Input 1 is used for the emergency stop. This input should be wired to GROUND through an Emergency Stop switch. The input can be set to activate on an active high (normally closed contact) or an active low (normally open contact). Activating the emergency stop input will cause the generator set to stop immediately. The emergency stop input will also prevent the generator set from starting. Once Digital Input 1 goes active, the engine will not start until the event has been cleared. Refer to System Operation, Troubleshooting, Testing and Adjusting, RENR7902, “Digital Input Resetting”.

Digital Input 2 – Digital Input 2 is used for remotely starting and stopping the generator set. This input should be wired to GROUND through a switch that can be initiated remotely. The input can be set to activate on an active high (normally closed contact) or an active low (normally open contact). If the input is active and the engine is in AUTO, the engine will attempt to start. Once the input becomes inactive the engine will enter into cooldown mode (if programmed) and then the engine will stop.

The remainder of the inputs can be configured. The main purpose for the other “DIGITAL” inputs is to add additional monitoring capabilities of the parameters for the engine or generator. The inputs can be configured by going to the “EVENT I/P FUNCTIONS” parameter under the “SETPOINTS” menu. The “DIGITAL INPUTS” parameter can only be set to “ACTIVE HIGH” or “ACTIVE LOW” in order to initiate a High Warning, Low Warning, High Shutdown, Low Shutdown, or Status.

The inputs can be programmed to monitor the following parameters or components. Refer to System Operation, Troubleshooting, Testing and Adjusting, RENR7902, “Digital Input Programming”.

Pressures

- Air filter differential pressure
- Engine oil pressure
- Fire extinguisher pressure
- Fuel filter differential pressure
- Oil filter differential pressure
- Starting air pressure

Temperatures

- Ambient air temperature
- Engine coolant temperature
- Engine oil temperature
- Exhaust temperature
- Rear bearing temperature
- Right exhaust temperature
- Left exhaust temperature

Levels

- Engine coolant level
- Engine oil level
- Fuel level
- External fuel tank level

Other

- Air damper closed
- ATS in normal position
- ATS in emergency position
- Battery charger failure
- Generator breaker closed
- Utility breaker closed
- Fuel leak detected
- Custom event

For detailed information about the electronic control module, see Systems Operation, Troubleshooting, Testing and Adjusting, RENR7902, “EMCP3”.

Service Maintenance Interval Reset

Follow the following steps in order to reset the service maintenance interval.

1. Connect a laptop computer that is equipped with Electronic Technician (ET) to the CAN 1 service connector.

2. Initiate ET and select an electronic control module (ECM).

3. Enter the configuration mode and select the Electronic Modular Control Panel (EMCP 3).

4. Expand the “Service Maintenance Interval” section from the menu.

5. Scroll to “Customer Password Security Level to Reset Service Maintenance Interval” . Double click the value and change “3-Factory, Single Use” to “0-No Security” . Refer to table 3 .

Table 3

Description	Value
Service Maintenance Interval	
Maintenance Level 1 Cycle Interval Hours	600
Maintenance Level 1 Cycle Interval Days	180
Customer Password Security Level to Reset Service Maintenance Interval	3-Factory, Single Use

6. Access the Electronic Modular Control Panel (EMCP 3) that is located on your engine.

7. Press the engine overview key (3).

8. Use the down key (15) in order to scroll to “RESET SERV INTRVL” . Press the enter key (14).

9. Press the enter key (14) again in order to reset the service maintenace interval.

10. Press the engine overview key (3).

11. Return to ET. Expand the “Service Maintenance Interval” section from the menu.

12. Scroll to “Customer Password Security Level to Reset Service Maintenance Interval” . Double click the value and change “0-No Security” to “3-Factory, Single Use” . Refer to table 4

Table 4

Description	Value
Service Maintenance Interval	
Maintenance Level 1 Cycle Interval Hours	600
Maintenance Level 1 Cycle Interval Days	180
Customer Password Security Level to Reset Service Maintenance Interval	0-No Security

13. Exit ET. The procedure is complete.

Control Panel

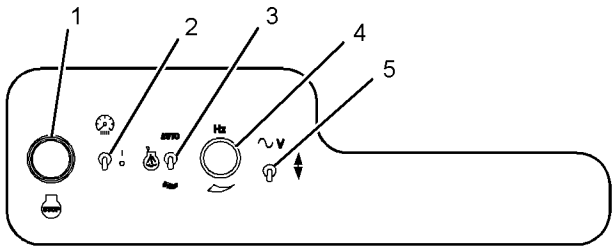


Illustration 35 g01194656

(1) Emergency stop push button
(2) Panel light switch
(3) Starting aid auto/manual switch (optional)
(4) Speed potentiometer (optional)
(5) Voltage adjust switch

Emergency Stop Push Button (1) – The emergency stop push button (ESPB) is used to shut down the engine during an emergency situation. If equipped, the ESPB shuts off the fuel and the ESPB activates the optional air shutoff.

Panel Light Switch (2) – The panel lights switch turns on or the panel lights switch turns off the panel lights.

Starting Aid Auto/Manual Switch (3) – The starting aid switch is optional. The starting aid switch is used to inject ether into the engine when you are starting the engine in cold weather conditions. When the starting aid switch is in the ON position, the switch energizes the starting aid solenoid valve and the switch meters a specific amount of ether into a holding chamber. When the starting aid switch is released, the solenoid releases the ether to the engine.

Speed Potentiometer (4) – The speed potentiometer is optional. The speed potentiometer can be used with the generator set that has an electronic governor.

Voltage Adjust Switch (5) – This switch can be used to raise the voltage. The switch can also be used to lower the voltage.

Annunciator Module

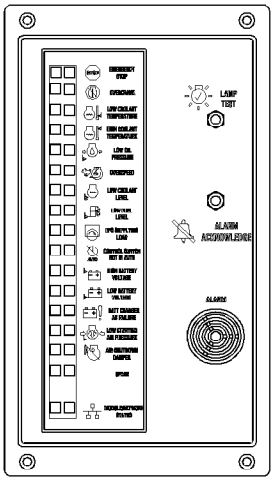


Illustration 36 g01101388

General Information

The annunciator module is used to indicate various system events and conditions. The annunciator module uses indicator lights and an audible horn to give the operator information about the current status of the system. The annunciator module can be used to announce faults and/or status signals to the operator. The annunciator module allows the operator to silence the horn. The annunciator module also allows the operator to acknowledge faults to the system.

There are seventeen pair of LED indicators on the annunciator's front panel. Sixteen pair of LED indicators are used to announce events, diagnostics, and ready signals. The seventeenth pair of LED indicators is used as a combined network/module status LED. The seventeenth pair of LED indicators can tell the operator if there is a problem with the J1939 data link connection.

Basic Operation

Each pair of LED indicators on the annunciator consists of two of the following three colors: green, yellow and red. For example, a pair of red and yellow LED indicators may be configured for engine oil pressure. If a low engine oil pressure warning is read over the data link, the annunciator will flash the yellow LED and the audible horn will sound. If the low engine oil pressure shutdown is read over the data link, the annunciator will flash the red LED and the audible horn will sound.

To acknowledge the shutdown and alarm conditions or to silence the horn, press the “Alarm Acknowledge” button that is located near the middle of the annunciator.

To test the LED indicators or to test the horn when the data link is connected or the data link is disconnected, hold in the “Lamp Test” button that is located near the top of the annunciator.

Configuration

The annunciator module can be customized in order to signal many different conditions that are related to the system. Each pair of LEDs must be configured by using the appropriate service tool. Once the service tool has been connected to the annunciator, the user must enter the “Configuration” screen. Each pair of LEDs has four settings: SPN, Trigger Type, Trigger Severity Level and Failure Mode Identifier (FMI).

For detailed information about the annunciator module, see Systems Operation, Troubleshooting, Testing and Adjusting, RENR7902, “EMCP3”.

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Electronic Modular Control Panel 4 (EMCP 4)

(EMCP 4.1 / 4.2 / 4.2B)

SMCS Code: 4490

Electronic Control Module (Generator Set)

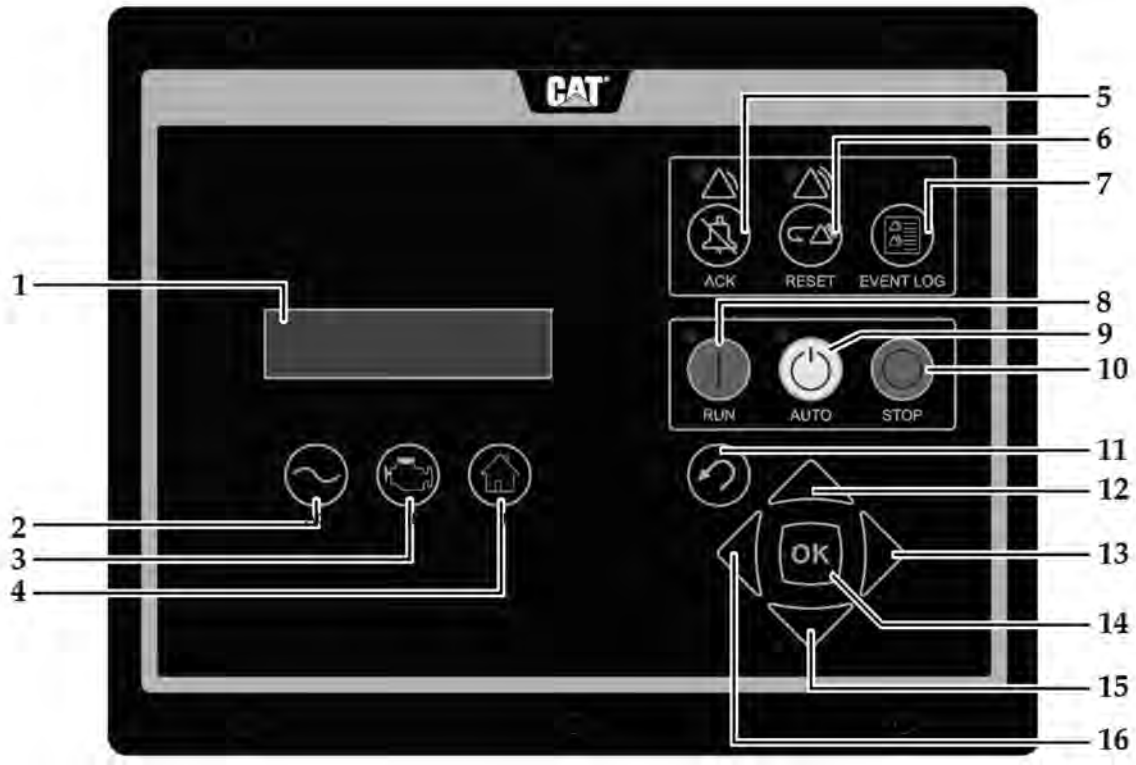

Illustration 37 g02082653

EMCP 4 Control System Panel

(1) Display screen
(2) AC overview key
(3) Engine overview key
(4) Main menu key
(5) Alarms acknowledge key
(6) Reset shut down Key
(7) Event log
(8) Run key
(9) Auto key
(10) Stop key
(11) Escape key
(12) Up key
(13) Right key
(14) OK key
(15) Down key
(16) Left key

Navigation Keys

AC Overview (2) – The “AC OVERVIEW” key will navigate the display to the first screen of AC information. The “AC OVERVIEW” information contains various AC parameters that summarize the electrical operation of the generator set.

Engine Overview (3) – The “ENGINE OVERVIEW” key will navigate the display to the first screen of engine information. The “ENGINE OVERVIEW” information contains various engine parameters that summarize the operation of the generator set.

Main Menu Key (4) – The “MAIN MENU” key will navigate the display to the main menu directly without having to navigate out of menus.

Acknowledge Key(5) – Pressing the “ACKNOWLEDGE” key will cause the horn relay to turn off. The horn relay being turned off will silence the horn. Pressing the “ACKNOWLEDGE” key will also cause any red or yellow flashing lights to either turn off or to come on continuously. The “ACKNOWLEDGE” key may also be configured to send out a global alarm silence signal on the J1939 Data Link. Sending out a global alarm silence signal on the J1939 Data Link will silence the horns on the annunciators.

Reset Key (6) – Pressing the “RESET” key will reset various events.

Event Log Key (7) – Pressing the “EVENT LOG” key will navigate the display to the event log.

RUN Key (8) – Pressing the “RUN” key will start the engine.

AUTO Key (9) – Pressing the “AUTO” key will cause the engine to enter the “AUTO” mode. The engine will start if the module receives a start command from a remote source.

STOP Key (10) – Pressing the “STOP” key will stop the engine.

Escape Key (11) – The “ESCAPE” key is used in order to navigate through the menus. When the key is pressed, the user moves backward or the user moves upward through the menus. The “ESCAPE” key is also used to exit out of entering data when the user is programming the setpoints. If the “ESCAPE” key is pressed while the user is programming the setpoints, changes made on the screen will not be saved to memory.

Up Key (12) – The “UP” key is used to navigate through the various menus and monitoring screens. The “UP” key is also used when a setpoint is entered. When entering numeric data, the “UP” key is used in order to increment the digits (0-9). If the setpoint requires selection from a list, the “UP” key is used to navigate UP through the list.

Right Key (13) – The “RIGHT” key is used during setpoint adjustment. The “RIGHT” key is used to select which digit is edited while entering numeric data. The “RIGHT” key is also used during some setpoint adjustments in order to select or to unselect a check box. If a check box has a check mark, the function has been enabled. Pressing the “RIGHT” key will disable the function. Pressing the “RIGHT” key will also cause the check mark to disappear. If the check box does not have a check mark, the function is disabled. Pressing the “RIGHT” key will enable the function. Pressing the “RIGHT” key will also cause a check mark to appear.

Enter Key (14) – The “ENTER” key is used in order to navigate through the menus. When the key is pressed, the user moves forward or the user moves downward through the menus. The “ENTER” key is also used to save any changes while the setpoints are being programmed. Pressing the “OK” key during programming the setpoints causes the changes to be saved to memory.

Down Key (15) – The “DOWN” key is used to navigate downward through the various menus or screens. The “DOWN” key is also used to program the setpoints. The “DOWN” key is used to decrease the digits when entering numeric data. If the setpoint requires selection from a list, the “DOWN” key is used to navigate DOWN through the list.

Left Key (16) – The “LEFT” key is used during setpoint adjustment. The “LEFT” key is used to select the digit that is edited during the entry of numeric data. The “LEFT” key is also used during some of the setpoint adjustments to select a check box. The key is also used to unselect a check box. If a check box has a check mark, pressing the “LEFT” key will disable the function. Pressing the key will also remove the check mark. Pressing the “LEFT” key will also cause the check mark to disappear. If the check box does not have a check mark, pressing the “LEFT” key will enable the function. Pressing the “LEFT” key will also cause a check mark to appear.

Alarm Indicators

Yellow Warning Lamp – A yellow warning lamp is located above the “ACKNOWLEDGE” key. A flashing yellow light indicates that there are active warnings that have not been acknowledged. A continuous yellow light indicates that there are acknowledged warnings that are active. If there are any active warnings, the yellow light will change from flashing yellow to continuous yellow after the “ACKNOWLEDGE” key is pressed. If there are no longer any active warnings, the yellow light will turn off after the “ACKNOWLEDGE” key is pressed.

Red Shutdown Lamp – A red shutdown lamp is located above the “RESET” key. A flashing red light indicates that there are active shutdowns that have not been acknowledged. A continuous red light indicates that there are active shutdowns that have been acknowledged. If there are any active shutdowns, the red light will change from flashing red to continuous red after the “ACKNOWLEDGE” key is pressed. Any condition that has caused a shutdown must be manually reset. If there are no longer any active shutdowns, the red light will turn off.

Digital Inputs

There are several digital inputs and outputs on “EMCP 4.1” and “EMCP 4.2” . For detailed information about the inputs on this electronic control module, see Systems Operation, Troubleshooting, Testing, and Adjusting, UENR1209, “EMCP4.1/ EMCP4.2”.

There are several digital inputs and outputs on “EMCP 4.2B” . For detailed information about the inputs on this electronic control module, see Systems Operation, Troubleshooting, Testing, and Adjusting, UENR7097, “EMCP4.2B”.

Control Panel

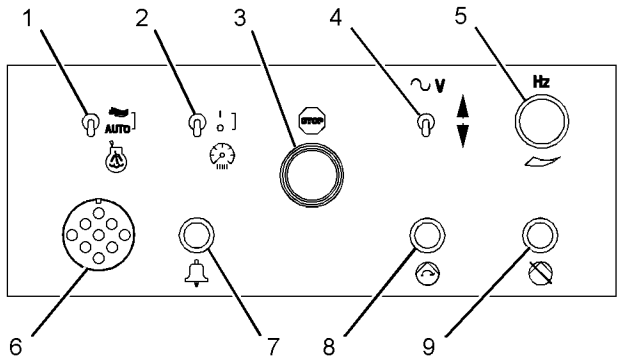

Illustration 38 g01185966

(1) Starting aid auto/manual switch (if equipped)
(2) Panel light switch
(3) Emergency stop push button
(4) Voltage adjust switch (if equipped)
(5) Speed potentiometer (if equipped)
(6) Customer connection (if equipped)
(7) Horn (if equipped)
(8) Pump run switch (if equipped)
(9) Pump stop switch (if equipped)

Starting Aid Auto/Manual Switch (1) – The starting aid switch is optional. The starting aid switch is used to inject ether into the engine when you are starting the engine in cold-weather conditions. When the starting aid switch is in the ON position, the solenoid valve is energized. The switch then meters a specific amount of ether into a holding chamber. When the starting aid switch is released, the solenoid releases the ether to the engine.

Panel Light Switch (2) – The panel lights switch turns on or the panel lights switch turns off the panel lights.

Emergency Stop Push Button (3) – The emergency stop push button (ESPB) is used to shut down the engine during an emergency situation. If equipped, the ESPB shuts off the fuel and the ESPB activates the optional air shutoff.

Voltage Adjust Switch (4) – This switch can be used to raise the voltage. The switch can also be used to lower the voltage.

Speed Potentiometer (5) – The speed potentiometer is optional. The speed potentiometer can be used with the generator set that has an electronic governor.

Customer Connection (6) – The customer connection is a 9-pin connector for connecting the Cat Electronic Technician.

Horn (7) – The horn provides an audible alarm.

Pump Run Switch (if equipped)(8) – Under normal circumstances, the fuel transfer process is automatic. In some instances, a manual operation may be required. Press the pump run switch once in order to start the pump manually.

Pump Stop Switch (if equipped)(9) – The pump stop switch is a push-button switch that locks into position. The pump stop switch will stop the pump if the switch is locked into position. Releasing the switch will place the pump back into the run mode.

Annunciator Module

Illustration 39 g02111119

(20) Alarm acknowledge button

General Information

The annunciator module is used to indicate various system events and conditions. The annunciator module uses indicator lights and an audible horn to give the operator information about the status of the system. The annunciator module can be used to announce faults and/or status signals to the operator. The annunciator module allows the operator to silence the horn. The annunciator module also allows the operator to acknowledge faults to the system.

There are 17 pairs of LED indicators on the front panel of the annunciator. The 16 pairs of LED indicators are used to announce events, diagnostics, and ready signals. The 17th pair of LED indicators is used as a combined network/module status LED. The 17th pair of LED indicators can tell the operator if there is a problem with the J1939 data link connection.

Basic Operation

Each pair of LED indicators on the annunciator consists of two of the following three colors: green, yellow and red. For example, a pair of red and yellow LED indicators may be configured for engine oil pressure. If a low engine oil pressure warning is read over the data link, the annunciator will flash the yellow LED. The audible horn will then sound. If the low engine oil pressure shutdown is read over the data link, the annunciator will flash the red LED. The audible horn will then sound.

To acknowledge the shutdown and alarm conditions or to silence the horn, press the “Alarm Acknowledge” button (20).

To test the LED indicators or the horn when the data link is either connected or disconnected, hold the “Lamp Test” button in.

Configuration

The annunciator module can be customized in order to signal many different conditions that are related to the system. Each pair of LEDs must be configured by using the appropriate service tool. Once the service tool has been connected to the annunciator, the user must enter the “Configuration” screen. Each pair of LEDs has four settings: SPN, Trigger Type, Trigger Severity Level and Failure Mode Identifier (FMI).

For detailed information about the annunciator module, see Systems Operation, Troubleshooting, Testing, and Adjusting, UENR1209, “EMCP4.1/4.2”.

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Electronic Modular Control Panel 4 (EMCP 4)
(EMCP 4.3/4.4)

SMCS Code: 4490

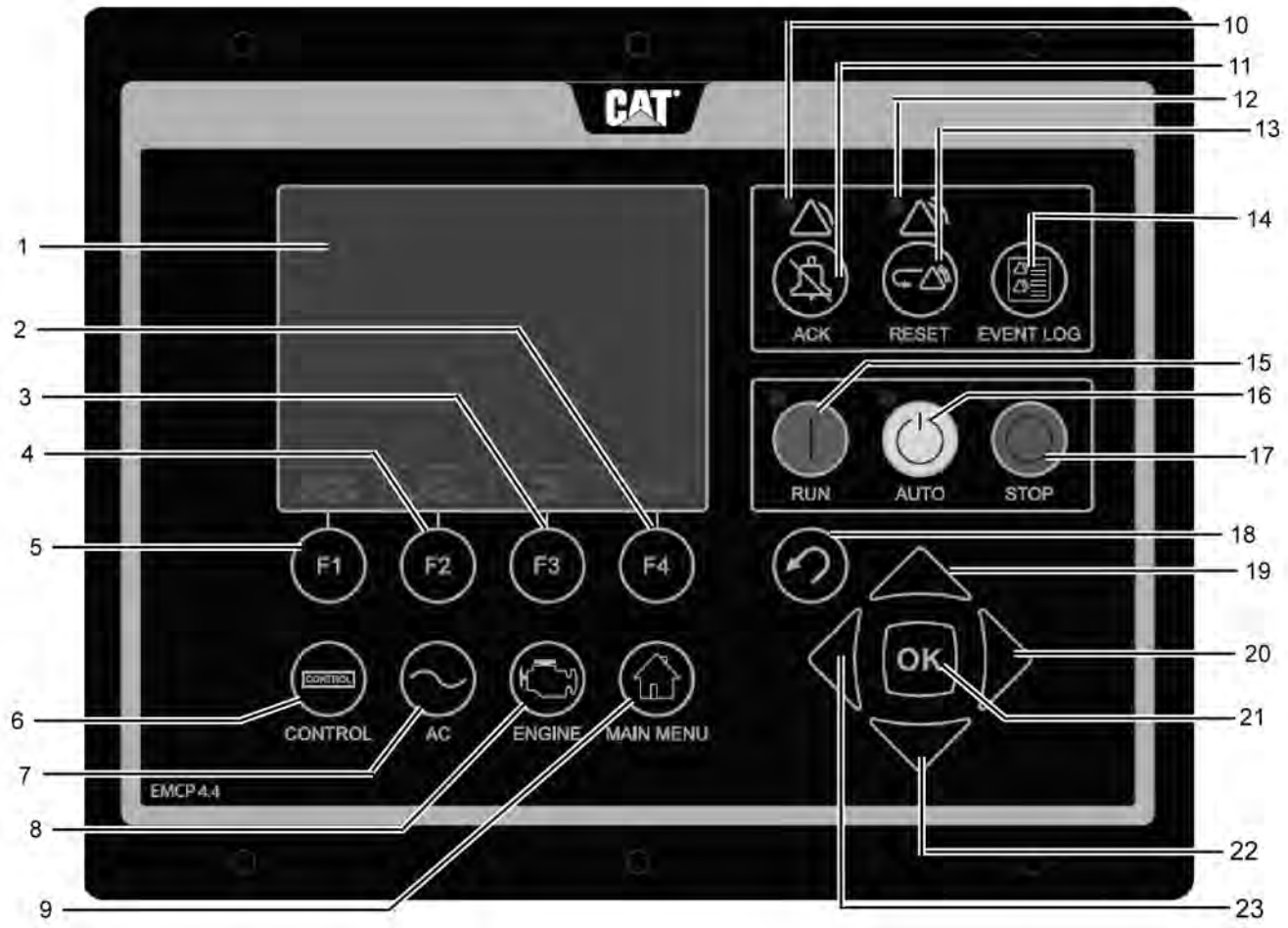

Illustration 40 g02118437

(1) Display screen
(2) F4 Soft key
(3) F3 Soft key
(4) F2 Soft key
(5) F1 Soft key
(6) Control key
(7) AC overview key
(8) Engine overview key
(9) Main menu
(10) Warning Indicator lamp (yellow)
(11) Alarms acknowledge key and silence key
(12) Shutdown Indicator lamp (red)
(13) Event reset key
(14) Event log key
(15) Run key
(16) Auto key
(17) Stop key
(18) Escape key
(19) Up key
(20) Right key
(21) OK key
(22) Down key
(23) Left key

General Information

The main component of the Electronic Modular Control Panel 4.3/4.4 (EMCP 4.3/4.4) is the electronic control module (ECM). This section discusses the display, keys, and indicators on the control system panel of the ECM. The EMCP 4.3/4.4 panel is used for monitoring and controlling many of the generator set functions. Some of the functions include:

- Sending start and stop signals to the engine
- Providing visual and audible indications when warning or shutdown events occur
- Displaying engine information and AC generator set information
- Displaying Suspect Parameter Number (SPN) and Failure Mode Identifier (FMI) information for events
- Programming set points for the standard EMCP 4.3/4.4 (The set points for optional modules are set with the use of Cat ET.)
- Annunciator configuration is done within the EMCP 4.3/4.4

ECM Front Panel Components

The following components can be found on the front panel of the ECM:

- Information Display
- Alarm Indicators
- Alarm Acknowledge/Silence Key
- Event Reset Key
- Function Keys
- Navigation Keys
- System Overview Keys

Information Display

(1) Display Screen – Information from the EMCP 4 is displayed on the display screen. This screen is used for the following programming and display functions.

- Displaying AC parameter information of the generator set
- Displaying engine parameter information of the generator set
- Programming set points for the generator
- Displaying engine event information
- Displaying event codes from other modules
- Programming the display preferences of the EMCP 4.3/4.4
- Changing password levels of the EMCP 4.3/4.4

Alarm Acknowledge/Silence Key

(10) Alarm Acknowledge/Silence Key – Pressing the alarm acknowledge/silence key will cause the horn relay output to turn off and silence the horn. Pressing the key will also cause any yellow or red flashing lights to turn off or to become solid depending on the active status of the alarms. The alarm acknowledge/silence key may also be configured to send out a global alarm silence on the J1939 Data Link which will silence horns on annunciators. However, other modules must be configured to listen to the global acknowledge.

Event Reset Key

(11) Event Reset Key – The event reset button will clear all inactive fault conditions.

Alarm Indicators

Yellow Warning Light – The yellow warning light (10) is located directly above the alarm acknowledge/silence key (11). A flashing yellow light indicates that there are unacknowledged active warnings. A solid yellow light indicates that there are acknowledged warnings active. If there are any active warnings, the yellow light will change from flashing yellow to solid yellow after the alarm acknowledge/silence key is pressed. If there are no longer any active warnings, the yellow light will turn off after the alarm acknowledge/silence key is pressed.

Red Shut down Light – The red shutdown (12) light is located directly above the event reset key (13). A flashing red light indicates that there are unacknowledged active shutdown events. A solid red light indicates that there are acknowledged shutdown events active. If there are any active shutdown events, the red light will change from flashing red to solid red after the alarm acknowledge/silence key is pressed. Any condition that has caused a shutdown event must be manually reset. If there are no longer any active shutdown events, the red light will turn off.

Function Keys

(2) F4 – Pressing the F4 key will enable the function that is described on the screen directly above this key. When this key is defined on screen to scroll up or down, the Scroll Up and Scroll Down keys will also function the same.

(3) F3 – Pressing the F3 key will enable the function that is described on the screen directly above this key. When this key is defined on screen to scroll up or down, the Scroll Up and Scroll Down keys will also function the same.

(4) F2 – Pressing the F2 key will enable the function that is described on the screen directly above this key. When this key is defined on screen to scroll up or down, the Scroll Up and Scroll Down keys will also function the same.

(5) F1 – Pressing the F1 key will enable the function that is described on the screen directly above this key. When this key is defined on screen to scroll up or down, the Scroll Up and Scroll Down keys will also function the same.

(15) RUN – Pressing the “RUN” key causes the EMCP 4.3/4.4 to enter the run mode.

(16) AUTO – Pressing the “AUTO” key causes the EMCP 4.3/4.4 to enter the auto mode.

(17) STOP – Pressing the “STOP” key causes the EMCP 4.3/4.4 to enter the stop mode or the cool down mode.

(18) Escape Key – The escape key is used during menu navigation to navigate up through the menu/submenu structure. Each key press causes the user to move backward (upward) through the menus. The escape key is also used to cancel of data entry screens during set point programming. If the escape key is pressed during set point programming, then none of the changes displayed on the screen will be saved to memory.

(21) OK Key – The OK key is used during menu navigation to move forward (downward) through the menu/submenu structure. The key is also used during set point programming to save set points changes. Pressing the OK key during set point programming causes set point changes to be saved to memory.

Navigation Keys

(6) Control Key – The control key will navigate the display to the screen that allows the user to monitor and/or adjust various special control features.

(9) Main Menu Key – The main menu will navigate the display to the main menu directly without having to navigate out of menus.

(14) Event Log – The event log button will navigate the display to the event log.

(19) Up Key – The up key is used to navigate up through the various menus or monitoring screens. The key is also used during set point entry. During numeric data entry, the key is used to increment the digits (0-9). If the set point requires selection from a list, then the key is used to navigate up through the list.

(20) Right Key – The right key is used during set point adjustment. During numeric data entry, the key is used to choose which digit is being edited. The key is also used during certain set point adjustments to select a check box or to deselect a check box. If a box has a check mark inside, then pressing the key will cause the check mark to disappear. If the box does not have a check mark inside, then pressing the key will cause a check mark to appear inside.

(22) Down Key – The down key is used to navigate down through the various menus or monitoring screens. The key is also used during set point entry. During numeric data entry, the key is used to decrement the digits (0-9). If the set point requires selection from a list, then the key is used to navigate down through the list.

(23) Left Key – The left key is used during set point adjustment. During numeric data entry, the key is used to choose which digit is being edited. The key is also used during certain set point adjustments to select a check box or to deselect a check box. If a box has a check mark inside, then pressing the key will cause the check mark to disappear. If the box does not have a check mark inside, then pressing the key will cause a check mark to appear inside.

System Overview Keys

(7) AC Overview – Pressing the AC overview key displays the first screen of AC information for the generator set. This initial information page contains various AC parameters that summarize the electrical operation of the generator set. Additional AC parameters can be viewed by pressing the down key multiple times.

(8) Engine Overview – Pressing the engine overview key displays the first screen of engine information. This initial information page contains various engine parameters that summarize the operation of the engine. Additional engine parameters can be viewed by pressing the down key multiple times.

Control Panel

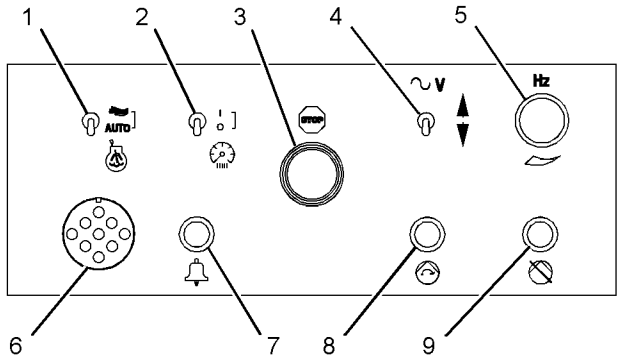

Illustration 41 g01185966

(1) Starting aid auto/manual switch (if equipped)
(2) Panel light switch
(3) Emergency stop push button
(4) Voltage-adjust switch (if equipped)
(5) Speed potentiometer (if equipped)
(6) Customer connection (if equipped)
(7) Horn (if equipped)
(8) Pump-run switch (if equipped)
(9) Pump stop switch (if equipped)

Starting Aid Auto/Manual Switch (1) – The starting aid switch is optional. The starting aid switch is used to inject ether into the engine when you are starting the engine in cold-weather conditions. When the starting aid switch is in the ON position, the switch energizes the starting aid solenoid valve. The starting aid solenoid valve meters a specific amount of ether into a holding chamber. When the starting aid switch is released, the solenoid releases the ether to the engine.

Panel Light Switch (2) – The panel lights switch turns on or the panel lights switch turns off the panel lights.

Emergency Stop Push Button (3) – The emergency stop push button (ESPB) is used to shut down the engine during an emergency situation. If equipped, the ESPB shuts off the fuel and the ESPB activates the optional air shutoff.

Voltage Adjust Switch (4) – This switch can be used to raise the voltage. The switch can also be used to lower the voltage.

Speed Potentiometer (5) – The speed potentiometer is optional. The speed potentiometer can be used with the generator set that has an electronic governor.

Customer Connection (6) – The customer connection is a 9-pin connector for connecting the Caterpillar Electronic Technician.

Horn (7) – The horn provides an audible alarm.

Pump Run Switch (if equipped)(8) – Under normal circumstances, the fuel transfer process is automatic. In some instances, a manual operation may be required. Press the pump run switch once to start the pump manually.

Pump Stop Switch (if equipped)(9) – The pump stop switch is a push-button switch that locks into position. The pump stop switch will stop the pump if the switch is locked into position. Releasing the switch will place the pump back into the run mode.

Annunciator Module

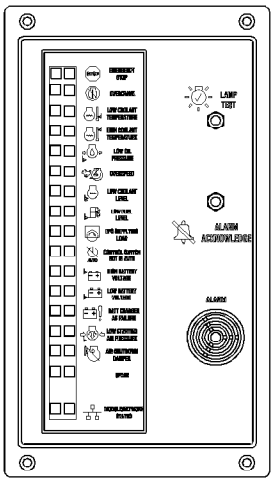

Illustration 42 g01101388

General Information

The annunciator module is used to indicate various system events and conditions. The annunciator module uses indicator lights and an audible horn to give the operator information about the status of the system. The annunciator module can be used to announce faults and/or status signals to the operator. The annunciator module allows the operator to silence the horn. The annunciator module also allows the operator to acknowledge faults to the system.

There are 17 pairs of LED indicators on the front panel of the annunciator. 16 pairs of LED indicators are used to announce events, diagnostics, and ready signals. The 17th pair of LED indicators is used as a combined network/module status LED. The 17th pair of LED indicators can tell the operator if there is a problem with the J1939 data link connection.

Basic Operation

Each pair of LED indicators on the annunciator consists of two of the following three colors: green, yellow, and red. For example, a pair of red and yellow LED indicators may be configured for engine oil pressure. If a low engine oil pressure warning is read over the data link, the annunciator will flash the yellow LED and the horn will sound. If the low engine oil pressure shutdown is read over the data link, the annunciator will flash the red LED and the horn will sound.

To acknowledge the shutdown and alarm conditions or to silence the horn, press the “Alarm Acknowledge” button that is on the annunciator.

Test the LED indicators or the horn when the data link is connected or disconnected, by pushing “Lamp Test” button on the annunciator.

Configuration

The annunciator module can be customized to signal many different conditions that are related to the system. Each pair of LEDs must be configured by using the appropriate service tool. Once the service tool has been connected to the annunciator, the user must enter the “Configuration” screen. Each pair of LEDs has four settings: SPN, Trigger Type, Trigger Severity Level, and Failure Mode Identifier (FMI).

For detailed information about the annunciator module, see Systems Operation, Troubleshooting, Testing and Adjusting, UENR1210, “EMCP4.3/4.4”.

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Gauges and Indicators

SMCS Code: 7450

Gauges provide indications of engine performance. Ensure that the gauges are in good working order. Compare the gauge readings to the data that were recorded during the engine commissioning. Determine the normal operating range by observing the gauges over a time.

Noticeable changes in gauge readings can indicate potential gauge or engine problems. Problems may also be indicated by gauge readings that change even if the readings are within specifications. Determine and correct the cause of any significant change in the readings. Consult your Cat dealer for assistance.

Your engine may not have the same gauges or all of the gauges that are described. For more information about the gauge package, refer to the literature that is provided by the OEM of the package.

NOTICE
If no oil pressure is indicated, STOP the engine. The engine will be damaged from operating without oil pressure.

Engine oil pressure – This gauge indicates the pressure of the engine oil. This pressure will be highest after a cold engine is started. The pressure will decrease as the engine warms up. The pressure will increase when the engine rpm is increased. The pressure will stabilize when the engine rpm and temperature are stable.

If the load is stabilized but the engine oil pressure fluctuates, perform the following procedure:

1. Remove the load.

2. Reduce the engine speed to low idle rpm.

3. Check the oil level. Maintain the oil level between the “ADD” and “FULL” marks on the “LOW IDLE” side of the oil level gauge (dipstick).

4. Inspect the lubrication system for leaks.

Engine Oil Temperature – This gauge indicates the engine oil temperature after the oil has passed through the oil cooler.

Engine oil performs several functions: keeping the engine clean, preventing rust and corrosion, acting as a coolant and reducing friction and wear. The oil cooler transfers heat from the oil to the engine jacket water. Oil temperature that is higher than normal indicates a problem with the lubrication system and/or the cooling system. Excessive oil temperature can adversely affect the cylinder heads, cylinder liners, pistons, and crankshaft bearings.

Jacket water coolant temperature – This gauge indicates the temperature of the engine coolant at the outlet for the jacket water. The temperature may vary according to the load. Do not allow the temperature to exceed the boiling temperature of the pressurized cooling system.

The sensor for jacket water coolant temperature must be submerged in order to detect the temperature correctly. If the engine is operating above the normal temperature range, perform the following procedure:

1. Reduce the load and/or the engine rpm.

2. Inspect the cooling system for leaks.

3. Determine if the engine must be shut down immediately or if the engine can be cooled by reducing the load and/or rpm.

System voltage – This gauge indicates the voltage of the electrical system. Normally, the system has 24 V.

Fuel pressure – This gauge indicates fuel pressure to the fuel injection pump from the fuel filter. A decrease in fuel pressure usually indicates a dirty fuel filter or a plugged fuel filter. As the fuel filter becomes plugged, there will be a noticeable reduction in the engine performance.

Exhaust temperature – This gauge indicates the exhaust temperature at the exhaust inlets to the turbochargers. The two exhaust temperatures may vary slightly. This variation may be due to variation of the sensitivity of the two thermocouples. The "LH/RH" switch on the instrument panel is used for toggling between the left side and the right side exhaust temperature.

The exhaust temperatures at the exhaust inlets to the turbochargers provide a good indication of engine performance. For engines with dry exhaust manifolds, the temperatures are representative of the actual temperatures of the valves. Monitor this parameter frequently.

If the recommendations for the engine installation, the rating, and engine maintenance are followed, most engines will operate at the normal limit or below the normal limit.

NOTICE
Severe damage to the engine can result if the exhaust temperature at the inlet to the turbocharger exceeds the extreme limit.

Table 5

Temperature Limits for the Exhaust Inlet to the Turbocharger		
Rating (1)	**Normal Limit**	**Extreme Limit**
"A"	650 °C (1202 °F)	702 °C (1295 °F)
"B"	700 °C (1292 °F)	728 °C (1342 °F)
"C"		
"D"	725 °C (1337 °F)	756 °C (1392 °F)
"E"		

(1) For the rating definitions, see this Operation and Maintenance Manual, "Engine Rating Definitions".

Pyrometer – The pyrometer displays the temperature of the exhaust for the exhaust port of each individual cylinder.

The exhaust port temperatures are a good indication of the condition of the cylinders. The displayed temperature is slightly lower than the actual temperature in the cylinder. This condition is because of the constant flow of exhaust gas past the thermocouple. For engines with dry exhaust manifolds, the exhaust port temperatures are lower than the temperatures at the inlet to the turbochargers.

Guttering of valves can be diagnosed with the exhaust port temperature. The ability to diagnose this problem may help to prevent additional damage that could cause further downtime with a higher repair cost.

During normal operation at rated load, the temperature of the hottest cylinder and the coldest cylinder may differ by 38 °C to 52 °C or 68 °F to 94 ° F.

Be alert if an exhaust port temperature varies by more than 50 °C or 90 °F from the average temperature of all the cylinders.

If a cylinder exhaust port temperature varies by more than 50 °C continue to monitor the cylinders temperature. At this point there is not a need to immediately troubleshoot the cylinder only monitor the cylinder to ensureit maintains temperature. During monitoring of the cylinder, if the temperature difference from the average increases close to 100 ° C troubleshooting on that cylinder should begin. See the troubleshooting guides for exhaust temperatures and cylinder performance."

Perform corrective measures immediately if an exhaust port temperature varies by more than 100 °C or 180 °F from the average temperature of all the cylinders.

The exhaust stack temperature is not a suitable substitute for the exhaust temperature at the inlet to the turbocharger. However, a comparison of the two temperatures can help to assess the performance of the turbocharger.

NOTICE
To help prevent engine damage, never exceed the high idle rpm. An overspeed can result in serious damage to the engine. The engine can be operated at high idle without damage, but the engine should never be allowed to exceed the high idle rpm.

Tachometer – The tachometer displays the engine rpm. The high idle rpm and the rated rpm are printed on the engine Information Plate.

Hour meter – This meter indicates the total number of hours of operation of the engine.

Inlet air restriction (air cleaner differential pressure) – This gauge indicates the difference in air pressure between the inlet side and the engine side of the air filter element. The differential pressure for the air cleaner is measured from the air inlet for the turbocharger. The “LH/RH” switch on the instrument panel is used for toggling either the left or right side. As the air filter element becomes plugged, the difference in pressure between the two sides of the air cleaner element will increase.

Fuel filter differential pressure (restriction) – This gauge indicates the difference in fuel pressure between the inlet side and the outlet side of the fuel filter. As the fuel filter element becomes plugged, the difference in pressure between the two sides of the fuel filter increases.

Oil filter differential pressure (restriction) – This gauge indicates the difference in pressure between the inlet side and the outlet side of the engine oil filters. As the oil filter elements become plugged, oil filter differential pressure will increase.

Inlet manifold air pressure (boost pressure) – This gauge indicates the air pressure (turbocharger boost pressure) in the air plenum (air inlet manifold) after the aftercooler.

Aftercooler coolant temperature – This gauge indicates the temperature of the coolant in the aftercooler system. Two methods of aftercooling are available. The separate circuit aftercooler operates at a temperature that is lower than the jacket water aftercooler. Determine the method of aftercooling in order to verify the gauge reading.

Marine transmission oil temperature – This gauge indicates the temperature of the marine transmission oil.

Marine transmission oil pressure – This gauge indicates the pressure of the marine transmission oil.

Engine Starting

i08232563

Before Starting Engine

SMCS Code: 1000; 1400; 1450

⚠ WARNING

Engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.

To obtain maximum service life for your engine, make a thorough inspection before starting the engine. Perform the required daily maintenance and other periodic maintenance before starting the engine. Perform the walk-around inspection as described in this Operation and Maintenance Manual, “Walk-Around Inspection” topic. Look for items such as oil or coolant leaks, loose bolts, and trash buildup. Remove any trash. Arrange for repairs, as needed.

NOTICE
For any type of leak (coolant, lube, or fuel) clean up the fluid. If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more often than recommended until the leak is found or fixed, or until the suspicion of a leak is proved to be unwarranted.

i08286698

Cold Weather Starting

SMCS Code: 1000; 1250; 1450; 1453; 1456; 1900

Starting fluid is required for temperatures below 0 °C (32 °F). The use of other optional cold starting aids is recommended for temperatures below −18 °C (0 °F).

Electric Starting Motor

Maintain the proper level of electrolyte in the batteries. Keep the batteries fully charged.

To maximize the battery power, heat the battery compartment or store the batteries in a warm location. Typically, batteries only have 50 percent of the capability at −10 °C (14 °F) versus 27 °C (80 °F).

Extra battery capacity may be necessary for cold temperatures.

Heaters

Note: Oil pan immersion heaters are not recommended for heating the lube oil. To ensure the compatibility of the components, only use equipment that is recommended by Caterpillar.

Startability will be improved at temperatures below 12 °C (55 °F) with a starting aid. A jacket water heater may be needed and/or the crankcase oil may need to be warmed.

Note: The fluid that is heated must be continuously circulated. This circulation will help to prevent localized overheating of the fluid.

A jacket water heater is available as an option for starting in temperatures as low as 0 °C (32 °F). The jacket water heater can maintain the water temperature at approximately 32 °C (90 °F). The heated water will help to keep the oil in the engine block warm enough to flow when the engine is started.

When No. 2 diesel fuel is used, a fuel heater will maintain the temperature of the fuel above the cloud point. Fuel line insulation will help to maintain the fuel temperature.

Consult your Cat dealer for more information on the starting aids that are available for cold weather starting.

Air Starting Motor

Note: The maximum air pressure for starting must not exceed 827 kPa (120 psi).

To start the engine at colder temperatures, the following conditions may be necessary:

- Maximum air pressure for the starting motor
- An additional volume of air

Starting With Ether

⚠ WARNING

Personal injury or property damage can result from alcohol or starting fluids.

Alcohol or starting fluids are highly flammable and toxic and if improperly stored could result in injury or property damage.

The optional ether starting aid is the only system that is recommended for the injection of starting fluid.

Perform the procedures that are described in this Operation and Maintenance Manual, “Before Starting Engine” topic (Operation Section).

1. Ensure that the driven equipment is unloaded.

NOTICE
Do not crank the engine continuously for more than 30 seconds. Allow the starting motor to cool for two minutes before cranking the engine again.

2. Crank the engine. Use of the starting aid depends on these conditions:

a. The engine control module controls the duration of automatic ether injection in these circumstances:

- The jacket water coolant temperature is between −40 to 30 °C (−40 to 86 °F).
- The engine rpm is more than 75 rpm and less than 400 rpm.

b. Manual ether injection can be performed in these circumstances:

- The momentary contact switch for the ether injection is activated.
- The jacket water coolant temperature is between −40 to 30 °C (−40 to 86 °F).
- The engine rpm is more than 75 rpm and less than 400 rpm.

NOTICE
Excessive starting fluid can cause piston and ring damage.

Use starting fluid for cold starting purposes only.

Do not use excessive starting fluid during starting or after the engine is running.

3. To inject ether manually, press the starting aid switch. Release the switch immediately.

Additional injections may be necessary to start the engine. Press the starting aid switch about every 2 seconds until the engine begins to idle smoothly.

i08331041

Starting the Engine

SMCS Code: 1000; 1450

⚠ WARNING

Engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.

Note: When electric power is cycled, the electronic thermostat will cycle, which will make a unique sound that is a normal sound for a start-up.

Note: To operate the engine at different speeds, refer to this Operation and Maintenance Manual, “Engine Operation”.

Automatic Starting

⚠ WARNING

When the engine is in the AUTOMATIC mode, the engine can start at any moment. To avoid personal injury, always remain clear of the the engine when the engine is in the AUTOMATIC mode.

To enable automatic starting, the EMCP 3 control panel must be in “AUTO” mode. To place the control panel into auto mode, press the “AUTO” key. The engine will automatically start when the remote start/stop initiate contact closes.

Manual Starting

NOTICE
For initial start-up of a new or rebuilt engine, and for start-up of an engine that has been serviced, make provision to shut the engine off should an overspeed occur. This may be accomplished by shutting off the air and/or fuel supply to the engine.

Do not start the engine or move the controls if there is a lockout tag attached. Do not start the engine or operate controls if a “DO NOT OPERATE” or similar warning tag is attached.

Ensure that no one will be endangered when the engine is started.

1. Perform all procedures that are described in this Operation and Maintenance Manual, “Before Starting Engine” (Operation Section).

NOTICE
Do not engage the starting motor when flywheel is turning. Do not start the engine under load.

If the engine fails to start within 30 seconds, release the starter switch or button and wait two minutes to allow the starting motor to cool before attempting to start the engine again.

2. To start an engine with an EMCP 3 control panel, press the “RUN” key.

For further information concerning the EMCP 3, refer to this Operation and Maintenance Manual, “Electronic Modular Control Panel 3 (EMCP 3)” topic.

Starting the Engine After an Overhaul or Major Repair

Use the following guidelines for operation and maintenance after an overhaul or a major repair. Using the guidelines will ensure that the engine is functioning correctly. The procedure for start-up requires approximately 1 hour and 45 minutes.

1. Perform the procedures that are described in this Operation and Maintenance Manual, “Before Starting Engine” topic (Operation Section).

2. Operate the jacket water heaters. Run the prelube pump and allow the lubricating oil to circulate for 1/2 hour. To operate the prelube pump without starting the engine when the starting oil pressure is reached perform the following: Access the configuration file in electronic technician (ET), change start system type 1 to “Not Installed” and change start system type 2 to “Not Installed” .

3. During prelube pump operation, use the barring device to rotate the crankshaft for a minimum of two revolutions.

4. Start the engine. Operate the engine at low idle rpm for 15 minutes. Refer to this Operation and Maintenance Manual, “Engine Operation” for the procedure on starting and running the engine at low idle. Allow the engine temperature to rise. Check for the correct temperatures and pressures. Inspect the installation for leaks.

5. Do not apply the load. Increase the engine rpm to high idle rpm for 5 minutes. Check for the correct temperatures and pressures. Inspect the installation for leaks.

6. Shut off the engine. Remove the side covers. Measure the temperature of the bearings with a 123-6700 Laser Infrared Thermometer. Ensure that the large ends of the connecting rod bearings move freely. Visually inspect the piston skirts, cylinder liners, and bearings for any abnormal signs such as flaking and/or scuffing. If the appearance of the components is satisfactory, install the side covers.

7. Start the engine. Operate the engine at low idle rpm for 5 minutes. Check for the correct temperatures and pressures. Inspect the installation for leaks.

8. The temperatures will not stabilize for some time because the engine will be operating without a load. To warm the engine up to “normal” operating temperature, increase the engine rpm to high idle rpm for 5 minutes. Check for the correct temperatures and pressures. Inspect the installation for leaks.

Note: Monitor the cooling system temperatures to ensure that the water to the engine is being properly cooled. Observe the water temperature of the aftercooler and oil cooler system. The temperature should not exceed 50 °C (122 °F).

9. Apply 25 percent of the rated load. Operate the engine with this load for 15 minutes. Check for the correct temperatures and pressures. Inspect the installation for leaks.

10. Increase the load to 50 percent of the rated load. Operate the engine with this load for 15 minutes. Check for the correct temperatures and pressures. Inspect the installation for leaks.

11. Increase the load to the full rated load. Operate the engine with this load for 15 minutes. Check for the correct temperatures and pressures. Inspect the installation for leaks.

If all temperatures and pressures are acceptable, the engine can be returned to service.

Maintenance Procedures After an Overhaul or Major Repair

After the initial start-up, perform the maintenance that is listed in Table 6 . See the maintenance procedures that are in this Operation and Maintenance Manual (Maintenance Section).

Table 6

Maintenance Procedures After an Overhaul or Major Repair	
Interval	**Maintenance Procedure**
Following the start-up procedure	Obtain an oil sample and analysis.
	Remove at least one oil filter element from each oil filter housing. Cut the element open. Inspect the filter material for debris.
100 operating hours	Obtain an oil sample and analysis.
500 operating hours	Replace all oil filter elements. Cut the used elements open. Inspect the filter material for debris.
	Perform the procedures that are described in this Operation and Maintenance Manual, “Engine Valve Lash - Check/Adjust” topic (Maintenance Section).

Starting the Engine After a System Generated Shut Down

Do not perform any procedure in this Special Instruction until you read this information and you understand this information.

This Special Instruction provides a procedure for inspecting the engine after a system-generated shutdown.

The cause of a system-generated shutdown must be corrected prior to an engine restart. Severe engine damage may occur if the problem is not corrected. Sometimes, the cause of the shutdown may be obvious and easily corrected. Sometimes, a visual inspection may not reveal the root cause of the shutdown. The engine must be started to determine the root cause.

The time that is required for the start-up procedure is approximately 1 hour and 45 minutes. Determining the root cause of a system-generated shutdown to avoid engine damage is important. This procedure is a method for an engine restart when the root cause of the system-generated shutdown cannot be determined by visual inspection alone.

Note: If the engine is shut down by the oil mist detector, refer to the engine Operation and Maintenance Manual.

The following conditions can cause a system-generated shutdown.

- High aftercooler and oil cooler water temperature (inlet)
- High jacket water coolant temperature (outlet)
- High fuel temperature (inlet)
- High inlet manifold air temperature
- High crankcase pressure
- High engine oil temperature
- Low engine oil pressure
- High engine oil filter differential pressure
- Presence of metal particles in the oil lines
- Overspeed

If the engine must be restarted, perform the following start-up procedure.

Starting Procedure

1. Inspect the condition and the level of all fluids. Correct any problem with the fluids.
2. Ensure that the engine is off-line or that the gearbox is in neutral.
3. Start and run the prelube pump, refer to “Starting the Engine After an Overhaul or Major Repair” step 2. Rotate the crankshaft with the barring device for a minimum of two revolutions.
4. Start the engine and allow the engine to idle at approximately 900 RPM. Do not run the engine at high-idle. Refer to this Operation and Maintenance Manual, “Engine Operation” for the procedure on starting and running the engine at low idle. Monitor the temperatures and pressures. Prepare to perform a manual engine shutdown if abnormal conditions exist.
5. Allow the engine to idle for 10 minutes. While the engine is at idle, walk around the engine and visually inspect the engine. Check for leaks and listen for any abnormal sounds. If any abnormal conditions exist, immediately perform an engine shutdown and correct the problem. If no problems are found, go to the next step.

6. Increase the engine to high idle for 10 minutes. Refer to this Operation and Maintenance Manual, “Engine Operation” for the procedure on starting and running the engine at high idle. Monitor the temperatures and pressures. Prepare to perform a manual engine shutdown if abnormal conditions exist. Walk around the engine and visually inspect the engine. Check for leaks and listen for any abnormal sounds. If any abnormal conditions exist, immediately perform an engine shutdown and correct the problem. If no problems are found, go to the next step.

Note: Due to the small amount of load on the engine, the temperatures will not stabilize for some time. Apply an engine load to warm up the engine to normal temperatures. Use the following procedure:

7. Apply 25 percent load to the engine and operate in this condition for 10 minutes. Monitor the temperatures and pressures. Prepare to perform a manual engine shutdown if abnormal conditions exist. Walk around the engine and visually inspect the engine. Check for leaks and listen for any abnormal sounds. If any abnormal conditions exist, immediately perform an engine shutdown and correct the problem. If no problems are found, go to the next step.

8. Apply 50 percent load to the engine and operate in this condition for 10 minutes. Monitor the temperatures and pressures. Prepare to perform a manual engine shutdown if abnormal conditions exist. Walk around the engine and visually inspect the engine. Check for leaks and listen for any abnormal sounds. If any abnormal conditions exist, immediately perform an engine shutdown and correct the problem. If no problems are found, go to the next step.

9. Apply rated load to the engine and operate in this condition for 10 minutes. Monitor the temperatures and pressures. Prepare to perform a manual engine shutdown if abnormal conditions exist. Walk around the engine and visually inspect the engine. Check for leaks and listen for any abnormal sounds. If any abnormal conditions exist, immediately perform an engine shutdown and correct the problem. If no problems are found, go to the next step.

10. Remove the load from the unit. Cool down function is automatic when the load is removed. The unit will remain at 1800 RPM for the amount of time that is programmed into the configuration file of the ECM.

11. Return the engine to low idle for 5 minutes. If all temperatures and pressures are acceptable, return the engine to service.

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Starting with Jump Start Cables

SMCS Code: 1000; 1401; 1402; 1900

⚠ WARNING

Improper jump start cable connections can cause an explosion resulting in personal injury.

Prevent sparks near the batteries. Sparks could cause vapors to explode. Do not allow jump start cable ends to contact each other or the engine.

Note: The engine is electronically controlled. The engine requires an isolated 24 volt DC power supply to operate. The power supply must be continuous. If the power supply is removed or disconnected, the engine will not operate.

NOTICE
When starting with power from an external source, only use a source that has the same voltage as the starting motor.

The use of a greater voltage or the use of a welder will damage the electrical system. A power surge could damage the engine's electronic control module.

When starting with power from an external source, only use batteries as a source of power.

Starting from an external power source is not recommended. A backup battery system is recommended.

i08232549

After Starting Engine

SMCS Code: 1000

Note: After the engine has been installed or rebuilt, carefully monitor the engine to detect any unusual performance.

Engaging the Driven Equipment

1. Ensure that the gauges are in the normal ranges for the engine rpm.

2. Make another walk-around inspection. Inspect the engine for fluid leaks and air leaks.

3. Apply the load. Begin operating the engine at low load.

The engine will reach normal operating temperature faster when the engine is operated at rated rpm and low-power demand. This procedure is more effective than idling the engine with no load. The engine should reach normal operating temperature in a few minutes.

4. After the temperature gauges begin to rise, the engine may be operated at full load.

5. Continue to check the gauges and the driven equipment.

Engine Operation

i08129123

Engine Operation

SMCS Code: 1000

Proper operation and maintenance are key factors in attaining the maximum service life and economy for the engine. Follow the instructions in this Operation and Maintenance Manual to minimize operating costs and maximize the service life of the engine.

Observe the gauges frequently while the engine is operating. Record the data from the gauges in a log regularly. Compare the data to the specifications for normal engine operation. Comparing the data over time will help to detect changes in engine performance.

Investigate any significant change in the gauge readings. Monitor the engine operation and take the appropriate action when discrepancies are found.

Operating the Generator Set

Check the gauges and the generator frequently while the engine is operating under a load. The engine can be operated for extended periods of time at full load.

Recommended Generator Set Exercise Requirements

The following recommendations provide guidance on the minimum exercise suggested for engines applied in data center electric power standby applications.

The following are risks that may result if the intervals between generator set starts are longer than recommended:

- Undetected loss of fuel prime or hard/slow to start issues
- Lack of lubrication and issues with rotating components and risk of oxidation
- Oil sump condensation
- Delayed detection of performance-related issues

The following are risks that may result if the intervals between loaded generator set operations are longer than recommended:

- Slobber and wet stacking
- Delayed detection of performance-related issues

Table 7

Engines Without Aftertreatment and Engines with Selective Catalytic Reduction (SCR) Equipped Clean Emissions Modules (CEM)		
Interval	**Load**	**Operating Time**
Month 1	No load	15 - 30 minutes
Month 2	No load	15 - 30 minutes
Month 3	Load(1)	30 minutes minimum
		60 minutes preferred

(1) Run to a minimum of a 30 percent load as stated in this Operation and Maintenance Manual, partial load section. Must operate at an exhaust temperature above the Technical Marketing Information (TMI) target for 30 percent load.

Table 8

Engines with (SCR) and Diesel Particulate Filter (DPF) Equipped Clean Emissions Modules (CEM)		
Interval	**Load**	**Time**
Month 1(1)	No load(2)	15 - 30 minutes
Month 2(1)	No load(2)	15 - 30 minutes
Month 3	Load(3)	30 minutes minimum
		60 minutes preferred

(1) Monitor back-pressure and Hydrocarbon (HC) alarms. If HC alarm is tripped, follow the HC mitigation protocol in the Operation and Maintenance Manual.
(2) If the back-pressure alarm is tripped, run engine at high load until back-pressure has returned to normal and is stable.
(3) Must operate at an exhaust temperature above the Technical Marketing Information (TMI) target for 30 percent load.

Partial Load Operation

Extended operation at low idle or at reduced load may cause increased oil consumption and carbon buildup in the cylinders. Carbon buildup results in a loss of power and/or poor performance.

When possible, apply a full load at least on an hourly basis. This load will burn excess carbon from the cylinders.

i08158988

Fuel Conservation Practices

SMCS Code: 1000; 1250

The efficiency of the engine can affect the fuel economy. Caterpillar design and technology in manufacturing provides maximum fuel efficiency in all applications. Follow the recommended procedures to attain optimum performance for the life of the engine.

- Avoid spilling fuel.

Fuel expands when the fuel is warmed up. The fuel may overflow from the fuel tank. Inspect fuel lines for leaks. Repair the fuel lines, as needed.

- Be aware of the properties of the different fuels. Use only the recommended fuels.

- Avoid unnecessary idling.

Shut off the engine rather than idle for long periods of time.

- Observe the service indicator frequently. Keep the air cleaner elements clean.

- Ensure that the turbochargers are operating correctly so that the proper air/fuel ratio is maintained. Clean exhaust indicates proper functioning.

- Maintain a good electrical system.

One defective battery cell will overwork the alternator which may cause the engine to consume excess power and excess fuel.

- Ensure that the belts are properly adjusted. The belts should be in good condition.

- Ensure that all connections of the hoses are tight. The connections should not leak.

- Ensure that the driven equipment is in good working order.

- Cold engines consume excess fuel. Utilize heat from the jacket water system and the exhaust system, when possible. Keep cooling system components clean and keep cooling system components in good repair. Never operate the engine without water temperature regulators. All of these items will help maintain operating temperatures.

- Settings for the fuel system and the limits for the operating altitude are stamped on the Engine Information Plate. If an engine is moved to a higher altitude, the settings must be changed by a Cat dealer. Changing the settings will help prevent damage to the turbocharger. Changing the settings will help to provide the maximum efficiency for the engine. Engines can be operated safely at higher altitudes, but the engines will deliver less horsepower. The fuel settings should be changed by a Cat dealer to obtain the rated horsepower.

Generator Operation

i08331029

Generator Operation

SMCS Code: 4450

Loading of the Generator

When a generator is installed or reconnected, be sure that the total current in one phase does not exceed the nameplate rating. Each phase should carry the same load, which allows the engine to work at the rated capacity. If one-phase current exceeds the nameplate amperage, an electrical unbalance can result in an electrical overload and overheating.

Allowable combinations of unbalanced loads are shown in Illustration 43 . When you operate with significant single-phase loads, the combinations of single-phase load and three-phase load may be used. Such combinations should be located below the line on the graph.

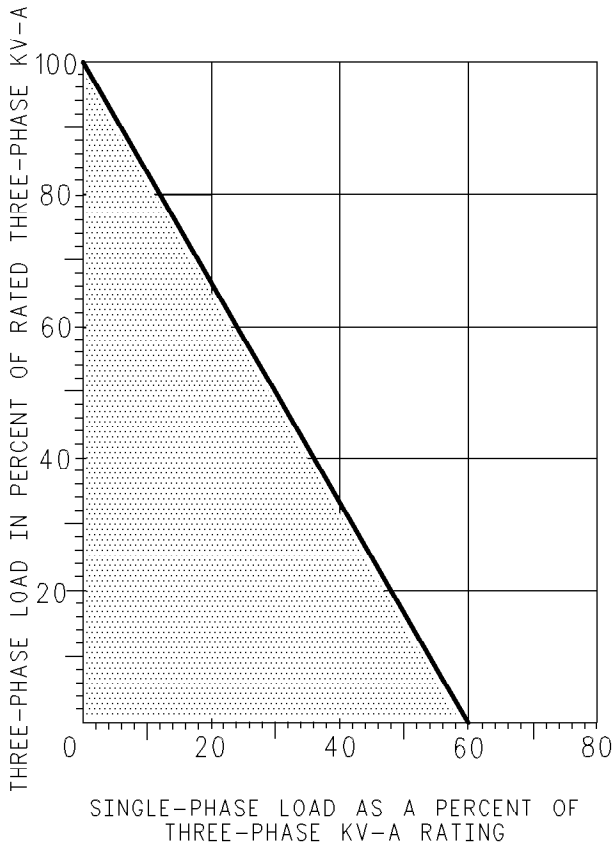

Illustration 43 g00627416

Allowable Combinations of Unbalanced Loads

Block Loading

Block loading is the instantaneous application of an electrical load to a generator set. This load may be anywhere from a moderate percentage of the rated load up to the rated load.

The block loading capability of a generator set depends on the following factors.

- Engine transient response
- Voltage regulator response
- Type of the voltage regulator
- Altitude of operation of the generator set
- Type of load
- Percent of load before the block load is applied.

If derating for the block load is required, refer to ISO 3046 Standards or SAE J1349 Standards. Also, reference Engine Data Sheet, LEKX4066, “Loading Transient Response”.

Note: ISO stands for International Standards Organization.

Power Factor

The power factor represents the efficiency of the load. Power factor is the ratio of apparent power to total power. The power factor is expressed as a decimal. The power factor represents that portion of the current which is doing useful work. The portion of current which is not doing useful work is absorbed in maintaining the magnetic field in motors or other devices.

In most applications, electric motors and transformers determine the power factor of the system. Induction motors usually have a 0.8 or smaller power factor. Incandescent lighting is a resistive load of about 1.0 power factor, or unity.

The power factor of a system may be determined by a power factor meter or by calculations. Determine the power requirement in kW by multiplying the power factor by the kVA that is supplied to the system. As the power factor increases, the total current, supplied to a constant power demand will decrease. For example, a 100 kW load at a 0.8 power factor will draw more current than a 100 kW load at 0.9 power factor. High-power factor will result in full engine load at less than the rated amperage of the generator. A lower power factor increases the possibility of overloading the generator.

Note: Cat generators are designed for a 0.8 power factor unless the generator is specified otherwise.

Excitation System

Permanent Magnet Pilot Excited Generators

Permanent Magnet Pilot Excited (PMPE) generators receive power for the voltage regulator from a pilot exciter, rather than the main armature. The pilot exciter consists of a permanent magnet rotor and a permanent magnet stator. The pilot exciter operates independently from the generator output voltage. Constant excitation during a large load application is possible because the irregularities that occur in generator output voltage are not fed back into the exciter. Such irregularities can be caused by load conditions. The independent operation also allows the generator to sustain an overload for a short duration. The pilot exciter also ensures that the generator will start properly even if the rotating field becomes demagnetized.

Low Idle Adjustment

⚠ WARNING

Do not operate the engine at speeds that are between 1250 RPM and 1450 RPM for 50 Hz applications. Engine speed between 1250 RPM and 1450 RPM for 50 Hz applications will result in radiator fan blades to rotate at a resonant speed, which can result in fan blade damage.

Do not operate the engine speeds that are between 1250 RPM and 1750 RPM for 60 Hz applications. Engine speed between 1250 RPM and 1750 RPM for 60 Hz applications will result in radiator fan blades to rotate at a resonant speed, which can result in fan blade damage.

The engine low idle speed should not be set higher than 1250 RPM and the engine high idle speed should be set no lower than rated speed.

NOTICE
To prevent fan blade problems on units that have a frame-mounted radiator, do not operate the unit under the following conditions: between 1250 and 1450 RPM for 50 Hz applications and between 1250 and 1750 RPM for 60 Hz applications.

Generator sets normally have a higher low idle setting than industrial engines. Low idle will be approximately 66% of the full load speed of 60 Hz units. Low idle will be approximately 80% of the full load speed of 50 Hz units.

There is no low idle stop on generator sets with electronic governors. On generator sets with mechanical governors and generator sets that are powered by natural gas, the low idle is set at the factory. Low idle adjustment is only to be adjusted by your Cat dealer if adjustment is required.

Note: Operating the generator set at low idle speed for an extended time will cause some voltage regulators to shut off. The generator set must be completely shut down. Then, the generator set must be restarted, which will allow the voltage regulator to produce an output.

Standby Generator Sets

Most standby units are installed with controls that will start the unit automatically. The standby units start and the unit will adjust to the load without an operator. The standby unit will also stop without an operator in attendance.

Standby units cannot automatically change the governor control. Standby units cannot automatically change the voltage settings. The governor speed and voltage level must be preset for the proper operation of the standby unit. Whenever the set is operated manually, be sure that the governor speed and voltage levels are correct for automatic operation. Check all switches for the proper setting. The start select switch should be in the AUTOMATIC position. Emergency Stop Switches should be in RUN position.

Generator Options

Space Heaters

Most of the generators are provided with space heaters. These space heaters are installed for operation in high humidity conditions. For more information on space heaters, refer to Maintenance Section, “Space Heater - Check”.

Embedded Temperature Detectors

The generators are available with embedded temperature detectors. The detectors are installed in the slots of the main armature. The main armature is also called a stator. The detectors are used with the equipment that is provided by the customer. Thus, the temperature of the main armature winding can be measured or monitored. Three types of temperature detectors are available. Contact your Cat dealer for more information.

Bearing Temperature Detectors

Bearing temperature detectors are available as an option on the generators. Bearing temperature detectors measure main bearing temperature. Bearing temperature detectors are used with the equipment that is provided by the customer. Thus, the temperature of the bearing can be measured or monitored. Bearing temperature measurements may help to prevent premature bearing failure. Two types of temperature detectors are available. Contact your Cat dealer for more information.

Oilfield Generators

Oilfield generators are available for some generator sets. Oilfield generators are used with SCR controlled electric oil rigs. Oilfield generators are not provided with a voltage regulator. The function of the generator control is performed by the drilling electrical control system. Consult the manufacturer of the oil rig for any questions that pertain to generator control such as voltage regulation, paralleling, or the load sharing.

i08230330

Single Unit Operation

SMCS Code: 4450

Initial Start-Up

Measure the insulation resistance of each winding if the generator was exposed to the following conditions:

- Rapid changes in temperature
- Freezing
- Wet climate during shipment
- Wet climate during storage

Refer to this Operation and Maintenance Manual, “Insulation - Test”.

Note: These tests should be conducted prior to any power connections or control connections that are being made.

Starting

1. Make all preliminary engine starting checks.
2. Be sure that the main circuit breaker or the line circuit breaker is open.
3. Start the engine. Allow the engine to warm up.
4. Adjust to the full load engine speed.
5. Close the main circuit breaker.

6. Apply the load. Do not try to apply the full load. Apply the load in increments to maintain system frequency at a constant level.

7. Readjust the governor for rated frequency.

Adjust the Voltage

Adjust the voltage regulator to obtain the proper voltage. **Refer to Operation and Maintenance Manual, "Voltage Regulators" for more information about the voltage regulator.**

1. Turn the remote adjustment potentiometer to the center position, if equipped.

2. Connect an analog voltmeter that is calibrated for 100 VDC on terminal E+ and terminal E-.

3. Connect a voltmeter that is calibrated for 300 VAC to 500 VAC or 1000 VAC to the output terminals of the generator.

4. Make sure that the ST3 wire is positioned on the desired frequency. Also, the engine speed must be changed from the factory setting to change the frequency of the generator.

5. Turn voltage potentiometer (P2) to a full counterclockwise position.

6. Turn frequency potentiometer (P4) to a full clockwise position.

7. Turn stability potentiometer (P3) counterclockwise to about 1/3 of the total rotation for the potentiometer.

8. Start the engine and set the engine speed to a frequency of 48 Hz for 50 Hz or 58 Hz for 60 Hz.

9. Adjust the output voltage to the correct value with potentiometer P2. This voltage should be the rated voltage UN for single operation or UN plus 2% to 4% for parallel operation with a current transformer. Use potentiometer P3 to make adjustments if the voltage oscillates. Adjust potentiometer P3 in both directions while you observe the voltage between E+ and E-. The voltage between E+ and E- should be approximately 10 VDC. The best response times are obtained at the limit of the instability. Try cutting or replacing the wire ST2 if no stable position can be obtained.

10. Check the LAM operation. ST5 must be closed.

11. Turn potentiometer (P4) slowly counterclockwise until there is a significant voltage drop. The voltage drop should be approximately 15 %.

12. Vary the frequency around 48 Hz or 58 Hz according to the operating frequency. Check the change in the voltage that was previously observed.

Stopping

1. Remove the load in increments.

2. Open the circuit breaker.

3. Allow the engine to run for 5 minutes to cool.

4. Stop the engine.

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Parallel Operation

SMCS Code: 4450

Initial Start-Up

Preparing a generator for parallel operation requires special attention. Before you attempt to parallel units for the first time, check all the units for the following three conditions.

- Same phase rotation
- Same alternating current frequency
- Same voltage adjustment

1. Check the phase rotation.

Units that operate in parallel must have the same phase rotation. There are two methods that may be used to determine if the incoming unit and the unit that is on-line have the same phase rotation. These methods are listed below:

- Using a phase rotation meter
- Using a set of three light bulbs

Use the procedure below to determine the proper phase rotation by using three light bulbs.

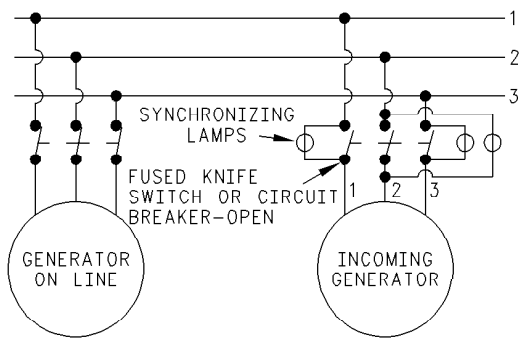

Illustration 44 g00695380

⚠ WARNING

When servicing or repairing electric power generation equipment:

Make sure the unit is off-line (disconnected from utility and/or other generators power service), and either locked out or tagged DO NOT OPERATE. Remove all fuses.

a. Connect the light bulbs with rated voltage between the generator leads and the corresponding line phase. For example, connect terminal 1 to line 1 across the open circuit breaker.

b. Start the units that will be in operating in parallel. Bring the units up to speed. As the units approach the same speed, the lights will start to blink.

- If the lights blink in sequence, one of the units is connected backward. To correct the problem, stop the units. Remove generator leads 1 and 3 at the circuit breaker. Exchange generator leads. This exchange reverses the direction of phase rotation. Connect terminal 2 to line 2.
- Both generators have the same phase rotation when the lights blink in unison. The first condition of “Initial Start-Up” has been met.

2. Adjust the frequency.

The units that will be operating in parallel must operate at the same speed. Speed is proportional to the alternating current frequency.

a. Allow each electric set to run under load for about 30 minutes.

b. Adjust the governor control to give the rated frequency at full load.

c. Remove the load and check the high idle speed. The high idle speed should be approximately 2 to 5 percent above full load speed for governors that are equipped with droop. If these speeds cannot be obtained, contact your Caterpillar dealer.

d. For the most consistent results, repeat 2b and 2c until the second condition of “Initial Start-Up” has been met.

3. Adjust the voltage. The potentiometers should be at the initial settings. **Refer to Operation and Maintenance Manual, “Voltage Regulators”.**

Note: Make sure that the speed droop is identical for all engines before adjustments are made to the generator.

a. Preset the unit for parallel operation by connecting the current transformer to S1 and S2 of the connector J2. Set potentiometer P1 for quadrature droop in the center position. Apply the rated load. The voltage should drop for 2% to 3%. Switch the positions of the two incoming secondary wires of the current transformer if the voltage increases.

b. The no-load voltages should be identical for all the generators that are operating in parallel. Connect the generators in parallel. Try to obtain a 0 kW power exchange by adjusting the speed of the generator. Try to minimize the circulating currents between generators by altering the voltage setting with potentiometer P2 or Rheostat on one of the generators.

Note: Do not change the voltage settings after this step.

c. Apply the available load. The setting is correct only if a reactive load is available. Equalize the Kilowatts or divide the rated power of the units proportionally by altering the speed. Alter the

quadrature droop potentiometer (P1) to equalize the currents or divide the currents.

Starting Multiple Units

Use the procedure for starting single units to start multiple units. Refer to Operation Section, “Single Unit Operation”.

Paralleling Multiple Units

Units may be paralleled at no load. Units may also be paralleled with units under load. After the initial conditions for start-up are satisfied, verify for the following requirements:

- One of the governors can be an isochronous governor. Electronic load sharing governors are an exception.
- Generators must have voltage droop compensation or cross-current compensation.

1. Start the unit which will be paralleled.

2. Turn on the synchronizer lights.

3. After the engine has run a few minutes, bring the engine up to synchronous speed. This speed means that the frequency of the incoming unit will be the same frequency as the unit that is on-line. The synchronizing lights will begin to blink.

Note: The frequency of the incoming unit should be slightly greater than the line frequency. This situation will allow the incoming unit to assume some of the load instead of adding to the system load.

4. By using the governor control, adjust the engine speed until the lights blink slowly.

5. The lights are off when the voltages of the two units are in-phase. At this point, quickly close the breaker while the lights are out.

6. Use governor controls to share kW load between engines.

7. Generator temperature will be stabilized in approximately 1 hour. After the generator temperature has been stabilized, adjust the voltage droop rheostat of each generator. This adjustment will share the reactive load and will limit the circulating currents. Less droop increases the reactive current that is carried by the generator. Adjusting the voltage droop rheostat in a counterclockwise direction will decrease the droop. Adjusting the voltage droop rheostat in a clockwise direction will increase droop.

Load Division and Speed Droop (If Equipped)

Once two units have been paralleled, the unit share of the kW load is determined by the governor control setting. If two units of the same capacity and the same governor characteristics have the same governor control settings, the units will share the load equally. The total load must not exceed the capacity of the one engine.

To transfer the load from one engine to another engine, use the following procedure:

1. Increase the governor speed control of one unit to increase the load.

2. Reduce the governor speed control of the other unit to decrease the load on that unit.

3. Raise the governor speed control or lower the governor speed control of both units to change system frequency.

Parallel Operation Of Governors

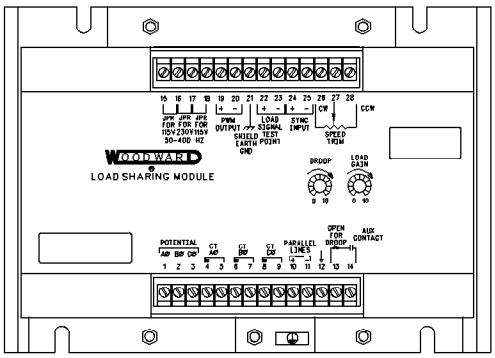

Illustration 45 g00630841

Load Sharing Module (Typical Example)

The generator set load sharing module provides either the droop load sharing or the isochronous load sharing for parallel applications. The load sharing module has a synchronizing parallel module SPM-A input. The module provides the proportional load sharing. More information is available in the System Operation, Testing and Adjusting, SENR6565, “Generator Set Load Sensor and Generator Load Sharing Module”.

Function of The Engine Governor

This section describes the function of the engine governor in relation to load division between parallel electric sets.

Understanding two basic facts about load division between generator sets which are operating in parallel is important.

1. The power which is supplied to the generator and to the load is a function of the engine. The setting of the engine governor and the position of the engine governor control determine the amount of power that is delivered by the engine. Therefore, the governor setting and the position of the governor control determine the kW load which is carried by the generator. A change in the engine power of units in a parallel will result in the same change in engine power for other units. The units that are operating in parallel will stay in parallel.

2. The division of power is not determined by generator excitation or terminal voltage. The excitation will determine the power factor for a generator when the generator is operating in parallel with other generators.

Governors that are used with Caterpillar powered electric sets can be of two types:

- Governors with fixed speed droop
- Governors with adjustable speed droop

The values of speed droop which are commonly used are 5 percent. Governors with adjustable speed droop can be adjusted so the characteristics match closely with the characteristics of governors with fixed speed droop. If the governor is adjusted for 0 percent speed droop or isochronous operation, then the same speed from no load to full load can be obtained.

Summary on Governor Operation

The preceding discussion of governor operation can be summarized below:

- Each governor should have a 5 percent speed droop to provide the simplest combination of governors for electric sets that are connected in parallel. If a constant frequency from no load to full load is required, one governor can be adjusted for isochronous operation. This isochronous unit will be called a “lead unit” .
- For all paralleled units to accept the full share of the load, the following governor adjustments are required. The governors should have the same full load speed. The governors should have the same high idle speed in the case of governors which are adjusted for speed droop operation. Governor controls should be set to the high idle position so that the full range of the governor is available.
- Operating an isochronous governor in parallel with a speed droop governor requires special techniques.
- Any number of electric sets can be operated in parallel. However, only one governor of the group can be adjusted for isochronous operation. The exception will be some special cases of electronic governors with automatic load sharing.

Stopping

To remove a generator from the line, perform the following procedure.

1. Check the load. The load must be less than the rated capacity of the remaining units.

2. Be sure that the neutral of one of the remaining units is grounded.

3. Remove the load from the outgoing unit. See the Parallel Operation, “Load Division - Speed Droop”. The amperage may never go to zero due to circulating currents.

4. Open the circuit breaker.

5. Allow the engine to cool for 5 minutes.

6. Stop the engine.

Circulating Currents

Understanding the circulating currents becomes important when you parallel the units. These circulating currents are flowing between generators in parallel operation. The circulating currents are caused by voltage differences between the generators. The circulating currents are not doing useful work. The amount of the circulating current can be determined by subtracting the amperage which is going to the load from the total generator amperage.

The circulating current may be as high as 25 percent of rated amperes with cold generator sets. Such current may not even be considered harmful. The total generator current should not exceed the amperage rating.

As the generators warm, the circulating currents will decrease. The ammeter readings should decrease slightly, but the voltage meter readings should remain constant.

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Voltage Regulators

SMCS Code: 4467

Cat Digital Voltage Regulator (Cat DVR)

DANGER

The Cat Digital Voltage Regulator presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

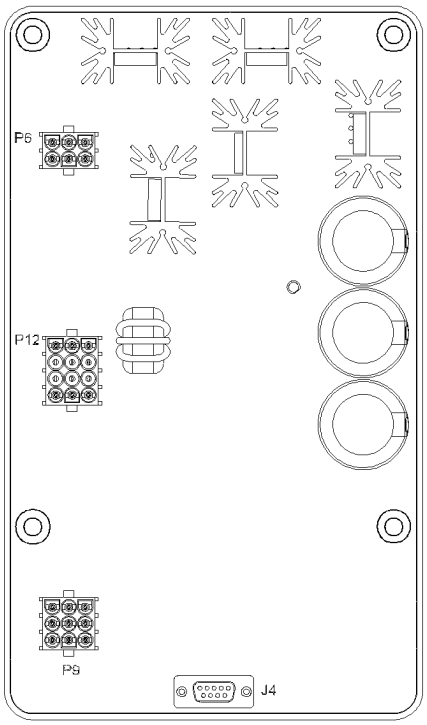

Illustration 46 g03844029

The Cat DVR is a microprocessor-based voltage regulator. Control power for the Cat DVR is supplied from an external source of 24 VDC. The power stage of the Cat DVR is supplied from a multiple pole high frequency permanent magnet generator. The multiple pole high frequency permanent magnet generator is mounted on the end of the generator shaft. Connections to the Cat DVR are made through three connectors. The communication between the Cat DVR and the service tool is accomplished by using a CANBUS protocol.

The Cat DVR has the following features:

- Three control modes:

1. Automatic voltage regulation (AVR)

2. Power factor (PF) regulation

3. Reactive power (VAR) regulation

- Programmable stability settings
- Soft start control with an adjustable time setting in AVR mode
- Dual slope voltage versus frequency (V/Hz) characteristic
- Three-phase or single-phase voltage sensing
- Single-phase current sensing

- Field current sensing and field voltage sensing
- Ten protection functions

Adjusting the Cat DVR

In order to view and configure the parameters of the Cat DVR, a PC with the Cat DVR software is required.

Refer to Specifications, Systems Operation, Testing and Adjusting, RENR7941, “Cat Digital Voltage Regulator” for complete information.

Integrated Voltage Regulator (IVR)

The Integrated Voltage Regulator (IVR) provides excitation current to the generator. The IVR is controlled by the IVR function in the EMCP4. The IVR function allows the EMCP4 to control the generator voltage, optimize transient performance, and provide feature specification.

The excitation module may interface with any of the following excitation systems: Self Excitation (SE), Internal Excitation (IE) and Permanent Magnet (PMG) excitation systems.

For additional information about the IVR, see Application and Installation, LEBE0006, and Special Instruction, REHS9106.

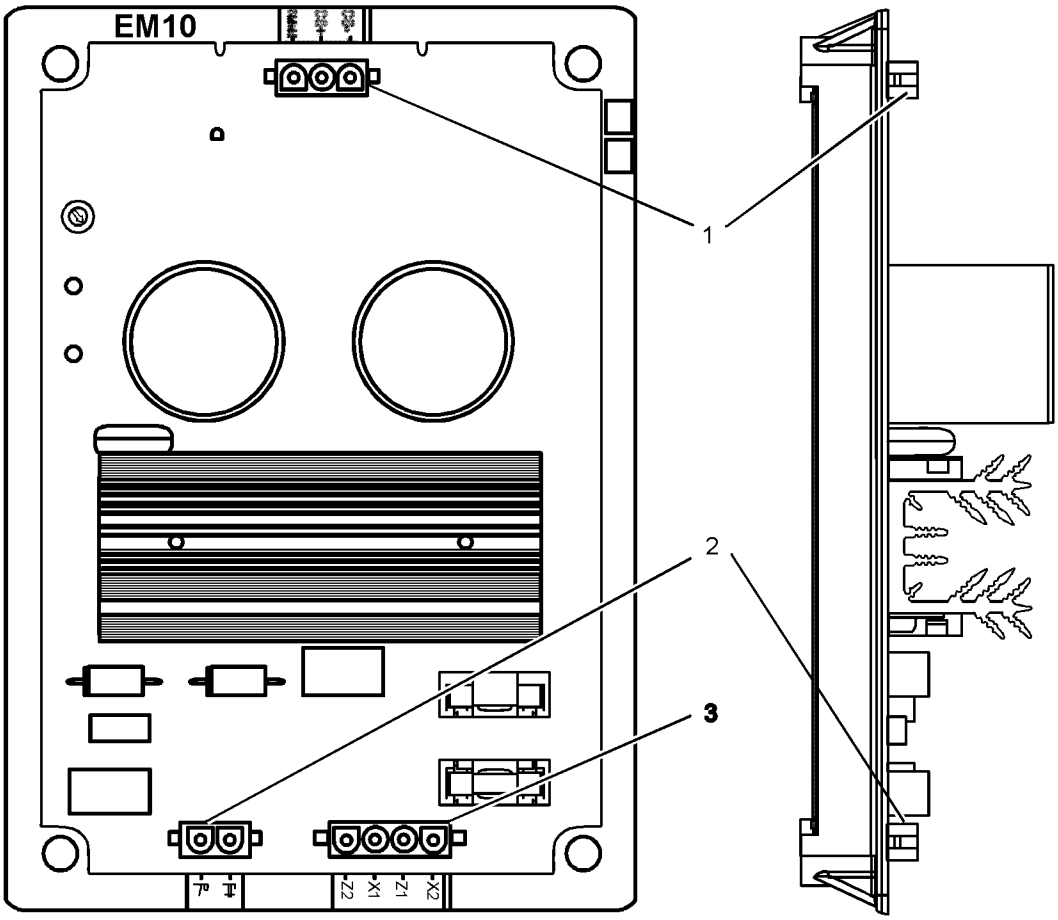

Illustration 47 g03844853

Excitation Module 10 (EM10)

(1) Connector P3 (2) Connector P2 (3) Connector P4

EMCP IVR Connection

To regulate the generator terminal voltage, the EMCP communicates the desired excitation command to the excitation module through a pulse width modulation (PWM) signal. A twisted pair of shielded cable must be used for the communication link. Table 9 details the connections to be made between the EMCP and Excitation Module.

Table 9

EMCP 4.1 and EMCP 4.2 Connections to Excitation Module (70-pin connector)			
EMCP 4.1 and EMCP 4.2 70-Pin Connector		Excitation Module 3-Pin Connector	
Digital Output #2 / IVR CS+	68	CS+	P3-2
Battery negative splice	60 or 65	CS-	P3-3
Battery negative splice	60 or 65	Shield	P3-1
EMCP 4.3 and EMCP 4.4 Connections to Excitation Module (120-pin connector)			
EMCP 4.3 and EMCP 4.4 120-Pin Connector		Excitation Module 3-Pin Connector	
PWM Output #2 Positive	28	CS+	P3-2
PWM Output #2 Negative	8	CS-	P3-3
Shield	19	Shield	P3-1

(continued)

Table 10 provides information on the technical specification of the EM10 and EM15 modules. Selection of the appropriate module must be determined by the following:

- Nominal and maximum generator excitation current at full load (standby 0.8 PF).
- The maximum AC voltage input.

Table 10

EM10 and EM15 Technical Specifications		
	EM10	**EM15**
Compatible Generator Excitation Types	Permanent Magnet (PM) Self-Excitation (SE) Internal Excitation (IE/AREP)(1)	
Nominal Field Current Output	6A	7A
Maximum (forcing) Field Current Output	10A	15A
Maximum AC Voltage Input	180Vms	240Vms

(1) Internal Excitation (IE is also referred to as “Auxiliary Regulation Excitation Principle”(AREP)

IVR Excitation Module Connections

The EM10 and EM15 excitation modules have three plug type multiple-pin connectors. The connectors are labeled P2, P3, and P4 as shown in illustration 47 . Table 11 describes the signal and function of each connector pin.

Table 11

Excitation Module Connections		
Terminal	**Label**	**Signal/Function**
P2-1	F+	Exciter Field Positive
P2-2	F-	Exciter Field Negative
P3-1	Shield	Excitation Command Control Signal Shield
P3-2	CS+	Excitation Command Control Signal Positive
P3-3	CS-	Excitation Command Control Signal Negative
P4-1	X2	Excitation Power Supply Input X2
P4-2	Z1	Excitation Power Supply Input Z1
P4-3	X1	Excitation Power Supply Input X1
P4-4	Z2	Excitation Power Supply Input Z2

Note: The X2 and Z1 connections are internally linked within the excitation module. The link provides a point of common connection for the auxiliary windings where an AREP or IE excitation supply is available. Also, the X2 and Z1 connections may be linked externally to the excitation module. Only three connections (X1, X2, and Z2) are needed for the EM. Refer to Systems Operation/Test and Adjust/ Troubleshooting, UENR1209, “Integrated Voltage Regulator Connections” for excitation module wiring connections. The wiring diagrams are for self-excitation (shunt), auxiliary windings (AREP/IE), and permanent magnet (PM) configurations.

The voltage regulator knee frequency must be configured for your specific package requirements. The knee frequency for 50 Hz operation will usually be between 48.0 and 49.8 Hz. For 60 Hz operation, the parameter must be set between 58.0 to 59.8 Hz.

Refer to Illustration 46 for an example under-frequency roll-off (loading) profile.

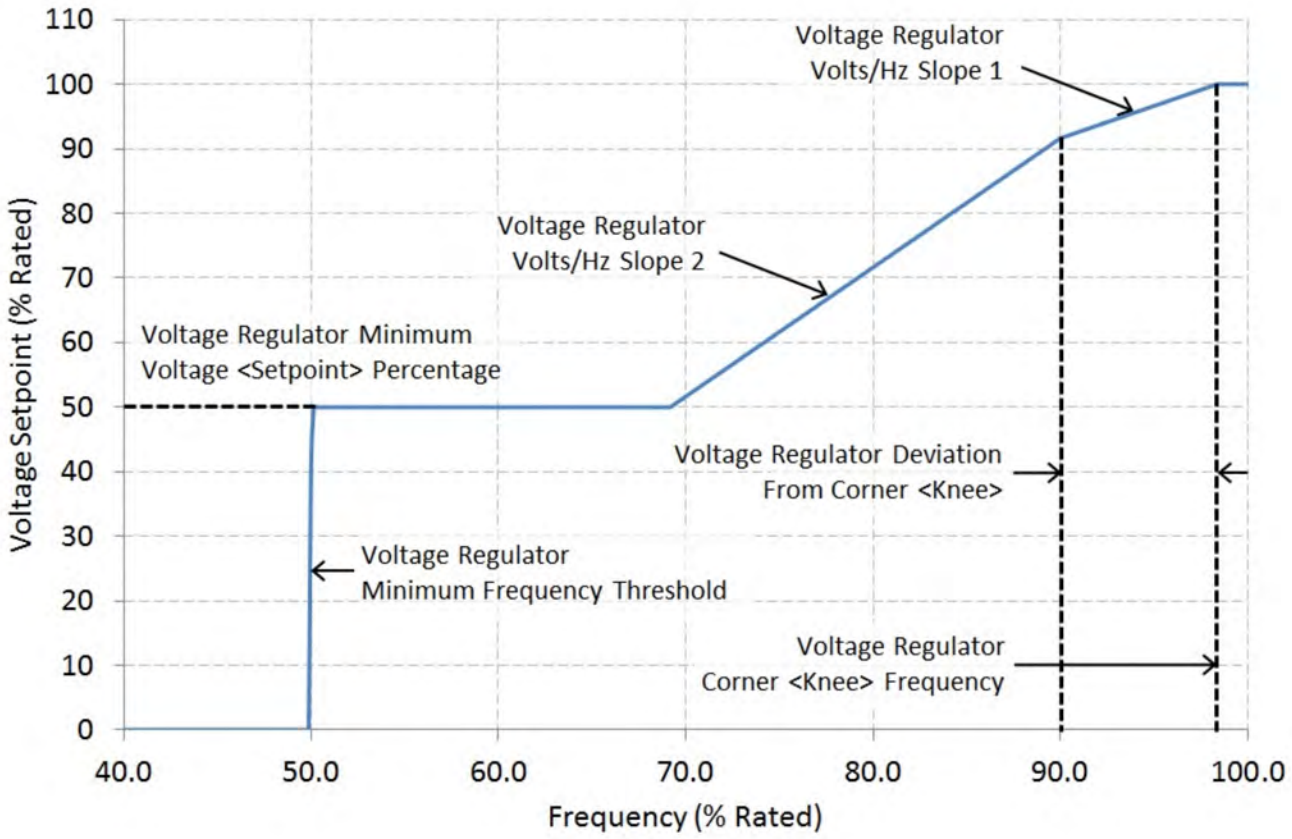

Illustration 48 g03487998

Under-frequency (loading) profile slope1 = 1.0 V/Hz, slope2 = 2.0 V/Hz

Cold Weather Operation

i08230315

Fuel and the Effect from Cold Weather

SMCS Code: 1000; 1250; 1280

The following fuels are the grades that are available for Cat engines:

- No. 1
- No. 2
- Blend of No. 1 and No. 2

No. 2 diesel fuel is the most commonly used fuel. Either No. 1 diesel fuel or a blend of No. 1 and No. 2 is best suited for cold-weather operation.

Quantities of No. 1 diesel fuel are limited. No. 1 diesel fuels are available during the months of the winter in the colder climates. During cold-weather operation, if No. 1 diesel fuel is not available, use No. 2 diesel fuel, if necessary.

There are three major differences between No. 1 and No. 2 diesel fuel. No. 1 diesel fuel has the following properties:

- Lower cloud point
- Lower pour point
- Lower rating of kJ (BTU) per unit volume of fuel

When No. 1 diesel fuel is used, a decrease in power and in fuel efficiency may be noticed.

The cloud point is the temperature when a cloud of wax crystals begins to form in the fuel. These crystals can cause the fuel filters to plug. The pour point is the temperature when diesel fuel will thicken. The diesel fuel becomes more resistant to flow through fuel pumps and through fuel lines.

Be aware of these values when diesel fuel is purchased. Anticipate the average ambient temperature of the area. Engines that are fueled in one climate may not operate well if the engines are moved to another climate. Problems can result due to changes in temperature.

Before troubleshooting for low power or for poor performance in the winter, check the type of fuel that is being used.

When No. 2 diesel fuel is used, the following components provide a means of minimizing problems in cold weather:

- Starting aids
- Engine oil pan heaters
- Engine coolant heaters
- Fuel heaters
- Fuel line insulation

For more information on cold-weather operation, see Special Publication, SEBU5898, “Cold-Weather Recommendations”.

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Fuel Related Components in Cold Weather

SMCS Code: 1000; 1250; 1280

Fuel Tanks

Condensation can form in partially filled fuel tanks. Top off the fuel tanks after operating the engine.

Fuel tanks should have a provision for draining water and sediment from the bottom of the tanks. Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe. Drain the water and sediment to help prevent freezing.

Fuel Heaters

Fuel heaters help prevent plugging of the fuel filters due to waxing in cold weather. Fuel heaters must be installed to heat the fuel before the fuel enters the primary fuel filters.

Use a fuel heater that is mechanically simple but adequate for the application. The fuel heater should also prevent the fuel from overheating. High fuel temperatures reduce the performance of the engine. Choose a fuel heater with a surface for heating that is as large as possible but also practical. Small heaters can be too hot because of a limited surface area.

For warm weather, disconnect the fuel heater or deactivate the fuel heater. Heat exchanger type fuel heaters should have a bypass provision to prevent the fuel from overheating in warm weather.

Only use thermostatically controlled fuel heaters or self-regulated fuel heaters with this engine. A fuel heater that is not thermostatically controlled can heat the fuel above 65 °C (149 °F). A loss of engine power can occur if the fuel supply temperature exceeds 29 °C (85 °F).

For further information on fuel heaters, consult your Cat dealer.

Engine Stopping

i08286696

Emergency Stopping

SMCS Code: 1000; 7418

NOTICE
Emergency shutoff controls are for EMERGENCY use ONLY. DO NOT use emergency shutoff devices or controls for normal stopping procedure.

Ensure that any components for the external system that aid the engine operation are secured after the engine is stopped.

Emergency Stop Button

Use of the emergency stop will disable the fuel injection. If equipped, the air shutoffs will also be activated. For operation of the emergency stop button, see the instructions that are provided by the OEM of the equipment.

NOTICE
Do not start the engine until the problem necessitating the emergency stop has been located and corrected.

Resetting the emergency stop button before the engine can be restarted may be necessary. Resetting the air shutoffs (if equipped) before the engine can be restarted may be necessary.

The power for the ECM must be cycled before the engine can be restarted.

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Manual Stop Procedure

SMCS Code: 1000; 7418

There may be several ways to stop the engine. Ensure that the stopping procedure is understood. Use the following general guidelines for stopping the engine.

1. Disengage the driven equipment. Unload the compressor, the pump, or the generator.

2. Press “Stop” on the “EMCP” . The unit will go into the cooldown period for the programmed amount of time. The unit will automatically shut down.

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After Stopping Engine

SMCS Code: 1000

- Check the engine crankcase oil level. Maintain the oil level between the “ADD” and “FULL” marks on the “ENGINE STOPPED” side of the oil level gauge.
- If necessary, perform minor adjustments. Repair any leaks and tighten loose bolts.
- Note the service hour meter reading. Perform the maintenance that is scheduled in this Operation and Maintenance Manual, “Maintenance Interval Schedule” (Maintenance Section).

NOTICE
Follow the guidelines for antifreeze/coolant mixtures that are recommended in this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic. Failure to do so can cause engine damage.

- Allow the engine to cool. Check the coolant level.
- Loosen the cooling system filler cap slowly to relieve any pressure. Remove the cooling system filler cap.
- If freezing temperatures are expected, check the coolant for protection against freezing. The cooling system must be protected against freezing to the lowest expected outside temperature. Add the proper coolant/water mixture, if necessary.
- Perform all required periodic maintenance on all driven equipment. Refer to the instructions that are provided by the OEM of the driven equipment.

Maintenance Section

Refill Capacities

i08335517

Refill Capacities

SMCS Code: 1000; 1348; 1395; 7560

Lubricant Capacities

The capacity of the engine lubrication system includes the capacity of the oil filters that are installed at the factory. Auxiliary oil filter systems (if equipped) will require additional oil. Refer to the specifications that are provided by the OEM of the auxiliary oil filter system.

Table 12

C175-16 Refill Capacities	
With oil filter change	530 L (140 US gal)
Without oil filter change	499.6 L (132 US gal)
Factory fill	598 L (158 US gal)
Volume between “ADD” and “Full” marks on the engine oil level gauge (dipstick).	94.6 L (25 US gal)

Table 13

C175-20 Refill Capacities	
With oil filter change	681 L (180 US gal)
Without oil filter change	662.4 L (175 US gal)
Factory fill	757 L (200 US gal)
Volume between “ADD” and “FULL” marks on the engine oil level gauge (dipstick).	94.6 L (25 US gal)

Fuel Injection Pump (Wet Sump Pump)

Table 14

Fuel Injection Pump	900 mL (30.6 oz)

Coolant Capacities

To maintain the cooling system, the total cooling system capacity must be determined. The total cooling system capacity will vary between individual installations. The total cooling system capacity can include the following components: engine, radiator, and radiator lines.

Refer to the specifications that are provided by Caterpillar or the OEM of the installation. Record the total cooling system capacity in the appropriate Table.

Table 15

C175-16 Refill Capacities	
Radiator	**Capacity**
64 SF Vertical	1025 L (271 US gal)
84 SF Vertical	1138 L (301 US gal)
Horizontal Remote	1167 L (308 US gal)(1)

(1) This capacity includes the engine and the radiator only. Actual capacity will vary by installation.

Table 16

C175-20 Generator Set with 94 SF Vertical Radiator		
Component	**Cooling System**	**Capacity**
Engine	Jacket Water	380 L (100.4 US gal)
	SCAC	75 L (20 US gal)
Radiator	Jacket Water	443 L (117 US gal)
	SCAC	300 L (79 US gal)
Lines	Jacket Water	37 L (10 US gal)
	SCAC	39 L (10.3 US gal)
Total	Jacket Water	860 L (227 US gal)
	SCAC	414 L (109.3 US gal)

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Fluid Recommendations

SMCS Code: 1280; 1348; 1395; 7560

Diesel Engine Oil

For more information, refer to Special Publication, SEBU6251, “Cat Commercial Engine Fluids Recommendations”.

Cat Diesel Engine Oil (Cat DEO)

Cat oils have been developed and tested to provide the full performance and service life that has been designed and built into Cat engines. Cat oils are currently used to fill Cat Diesel Engines at the factory. These oils are offered by Cat dealers for continued use when the engine oil is changed. Consult your Cat dealer for more information on these oils.

Due to significant variations in the quality and in the performance of commercially available oils, Caterpillar recommends the following:

Table 17

Cat Lubricants		Viscosity Grade
Diesel Engine Oil-Ultra Low Sulfur	Cat DEO-ULS	SAE 15W-40
		SAE 10W-30
	Cat DEO-ULS SYN	SAE 5W-40
	Cat Cold-Weather DEO-ULS	SAE 0W-40
Diesel Engine Oil	Cat DEO	SAE 15W-40
		SAE 10W-30
	Cat DEO SYN	SAE 5W-40

Note: Cat DEO and Cat DEO-ULS multigrade oils are the preferred oils for use in this Cat Diesel Engine.

Commercial Oil

Note: Commercial oils that are not Cat oils are second choice oils for your engine.

NOTICE
Caterpillar does not warrant the quality or performance of fluids that are not Cat fluids.

The three current Cat ECF specifications are: Cat ECF-1-a, Cat ECF-2, and Cat ECF-3. Each higher Cat ECF specification provides increased performance over lower Cat ECF specifications.

A commercial oil must meet the following standards to be considered an equivalent of a Cat Diesel Engine Oil:

Table 18

Cat Engine Crankcase Fluids (ECF) Definitions	
Cat Performance Requirement	Cat ECF Specifications Requirements
Cat ECF-3	API CJ-4 Oil Category performance requirements
Cat ECF-2	API CI-4 / CI-4 PLUS Oil Category performance requirements
	Passing standard Cat C13 engine test per API requirements
	Oils of sulfated ash > 1.50 percent are not allowed
Cat ECF-1-a	API CH-4 Oil Category performance requirements
	For oils that are between 1.30 percent and 1.50 percent sulfated ash, passing one extra Cat 1P SCOTE test (“ASTM D6681”) is required
	Oils of sulfated ash > 1.50 percent are not allowed

In selecting oil for any engine application, both of the following must be satisfied: the oil viscosity and the category of oil performance or the specification for oil performance . Using only one of these parameters will not sufficiently define oil for an engine application.

The proper SAE viscosity grade of oil is determined by the following temperatures: minimum ambient temperature during cold engine start-up and maximum ambient temperature during engine operation.

Refer to Table 19 (minimum temperature) to determine the required oil viscosity for starting a cold engine.

Refer to Table 19 (maximum temperature) to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

Note: Generally, use the highest oil viscosity that is available to meet the requirement for the temperature at start-up.

Table 19

Lubricant Viscosities for Ambient Temperatures for Cat Diesel Engines					
Oil Type and Performance Requirements	**Viscosity Grade**	**°C**		**°F**	
		Min	**Max**	**Min**	**Max**
Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 0W-30	−40	30	−40	86
Cat Cold-Weather DEO-ULS Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 0W-40	−40	40	−40	104
Cat DEO-ULS Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 5W-30	−30	30	−22	86
Cat DEO-ULS SYN **Cat DEO** Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 5W-40	−30	50	−22	122
Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 10W-30	−18	40	0	104
Cat DEO-ULS **Cat DEO**	SAE 10W-40	−18	50	0	122
	SAE 15W-40	−9.5	50	15	122

Note: A cold soaked start occurs when the engine has not been operated recently, allowing the oil to become more viscous due to cooler ambient temperatures. Supplemental heat is recommended for cold soaked starts below the minimum ambient temperature. Supplemental heat may be necessary for cold soaked starts that are above the minimum temperature depending on factors such as parasitic load.

Total Base Number (TBN) and Fuel Sulfur Levels

The use of Cat S·O·S Services oil analysis is recommended strongly for determining oil life.

The minimum required Total Base Number (TBN) for oil depends on the fuel sulfur level. The TBN for new oil is typically determined by the “ASTM D2896” procedure. For direct injection engines that use distillate fuel, the following guidelines apply:

Table 20

TBN recommendations for applications in Cat engines (1)		
Fuel Sulfur Level percent (ppm)	Cat Engine Oils	TBN of Commercial Engine Oils
≤0.05 percent (≤500 ppm)	Cat DEO-ULS Cat DEO	Min 7
0. 1- 0.05 percent (1000-500 ppm)	Cat DEO-ULS Cat DEO	Min 7
Above 0.1 percent (above 1000 ppm)(2)	Cat DEO(3)	Min 10

(1) When using fuel with 0.10% sulfur (1000 ppm) or higher, refer to this Operation and Maintenance Manual, “Severe Service Application” for more information.
(2) For fuels of sulfur levels that exceed 1.0 percent (10,000 ppm), refer to TBN and engine oil guidelines given in this section.
(3) Cat DEO-ULS may be used if an oil analysis program is followed. Base the oil change interval on the analysis.

S·O·S Services Oil Analysis

Caterpillar has developed a maintenance tool that evaluates oil degradation. the maintenance management also detects the early signs of wear on internal components. The Cat tool for oil analysis is called S·O·S oil analysis and the tool is part of the S·O·S Services program. S·O·S oil analysis divides oil analysis into four categories:

- Component wear rate
- Oil condition
- Oil contamination
- Identification of oil

These four types of analysis are used to monitor the condition of your equipment. The four types of analysis will also help you identify potential problems. A properly administered S·O·S oil analysis program may result in reduced repair costs and the program will lessen the impact of downtime.

The S·O·S Oil Analysis program uses a wide range of tests to determine the condition of the oil and the crankcase. Guidelines that are based on experience and a correlation to failures have been established for these tests. Exceeding one or more of these guidelines could indicate serious fluid degradation or a pending component failure. A trained person at your Cat dealership should make the final analysis.

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. Contaminates may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

Refer to Special Publication, SEBU6251, “Cat Commercial Engine Fluids Recommendations” to obtain additional information about S·O·S Services oil analysis. You can also contact your local Cat dealer.

Fuel

Note: Caterpillar strongly recommends the filtration of fuel through a fuel filter with a rating of four microns(c) absolute or less. This filtration should be on the device that dispenses the fuel to the fuel tank for the engine. This filtration should also be on the device that dispenses fuel from the bulk storage tank. Series filtration is recommended.

NOTICE
To meet expected fuel system component life, secondary fuel filtration of 4 micron(c) absolute or less is required for all unit injected Cat Diesel Engines. All current Cat Diesel Engines are factory equipped with Cat Advanced Efficiency 4 micron (c) absolute fuel filters.

Caterpillar does not warrant the quality or performance of non-Cat fluids and filters.

Diesel engines can burn a wide variety of fuels. These fuels are divided into two general groups. The two groups are called the preferred fuels and the permissible fuels.

Note: The permissible fuels are some crude oils, some blends of crude oil with distillate fuel, some biodiesel, and some marine diesel fuel. These fuels are not suitable for use in all engine applications. The acceptability of these fuels for use is determined on an individual basis. A complete fuel analysis is required.

For more information, refer to Special Publication, SEBU6251, “Cat Commercial Engine Fluids Recommendations” or consult your Cat dealer for further information.

Diesel Distillate Fuel

Diesel engines may burn a wide variety of fuels. These fuels are divided into two general groups. The two groups are called the preferred fuels and the permissible fuels.

The preferred fuels provide maximum engine service life and performance. The preferred fuels are distillate fuels. These fuels are commonly called diesel fuel, furnace oil, gas oil, or kerosene. These fuels must meet the “Cat Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines” found in this Special Publication, “Distillate Diesel Fuel” article.

Note: The permissible fuels are some crude oils, some blends of crude oil with distillate fuel, some biodiesel, and some marine diesel fuel. **These fuels are not suitable for use in all engine applications.** The acceptability of these fuels for use is determined on a case by case basis. A complete fuel analysis is required. Consult your Cat dealer for further information.

NOTICE
The footnotes are a key part of the “Cat Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines” Table. Read ALL of the footnotes.

Table 21

Cat Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	**Requirements**	**ASTM Test**	**ISO Test**
Aromatics	35% maximum	“D1319”	“ISO 3837”
Ash	0.01% maximum (weight)	“D482”	“ISO 6245”
Carbon Residue on 10% Bottoms	0.35% maximum (weight)	“D524”	“ISO 4262”
Cetane Number (1)	40 minimum (DI engines)	“D613” or “D6890”	“ISO 5165”
	35 minimum (PC engines)		
Cloud Point	The cloud point must not exceed the lowest expected ambient temperature.	“D2500”	“ISO 3015”
Copper Strip Corrosion	No. 3 maximum	“D130”	“ISO 2160”
Distillation	10% at 282 °C (540 °F) maximum	“D86”	“ISO 3405”
	90% at 360 °C (680 °F) maximum		
Flash Point	legal limit	“D93”	“ISO 2719”
Thermal Stability	Minimum of 80% reflectance after aging for 180 minutes at 150 °C (302 °F)	“D6468”	No equivalent test
API Gravity (2)	30 minimum	“D287”	No equivalent test
	45 maximum		
Pour Point	6 °C (10 °F) minimum below ambient temperature	“D97”	“ISO 3016”
Sulfur	(3)(4)(5)	“D5453” or “D2622”	ISO 20846 or ISO 20884
Kinematic Viscosity	1.4 cSt minimum and 20.0 cSt maximum as delivered to the fuel injection pumps	-	-
	1.4 cSt minimum and 4.5 cSt maximum as delivered to the rotary fuel injection pumps		
Water and Sediment	0.05% maximum	“D1796” or “D2709”	“ISO 3734”
Water	0.05% maximum	“D6304”	No equivalent test
Sediment	0.05% maximum (weight)	“D473”	“ISO 3735”

(continued)

(Table 21, contd)

(continued)

(Table 21, contd)

Cat Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	**Requirements**	**ASTM Test**	**ISO Test**
Gums and Resins (6)	10 mg per 100 mL maximum	“D381”	“ISO 6246”
Lubricity	0.52 mm (0.0205 inch) maximum at 60 °C (140 °F)	“D6079”	No equivalent test

(1) Alternatively, to ensure a minimum cetane number of 35 (PC engines), and 40 (DI engines), distillate diesel fuel should have a minimum cetane index. This index is 37.5 (PC engines), and 44.2 (DI engines) when the “ASTM D4737-96a” test method is used. A fuel with a higher cetane number may be required for operation at a higher altitude or in cold weather.
(2) Via standards tables, the equivalent kg/m^3 (kilograms per cubic meter) using the “ASTM D287” test method temperature. This temperature is 15.56° C (60° F) for the minimum API gravity. The API gravity of 30 is 875.7 kg/m^3, and for the maximum API gravity of 45 is 801.3 kg/m^3.
(3) ULSD 0.0015% (<15 ppm S) is required by law for Tier 4 engines and engines with aftertreatment devices.
(4) Certain Cat fuel systems and engine components can operate on fuel with a maximum sulfur content of 3%. Contact your Cat dealer for guidance about appropriate maintenance intervals and fluids for engines operating on fuel with sulfur levels between 0.1% and 3%.
(5) An engine which operates on fuel with 0.1% (1000 ppm) of sulfur or more is operating in a severe service application. Refer to this Operation and Maintenance Manual, “Severe Service Application” for information about operating an engine in a severe service application.
(6) Follow the test conditions and procedures for gasoline (motor).

Biodiesel

Biodiesel blends of up to 20 percent may be used in the engine. This blend can be used when the fuel blend meets the recommendations in table 22 and meets the recommendations in Special Publication, SEBU6251, “Biodiesel”.

Note: A complete Cat S·O·S Services oil analysis program is recommended when using biodiesel blends above 5 percent.

Table 22

Biodiesel Blends for Cat Commercial Engines		
Biodiesel blends stock	Final blend	Distillate diesel fuel used for blend
Cat biodiesel specification, “ASTM D6751”or “EN14214”	B20: “ASTM D7467” and “API” gravity 30-45	Cat distillate diesel fuel specification, “ASTM D975”or “EN590”

Fuel Additives

Cat Diesel Fuel Conditioner

Cat Diesel Fuel Conditioner is a proprietary formulation that has been extensively tested for use with distillate diesel fuels for use in Cat Diesel Engines. Cat Diesel Fuel Conditioner is a high-performance diesel fuel conditioner. The conditioner is for use with lower quality fuels that do not meet the minimum requirements of any of the following:

- “Cat Specification for Distillate Diesel Fuel”
- National Conference on Weights and Measures (NCWM) Premium Diesel definition (refer to 2004or newer National Institute of Standards & Technology (NIST) Handbook).
- EN590 (non-arctic)
- ASTM D975

Cat Diesel Fuel Conditioner is the only fuel conditioner/additive available to the end user that is tested and approved by Caterpillar for use in Cat Diesel Engines.

Refer to Special Publication, SEBU6251, “Cat Commercial Diesel Engine Fluids Recommendations” for information about the use of Cat Diesel Fuel Conditioner.

Cat Diesel Fuel System Cleaner

Note: Cat Diesel Fuel System Cleaner is the only fuel system cleaner available to the end user that is tested and approved by Caterpillar for use in Cat Diesel Engines.

Cat Diesel Fuel System Cleaner is a proven high-performance detergent product designed specifically for cleaning deposits that form in the fuel system. Deposits in the fuel system reduce system performance and can increase fuel consumption. Cat Diesel Fuel System Cleaner addresses deposits formed in the fuel system. These deposits can be formed from degraded diesel fuel, poor quality diesel fuel, and diesel fuel containing high quantities of high molecular weight compounds. Cat Diesel Fuel System Cleaner addresses deposits formed due to the use of biodiesel, biodiesel blends, and biodiesel that does not meet the appropriate quality specifications. Continued use of Cat Diesel Fuel System Cleaner is proven to inhibit the growth of new deposits.

Caterpillar strongly recommends that Cat Diesel Fuel System Cleaner be used with biodiesel and biodiesel blends. Cat Diesel Fuel System Cleaner is suitable for use with biodiesel/biodiesel blends that meet Cat biodiesel recommendations and requirements. Not all fuel cleaners are suitable for use with biodiesel/biodiesel blends. Read and follow all applicable label usage instructions. Also, refer to Special Publication, SEBU6251, “Cat Commercial Diesel Engine Fluids Recommendations” “Distillate Diesel Fuel”, article and also refer to the “Biodiesel” article, which includes Caterpillar biodiesel recommendations and requirements.

Aftermarket Fuel Additives

There are many different types of fuel additives that are available to use. Caterpillar does not generally recommend the use of fuel additives.

In special circumstances, Caterpillar recognizes the need for fuel additives. Use fuel additives with caution. The additive may not be compatible with the fuel. Some additives may precipitate. This action causes deposits in the fuel system. The deposits may cause seizure. Some additives may plug fuel filters. Some additives may be corrosive, and some additives may be harmful to the elastomers in the fuel system. Some additives may damage emission control systems. Some additives may raise fuel sulfur levels above the maximum levels that are allowed by the following agencies: EPA and other regulatory agencies. Contact your fuel supplier for those circumstances when fuel additives are required. Your fuel supplier can make recommendations for additives to use and for the proper level of treatment.

Note: For best results, your fuel supplier should treat the fuel when additives are needed.

Cooling System

Note: Refer to Special Publication, SEBU6251, “Cat Commercial Diesel Engine Fluids Recommendations” for complete information about the proper fluids for use in the cooling system.

Note: The interval for changing the coolant varies depending on the type of coolant being replaced. Refer to this article “Coolant Recommendations”, for the intervals for changing the coolant.

NOTICE
Never add coolant to an overheated engine. Engine damage could result. Allow the engine to cool first.

NOTICE
If the engine is to be stored in, or shipped to an area with below freezing temperatures, the cooling system must be either protected to the lowest outside temperature or completely drained. Draining will prevent damage caused by freezing coolant.

NOTICE
Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the proper operating temperature. Cooling system problems can develop without water temperature regulators. Removing the regulators allows some coolant to bypass the radiator, potentially causing overheating.

Coolant Recommendations

Note: A Cat Diesel Engine equipped with air-to-air aftercooling (ATAAC) requires a minimum of 30 percent glycol to help prevent water pump cavitation.

Table 23

Coolant Recommendations for Cat Diesel Engines			
Recommendations	**Product**	**Service Hours(1)(2)(3)**	**Required Maintenance**
Preferred	Cat ELC and Cat ELI	12000 hours or 6 years	Add Cat ELC Extender at 6000 service hours or one half of service life
Min requirements	Cat EC-1 specification and “ASTM D6210” and Organic Additive Technology (OAT) based on a combination of a monocarboxylic acid and a dicarboxylic acid Phosphate, borate, and silicate free Tolyltriazole: minimum typical concentration of 900 ppm Nitrite: minimum typical concentration of 500 ppm in new coolants	6000 hours or 6 years	Add Extender at 3000 service hours or one half of service life
Acceptable	Cat DEAC	3000 hours or 3 years	SCA at maintenance intervals
	Cat SCA in water	3000 hours or 2 years	SCA at maintenance intervals
Min requirements for fully formulated Heavy-Duty Commercial coolants	“ASTM D6210” and Nitrite (as NO2) concentration: Minimum of 1200 ppm (70 grains/US gal) and maximum of 2400 ppm (140 grains/US gal) Silicon concentration: minimum of 100 ppm and maximum of 275 ppm	3000 hours or 2 years	SCA at maintenance intervals
Min requirements for Commercial coolants requiring SCA precharge	“ASTM D4985” and(1) Nitrite (as NO2) concentration: Minimum of 1200 ppm (70 grains/US gal) and maximum of 2400 ppm (140 grains/US gal) Silicon concentration: minimum of 100 ppm and maximum of 275 ppm	3000 hours or 1 year	SCA at initial fill and SCA at maintenance intervals
Min requirements for SCA and water	Commercial supplemental coolant additive and water	3000 hours or 1 year	Per manufacturer recommendations

(1) New Coolants at 50 volume percent diluted. Coolants that are prediluted at the coolant manufacturer must be diluted with water that meets Reagent 4 “ASTM D1193” requirements.
(2) Maintain the in-service coolant at the given limits.
(3) When referring to the service hours, use the interval that occurs first. These coolant change intervals are only achievable with annual S·O·S Services Level 2 coolant sampling analysis.

Table 24

Special Requirements	
Cat C7-C32 Marine Engines with heat exchangers	Minimum of 30% glycol is required. 50% Glycol is recommended. Water alone or water with SCA or with ELI is **NOT** allowed.

Table 25

Phosphate Dosing Applicability(1)				
	Aluminum Radiator	**Copper Radiator**	**Comments**	**Comments**
Cat ELC	YES	NO	Extended Life Coolants	
Cat DEAC/NGEC	NO	NO	Conventional Coolants (Diesel Engine Antifreeze Coolant), (Natural Gas Engine Coolant)	Silicate Based

(continued)

(Table 25, contd)

Non-Cat Long Life Coolant - with Nitrites	YES	NO		
Non-Cat Long Life Coolant - with Nitrites and Silicates	NO	NO		Silicate Based
Non-Cat Long Life Coolant - without Nitrites	NO	NO		
Non-Cat Long Life Coolant - without Nitrites	NO	NO		
Non-Cat Conventional Coolants	NO	NO		Silicate Based
Treated Water Systems - using SCA	NO	NO	Supplemental Coolant Additive	Silicate Based
Treated Water Systems - using Cat ELI	YES	NO	Extended Life Inhibitors PELF1212	Additives similar to ELC

(1) Required to maintain nitrites and coolant color.

NOTICE

Use Only Approved SCAs and Extenders

Conventional coolants require the maintenance addition of SCA throughout the expected life of the coolants. Do NOT use an SCA with a coolant unless approved specifically by the coolant supplier. The coolant manufacturer is responsible for ensuring compatibility and acceptable performance.

To help ensure expected performance, EC-1 coolants require the one time maintenance addition of an extender at coolant service mid-life. Do not use an extender with a coolant unless the extender has been approved specifically for use by the coolant manufacturer. The coolant manufacturer is responsible for ensuring compatibility and acceptable performance.

Failure to follow these recommendations can result in shortened cooling system component life.

Cat ELC can be recycled into conventional coolants.

For more information, refer to Special Publication, SEBU6251, “Cat Commercial Engine Fluids Recommendations”.

Cat Coolant Conditioner

Aluminum radiators require Cat Coolant Conditioner for Aluminum Components (CCAC) to be added to the coolant to passivate the radiator. CCAC passivation creates an oxidation coating on the aluminum that prevents nitrites in the coolant from reacting with the aluminum in the radiator. For more information, refer to Special Instructions, REHS7296, “Instructions for Use of Cat Coolant Conditioner for Aluminum Components”.

S·O·S Services Coolant Analysis

Testing the engine coolant is important to ensure that the engine is protected from internal cavitation and corrosion. The analysis also tests the ability of the coolant to protect the engine from boiling and freezing. S·O·S coolant analysis can be done at your Cat dealer. Cat S·O·S coolant analysis is the best way to monitor the condition of your coolant and your cooling system. S·O·S coolant analysis is a program that is based on periodic samples.

Table 26

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**
Cat DEAC Cat SCA Conventional Heavy-Duty Coolants	Every 250 hours	Yearly(1)
Cat ELC Cat ELI Commercial EC-1 Coolants	Optional(1)	Yearly(1)

(1) The Level 2 Coolant Analysis should be performed sooner if a problem is suspected or identified.

Note: Check the SCA (Supplemental Coolant Additive) of the conventional coolant at every oil change or at every 250 hours. Perform this check at the interval that occurs first.

S·O·S Services Coolant Analysis (Level 1)

A coolant analysis (Level 1) is a test of the properties of the coolant.

The following properties of the coolant are tested:

- Glycol concentration for freeze protection and boil protection
- Ability to protect from erosion and corrosion
- pH
- Conductivity
- Visual analysis
- Odor analysis

The results are reported, and appropriate recommendations are made.

S·O·S Services Coolant Analysis (Level 2)

A coolant analysis (Level 2) is a comprehensive chemical evaluation of the coolant. This analysis is also a check of the overall condition of the cooling system.

The S·O·S coolant analysis (Level 2) has the following features:

- Full coolant analysis (Level 1)
- Identification of metal corrosion and of contaminants
- Identification of buildup of the impurities that cause corrosion
- Identification of buildup of the impurities that cause scaling
- Determination of the possibility of electrolysis within the cooling system of the engine

The results are reported, and appropriate recommendations are made.

For more information on S·O·S coolant analysis, consult your Cat dealer.

Greases

If choosing a single grease is necessary, choose a grease that meets or exceeds the requirements of the most demanding application. Remember that the products which meet the minimum performance requirements can be expected to produce the minimum lives of your parts. False economy is being used if a grease is purchased with the lowest cost as the only consideration. Instead, use the grease that yields the lowest total operating cost. The cost should be based on analysis that includes the costs of parts, labor, downtime, and the amount of grease that is required.

For more information, refer to Special Publication, SEBU6251, “Cat Commercial Engine Fluids Recommendations”.

Maintenance Recommendations

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General Maintenance Information

SMCS Code: 4450; 7000

Note: Read the warnings and read the instructions that are contained in the Safety Section of this manual. These warnings and instructions must be understood before you perform any operation or any maintenance procedures.

Rotating electric machines are complex structures that are exposed to the following forms of stress:

- mechanical
- electrical
- thermal
- environmental

These stresses may be of varying magnitudes. The insulation systems are susceptible to damage that is caused by the stresses that are listed above. Exposure to these stresses may shorten the effective life of the insulation system. Therefore, the service life of an electric machine will largely depend on the serviceability of the insulation systems. An inspection program and a testing procedure are recommended. An inspection program and a testing procedure will ensure that the equipment is maintained in satisfactory condition. This maintenance will increase field reliability.

A regular maintenance and inspection program can provide an evaluation of the present condition of the equipment. A regular maintenance program and a regular inspection program can also reveal future problems. The frequency of this maintenance program will depend on the following factors:

- application
- environmental conditions
- operator experience
- operator philosophy

A regular maintenance program is recommended. This program would involve the following steps:

- periodic disassembly
- knowledgeable visual examination of the equipment
- the application of electrical tests

Never perform a test over the rated potential. These tests can damage insulation that is contaminated or insulation that is in marginal condition. For more information, refer to “I.E.E.E. Standard 432-1992” or consult a Caterpillar dealer.

Space Heaters

The generators can operate in high humidity conditions without problems. However, problems can occur when the generator is idle and the surrounding air is warmer than the generator. Moisture can form on the windings that will result in poor performance from the windings. Moisture can also result in damage to the windings. Whenever the generator is not active, ensure that the space heaters are in operation.

Whenever the generator is operating, ensure that the space heaters are disconnected.

An external source of either 115 VAC or 230 VAC is required to operate the space heaters.

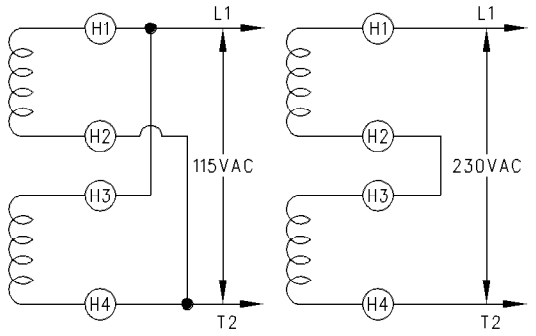

Illustration 49 g00556903

Space Heater Connection to External Source (H1), (H2), (H3), and (H4) Terminals.

If a 115 VAC source is available, connect both heaters in parallel across the source. If a 230 VAC source is available, connect both heaters in series across the source. Refer to Illustration 49 .

Field Conditions that Reduce Insulation Life

Electric machines and associated insulation systems are exposed to the following types of stress: mechanical, electrical, thermal, and environmental. These stresses produce many deteriorating influences. The following list defines the most significant influences.

Thermal Aging – A deteriorating influence on insulation that is caused by the normal service temperature.

Overtemperature – The unusually high temperature of operation that is caused by the following conditions: overload, high ambient temperature, restricted ventilation, winding faults and foreign materials that are deposited on windings.

Overvoltage – A voltage that is much higher than the rated nameplate voltage. This voltage can be caused by switching surges or lightening surges. Operating above the rated nameplate voltage will reduce the life of the insulation.

Contamination – Contamination deteriorates electrical insulation in the following ways:

- conducting current over insulated surfaces
- attacking the material and reducing the quality of the material electrical insulation
- attacking the material and reducing the physical strength of the material
- creating a thermal insulation that causes the material to operate at higher than normal temperatures

Some potential contaminants are listed below:

- water or extreme humidity
- unstable antiwear oil or grease
- oil or grease that contains extreme pressure additives
- conductive dust and conductive particles
- nonconductive dust and nonconductive particles
- industrial chemicals such as acids, solvents, and cleaning solutions

Physical Damage – Contributes to the failure of electrical insulation by opening a conductive path through the insulation.

The following list includes some of the physical damages that can occur:

- physical shock
- vibration
- overspeed
- erosion by foreign matter
- damage by foreign objects
- thermal cycling

Ionization Effects – Ionization (corona) can occur at higher operating voltages. Ionization is accompanied by several undesirable effects such as chemical action, heating, and erosion.

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System Pressure Release

SMCS Code: 1250; 1300; 1350; 5050

Coolant System

WARNING

Pressurized system: Hot coolant can cause serious burn. To open cap, stop engine, wait until radiator is cool. Then loosen cap slowly to relieve the pressure.

To relieve the pressure from the coolant system, turn off the machine. Allow the cooling system pressure cap to cool. Remove the cooling system pressure cap slowly to relieve pressure.

Fuel System

To relieve the pressure from the fuel system, turn off the engine.

High-Pressure Fuel Lines

WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

High-pressure fuel lines are the fuel lines that are between the high-pressure fuel pump and the high-pressure fuel manifold. The fuel lines are also between the fuel manifold and cylinder head. The high-pressure fuel lines are constantly charged with high pressure. Also, the internal pressures of the high-pressure fuel lines are higher than other types of fuel system.

Before any service or repair is performed on the engine fuel lines, perform the following tasks:

1. Stop the engine.

2. Wait for 10 minutes.

Do not loosen the high-pressure fuel lines to remove air pressure from the fuel system.

Engine Oil System

To relieve the pressure from the engine oil system, turn off the machine.

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Welding on Engines with Electronic Controls

SMCS Code: 1000

NOTICE
Because the strength of the frame may decrease, some manufacturers do not recommend welding onto a chassis frame or rail. Consult the OEM of the equipment or your Cat dealer regarding welding on a chassis frame or rail.

Proper welding procedures are necessary to avoid damage to the engine ECM, sensors, and associated components. When possible, remove the component from the unit and then weld the component. If removal of the component is not possible, the correct procedure must be followed. When welding on a unit that is equipped with a Cat Electronic Engine, the following is considered to be the safest procedure:

NOTICE
Do not ground the welder to electrical components such as the ECM or sensors. Improper grounding can cause damage to the drive train, the bearings, hydraulic components, electrical components, and other components.

Do not ground the welder across the centerline of the package. Improper grounding could cause damage to the bearings, the crankshaft, the rotor shaft, and other components.

Clamp the ground cable from the welder to the component that will be welded. Place the clamp as close as possible to the weld. This will help reduce the possibility of damage.

Note: Perform the welding in areas that are free from explosive hazards.

1. Stop the engine. Turn the switched power to the OFF position.

2. Disconnect the negative battery cable from the battery. If a battery disconnect switch is provided, open the switch.

3. Disconnect the J1/P1 and J2/P2 connectors from the ECM. Move the harness to a position that will not allow the harness to move back accidentally, and contact any of the ECM pins.

4. Disconnect any component with a microprocessor from the engine harness, such as:

- Engine ECM
- Product Link
- Cell/Sat Radio
- DOC Identity Modules

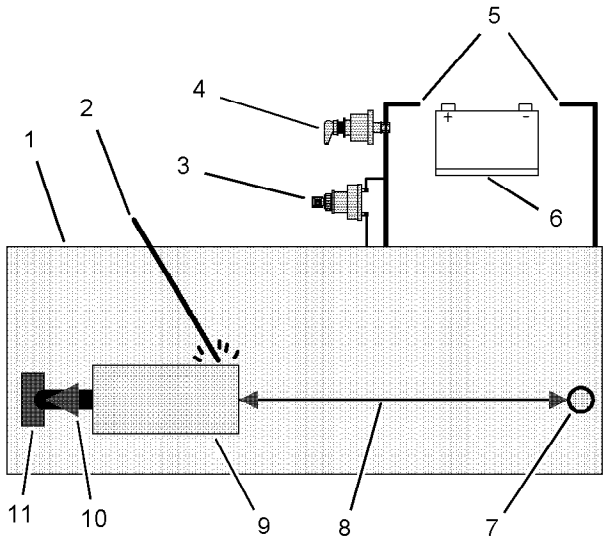

Illustration 50 g01075639

Use the example above. The current flow from the welder to the ground clamp of the welder will not damage any associated components.

(1) Engine
(2) Welding electrode
(3) Keyswitch in the OFF position
(4) Battery disconnect switch in the open position
(5) Disconnected battery cables
(6) Battery
(7) Electrical/Electronic component
(8) Minimum distance between the component that is being welded and any electrical/electronic component
(9) The component that is being welded
(10) Current path of the welder
(11) Ground clamp for the welder

5. Connect the welding ground cable directly to the part that will be welded. Place the ground cable as close as possible to the weld. This location will reduce the possibility of welding current damage to bearings, hydraulic components, electrical components, and ground straps.

Note: If electrical/electronic components are used as a ground for the welder, current flow from the welder could severely damage the component. Current flow from the welder could also severely damage electrical/electronic components that are located between the welder ground and the weld.

6. Protect the wiring harness from welding debris and spatter.

7. Use standard welding practices to weld the materials.

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Generator Start-up Checklist

SMCS Code: 4450

Table 27

GENERATOR START-UP CHECKLIST							
RATING INFORMATION							
Engine Serial Number: _____				Arrangement Number: _____			
Generator Serial Number: _____				Arrangement Number: _____			
GENERATOR NAME PLATE INFORMATION							
Voltage: _____			Package (prime, continuous, standby): _____				
Amperage: _____			Kilowatts: _____				
Storage Location:							
Main Stator Megohmmeter Reading:		Before Storage:		After Storage:			
Generator dried for 24 hours prior to start up?		(Y/N)		Drying method:			
SPACE HEATERS		**Yes**	**No**	**Comments**			
Space heaters operating properly?							
Space heater operated 48 hours before start-up?							
MEGOHMMETER TEST (“SEHS9124”)		30 sec. reading	60 sec. reading	30 sec. corrected	60 sec. corrected	Ambient temp.	Comments
Beginning of Storage	Main Stator						
	Main Rotor						
	Exciter Stator						
	Exciter Rotor						
	PMG Stator						
Start-up	Main Stator						
	Main Rotor						
	Exciter Stator						
	Exciter Rotor						
	PMG Stator						
Regulator		**Voltage**	**Amps**	**Comments**			

(continued)

(Table 27, contd)

GENERATOR START-UP CHECKLIST				
No Load	“T1” to “T2”	AC		
	“T1” to “T3”	AC		
	“T2” to “T3”	AC		
	“11” to “12”	AC		
	“11” to “13”	AC		
	“12” to “13”	AC		
Full Load	“T1” to “T2”	AC		
	“T1” to “T3”	AC		
	“T2” to “T3”	AC		
	“11” to “12”	AC		
	“11” to “13”	AC		
	“12” to “13”	AC		

Table 28

GENERATOR START-UP CHECKLIST (CONT.)					
ELECTRICAL		**Yes**	**No**	**Comments**	
	Unit properly grounded				
	Check diodes				
	Over current protection				
	Over voltage protection				
	Check for loose wiring				
	Adjust voltage				
	Adjust frequency				
MECHANICAL		**Data**			**Comments**
	Bearing temperature readings at full load	Front _____ Rear _____			
	Stator temperature readings at full load	A0 _____ B0 _____ C0 _____			
	Air gap on main stator	Top _____ Bottom _____			
	Air gap on exciter stator	Top _____ Bottom _____			
	Air gap of PMG	Top _____ Bottom _____			
	Ambient air to generator at full load	Temperature _____			
	Supplier air opening to generator	Size of Opening _____			
SWITCH GEAR/PARALLEL OPERATION					
	Manufacturer:				
		Setting 1	**Setting 2**	**Setting 3**	**Comments**
	Circuit breaker type				
	Overload setting				
	Reverse power relay				

(continued)

(Table 28, contd)

	VAR/PF Controller							
	Load share							
INSTALLATION & LOAD INFORMATION								
	Neutral grounding system				UPS			
	Enclosure type				- Size			
	Motor:				Other loads:			
	- Total SKVA				- Lighting			
	- Total HP				- Computers			
					- Welding			
					- Non-linear			
					- Other			
FULL LOAD DATA								
Voltage	Amps		KW	KVARS	P.F.			

i08337083

Maintenance Interval Schedule (Prime/Continuous)

SMCS Code: 1000; 4450; 7500

Ensure that all safety information, warnings, and instructions are read and understood before any operation or any maintenance procedures are performed. The user is responsible for the performance of maintenance, including all adjustments, the use of proper lubricants, fluids, and filters. The user is also responsible for the replacement of components due to normal wear and aging. Failure to adhere to proper maintenance intervals and procedures may result in diminished performance of the product and/or accelerated wear of components. Use fuel consumption, service hours, or calendar time, WHICH EVER OCCURS FIRST, to determine the maintenance intervals. Products that operate in severe operating conditions may require more frequent maintenance. Before each consecutive interval is performed, all maintenance from the previous interval must be performed.

When Required

Daily

Every Week

Initial 300 Service Hours

Every 300 Service Hours

Every 600 Service Hours

Every 1200 Service Hours

Every 2400 Service Hours

Every Year

Every 3000 Service Hours or 3 Years

Every 4200 Service Hours

Every 6000 Service Hours or 3 Years

Every 7200 Service Hours

Every 12 000 Service Hours or 6 Years

Every 16 500 Service Hours

i08337085

Maintenance Interval Schedule (Standby)

SMCS Code: 1000; 4450; 7500

Ensure that all safety information, warnings, and instructions are read and understood before any operation or any maintenance procedures are performed. The user is responsible for the performance of maintenance, including all adjustments, the use of proper lubricants, fluids, and filters. The user is also responsible for the replacement of components due to normal wear and aging. Failure to adhere to proper maintenance intervals and procedures may result in diminished performance of the product and/or accelerated wear of components. Use fuel consumption, service hours, or calendar time, WHICH EVER OCCURS FIRST, to determine the maintenance intervals. Products that operate in severe operating conditions may require more frequent maintenance. Before each consecutive interval is performed, all maintenance from the previous interval must be performed.

When Required

Daily

Every Week

Every 300 Service Hours

Every 6 Months

Every Year

Every 3 Years

Every 6 Years

Every 12 000 Service Hours or 6 Years

i06536967

Aftercooler Core - Inspect/ Clean

SMCS Code: 1063-040; 1064-571-Z3; 1064-571

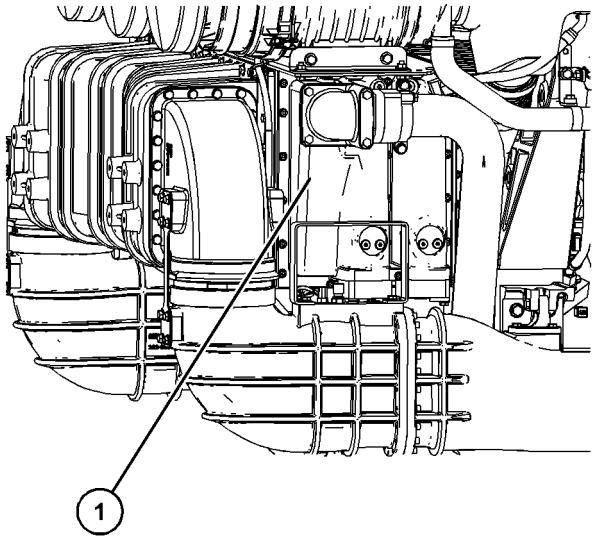

Illustration 51 g06012680

(1) Aftercooler

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

1. Remove the core. Refer to the Disassembly and Assembly Manual, “Aftercooler - Remove and Install” for the procedure.

2. Turn on the aftercooler core one side to remove debris. Remove the debris that is accessible.

NOTICE
Do not use a high concentration of caustic cleaner to clean the core. A high concentration of caustic cleaner can attack the internal metals of the core and cause leakage. Only use the recommended concentration of cleaner.

3. Back flush the core with cleaner.

Caterpillar recommends the use of Hydrosolv liquid cleaner. Table 29 lists Hydrosolv liquid cleaners that are available from your Caterpillar dealer.

Table 29

Hydrosolv Liquid Cleaners(1)		
Part Number	**Description**	**Size**
1U-5490	Hydrosolv 4165	19 L (5 US gal)
174-6854	Hydrosolv 100	19 L (5 US gal)

(1) Use a 2 percent to 5 percent concentration of the cleaner at temperatures up to 93°C (200°F). Consult your Caterpillar dealer for more information.

4. Remove the drain plug.

5. Clean the core with steam to remove any residue. Flush the fins of the aftercooler core. Remove any other trapped debris from the inside and from the outside of the core.

Note: Do not use high pressure when the fins are cleaned. High pressure can damage the fins.

6. Wash the core with hot, soapy water.

7. Flush the core thoroughly to remove residue and remaining debris. Flush the core with clean, fresh water until the water that is exiting the core is clear and free of debris.

⚠ WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

The maximum air pressure for cleaning purposes must be reduced to 205 kPa (30 psi) when the air nozzle is deadheaded.

8. Dry the core with compressed air. Direct the air in the reverse direction of the normal flow.

9. Prior to installation, inspect any O-rings or seals for damage. If necessary, replace the O-rings or seals.

10. Inspect the core for trapped debris and cleanliness. If necessary, remove the debris and repeat the cleaning procedure.

11. Inspect the core for damage and perform a pressure test to detect leaks. Many shops that service radiators are equipped to perform pressure tests.

12. Install the core. Refer to Disassembly and Assembly Manual, “Aftercooler - Remove and Install” for the procedure.

For more information on cleaning the core, consult your Cat dealer.

i08287144

Air Starting Motor Lines Screen - Clean

SMCS Code: 1451-070-LI

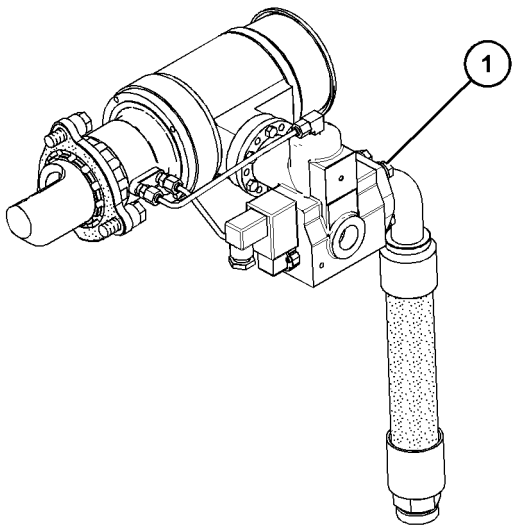

Illustration 52 g06612078

⚠ WARNING

Do not disconnect the air lines until the air pressure in the system is at zero. If hose is disconnected under pressure it can cause personal injury.

Note: Ensure that the air system is not pressurized.

1. Disconnect inlet air line to the starting motor (1).

2. Remove the retaining ring.

3. Remove the screen and clean the screen.

4. Reinstall the screen.

5. Reinstall the retaining ring.

6. Connect the inlet air line to the starting motor (1).

i08233932

Alternator - Inspect

SMCS Code: 1405-040

Inspect the alternator for the following conditions:

- Proper connections
- Clean ports for cooling airflow
- Proper charging of the battery

Observe the ammeter during engine operation to ensure proper battery performance and/or proper performance of the electrical system.

Make repairs, if necessary. See the Service Manual for service procedures. Consult your Cat dealer for assistance.

i08232552

Battery - Recycle

SMCS Code: 1401; 1401-561; 1401-535; 1401-005; 1401-510

Always recycle a battery. Never discard a battery. Return used batteries to one of the following locations:

- A battery supplier
- An authorized battery collection facility
- A recycling facility

i08232562

Battery - Replace

SMCS Code: 1401-510

1. Turn the key start switch to the OFF position. Remove the key and all electrical loads.

2. Turn OFF the battery charger. Disconnect the charger.

3. The NEGATIVE “-” cable connects the NEGATIVE “-” battery terminal to the ground plane. Disconnect the cable from the NEGATIVE “-” battery terminal.

4. The POSITIVE “+” cable connects the POSITIVE “+” battery terminal to the starting motor. Disconnect the cable from the POSITIVE “+” battery terminal.

Note: Always recycle a battery. Never discard a battery. Return used batteries to an appropriate recycling facility.

5. Remove the used battery.

6. Install the new battery.

Note: Before connecting the cables, ensure that the key start switch is OFF.

7. Connect the cable from the starting motor to the POSITIVE “+” battery terminal.

8. Connect the cable from the ground plane to the NEGATIVE “-” battery terminal.

i08230703

Battery Charger - Check

SMCS Code: 1401-535

Checking Before Start-Up

Check the battery charger for proper operation. If the batteries are properly charged, the needle of the ammeter will register near “0” (zero).

The battery charger must not produce excessive current during start-up. Alternatively, the charger must be automatically disconnected for start-up. If the engine has an alternator, the charger must be automatically disconnected during start-up and during engine operation.

Charging the Battery

⚠ WARNING

Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operated. A spark can cause an explosion from the flammable vapor mixture of hydrogen and oxygen that is released from the electrolyte through the battery outlets. Injury to personnel can be the result.

Perform the following procedure to charge the battery:

1. Ensure that the charger is turned OFF.

2. Adjust the voltage of the charger to match the voltage of the battery.

3. Connect the POSITIVE “+” lead of the charger to the POSITIVE “+” battery terminal. Connect the NEGATIVE “-” lead of the charger to the NEGATIVE “-” battery terminal.

4. Turn ON the battery charger.

Overcharging of Batteries

Overcharging reduces the service life of batteries. Use a battery charger that will not overcharge the battery. DO NOT charge the battery if the meter of the battery charger is in the RED zone.

Overcharging is indicated by the following symptoms:

- The battery is warm to the touch.
- A strong odor of acid is present.
- The battery emits smoke or a dense vapor (gas).

Perform one of the following procedures if the battery shows symptoms of overcharging:

- Reduce the rate of charging by a significant amount. Complete the charging at the reduced rate.
- Turn OFF the charger.

Table 30 describes the effects of overcharging on different types of batteries.

Table 30

Effects of Overcharging Batteries	
Type of Battery	**Effect**
Cat General Service Batteries Cat Premium High Output Batteries	All battery cells have a low level of electrolyte.
	When the plates of the battery are inspected through the filler holes, the plates may appear to be warped. This condition can be caused by excessive temperature.
	The battery may not pass a load test.
Cat Maintenance Free Batteries	The battery may not accept a charging current.

(continued)

(Table 30, contd)

	The battery may not pass a load test.

Checking After Stopping

Ensure that the battery charger is connected properly. Observe the meter of the charger. Record the amperage.

i08265744

Battery Electrolyte Level - Check

SMCS Code: 1401-535-FLV

When the engine has not run for long or short periods of time, the batteries may not fully recharge. Ensure a full charge to help prevent the battery from freezing.

In warmer climates, check the electrolyte level more frequently.

Ensure that the electrolyte level is 13 mm (0.5 inch) above the top of the separators.

⚠ WARNING

All lead-acid batteries contain sulfuric acid which can burn the skin and clothing. Always wear a face shield and protective clothing when working on or near batteries.

1. Remove the filler caps. Maintain the electrolyte level to the “FULL” mark on the battery.

   If the addition of water is necessary, use distilled water. If distilled water is not available, use clean water that is low in minerals. Do not use artificially softened water.

2. Check the condition of the electrolyte with the 245-5829 Coolant Battery Tester Refractometer.

3. Keep the batteries clean.

   Clean the battery case with one of the following cleaning solutions:

   - A mixture of 0.1 kg (0.2 lb) of baking soda and 1 L (1 qt) of clean water
   - A mixture of 0.1 L (0.11 qt) of ammonia and 1 L (1 qt) of clean water

   Thoroughly rinse the battery case with clean water.

   Use the 1U-9921 Battery Service Tool to clean the battery terminals. Use a wire brush to clean the cable clamps. Clean the items until the surfaces are bright or shiny. DO NOT remove material excessively. Excessive removal of material can cause the clamps to fit improperly. Coat the clamps and the terminals with the Loctite® product listed below, petroleum jelly or MPGM.

   - For Americas North - Loctite LB8632
   - For Europe and Africa, Middle East, CIS (AMEC) - Loctite LB8104
   - For Asia Pacific - Loctite LB8801
   - For Americas South - Loctite LB Superlube

   For ordering the products listed above, go to the following address.

   http://www.loctite.com/en/meta/meta-nav/location-selector.html

i08230783

Battery or Battery Cable - Disconnect

SMCS Code: 1401; 1402-029

⚠ WARNING

The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Switch the engine to the OFF position. Turn the ignition switch (if equipped) to the OFF position and remove the key and all electrical loads.
2. Disconnect the negative battery terminal at the battery that goes to the start switch. Ensure that the cable cannot contact the terminal.
3. Tape the leads to help prevent accidental starting.
4. Proceed with necessary system repairs. Reverse the steps to reconnect all cables.

i08156107

Belts - Inspect/Replace

SMCS Code: 1397-040; 1397-510

Fan Drive Belt

Inspection

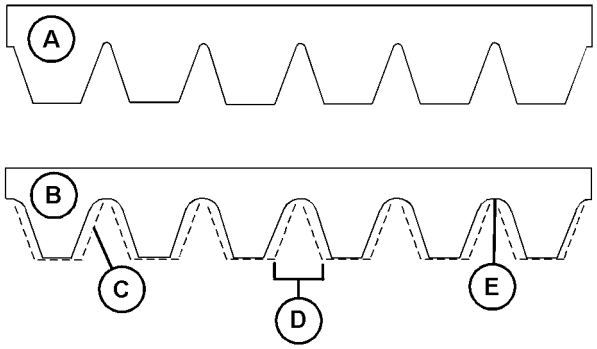

Illustration 53 g06114636

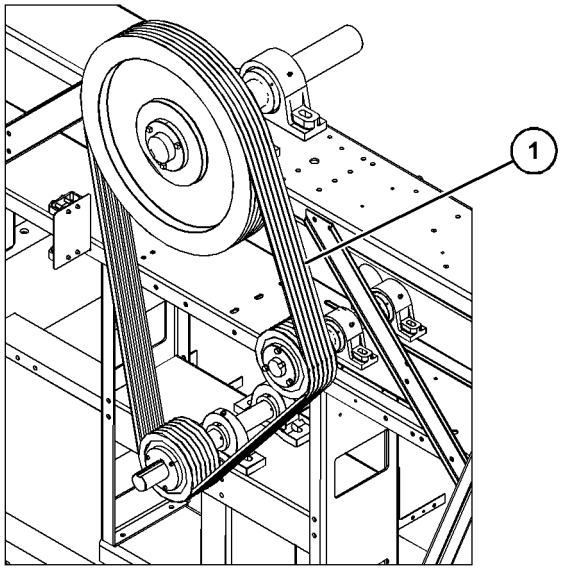

Illustration 54 g06571748

(1) Fan drive V-belts

To inspect the fan drive belts, perform the following:

1. Remove the belt guard.

2. Inspect the condition of the V-belts. Over time the belt ribs will lose material (C). The space between the belt ribs will increase (D). The loss of material will cause the pulley sheave to contact the belt valley. This contact will lead to belt slippage and accelerated wear (E). Replace the belt if the belt is worn or frayed.

Note: For more information on belt failure, refer to Special Instruction, M0086279.

Tension

Note: For information on setting fan drive belt tension, refer to Special Instruction, M0115203.

Note: Utilize belt tension tool 491 - 2178 Meter - Belt Tension to check fan drive V-belts. For information on using the belt tension tool, refer to Tool Operating Manual, NEHS1344. For belt tension specifications, refer to Tool Operating Manual, NEHS1344 belt tension tables.

Note: Belts that have more than 4000 hours have exceeded the intended life target for most applications. Extension of belt life is possible for some applications through regular belt inspections.

Replacement

⚠ WARNING

Sudden release of spring force can cause injury.

To prevent the possibility of injury, follow the procedure to relieve the spring pressure.

The belt tensioner is under spring force. Make sure that the tooling is properly engaged with the belt tensioner. Slowly release the spring force from the belt tensioner.

For information on replacing the fan drive belt, refer to the applicable Disassembly and Assembly document.

Alternator Belt

Inspection

Check the alternator belt tension. Belt slippage will decrease the life of the belt. Refer to Specifications, manual RENR9337, “C175-16 and C175-20 Generator Set Engines” “Belt Tension Chart”.

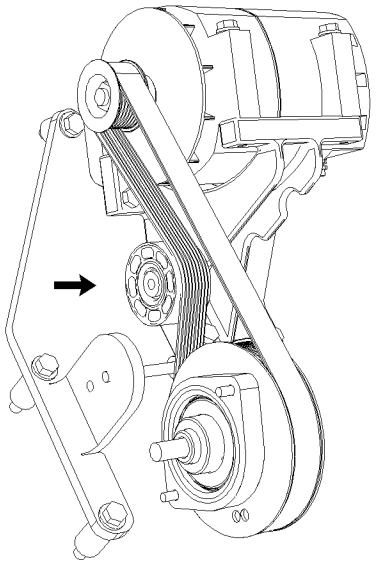

Illustration 55 g01244959

Replacement

1. Remove the belt guard.
2. Turn the belt tensioner to release the tension from the belt.
3. Replace the belt.
4. Reposition the tensioner.
5. Use a 144-0235 Belt Tension Gauge to measure the belt tension. Compare the reading to the figure in the Specifications manual for the engine.
6. Reinstall the belt guard.

If a new belt is installed, check the drive belt tension again after 30 minutes of engine operation at the rated rpm.

i03962292

Control Panel - Inspect/Test

SMCS Code: 4490-081; 4490-040; 7451-081; 7451-040

Inspect the condition of the panel. If a component is damaged, ensure that the component is repaired or that the component is replaced. If equipped, ensure that the electronic displays are operating properly. Inspect the wiring for good condition. Ensure that the wiring connections are secure.

Electronic Modular Control Panel 3 (EMCP 3)

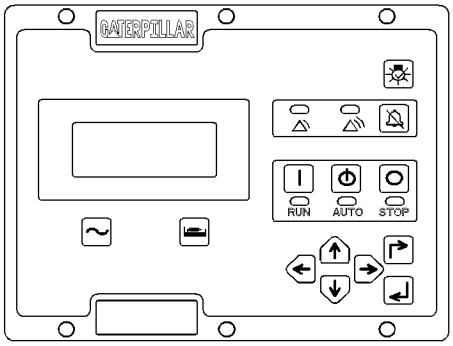

Illustration 56 g01184041

The Lamp Test button is located on the top right side of the electronic control module. Press and hold the Lamp Test button in order to test all of the LED lights and the display screen. The LED lights and the display screen should remain on until the button is released. If any of the components do not pass this test, replace the faulty components before starting the engine.

Switch Panel

The Panel Lights switch should turn on the panel lights. Toggle the switch in order to ensure that the panel lights are working.

Annunciator Panel

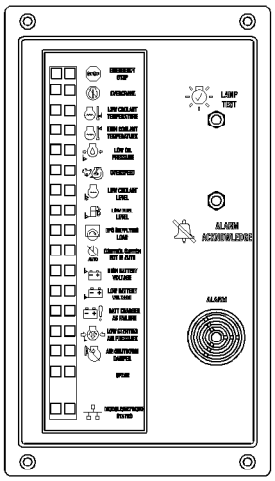

Illustration 57 g01101388

Test the LED indicators and the horn when the data link is connected and when the data link is not connected. The Lamp Test button is located near the top of the annunciator panel. Test both the horn and the indicators by pressing and holding the Lamp Test button. Replace any faulty components before starting the engine.

i08331059

Coolant (DEAC) - Change

SMCS Code: 1350-070; 1395-044

Clean the cooling system before the recommended maintenance interval if the following conditions exist:

- The engine overheats frequently.
- Foaming is observed.
- Oil has entered the cooling system and the coolant is contaminated.
- Fuel has entered the cooling system and the coolant is contaminated.

Drain the Cooling System

1. Drain the Cooling System

2. Loosen the cooling system filler cap slowly to relieve any pressure. Remove the cooling system filler cap.

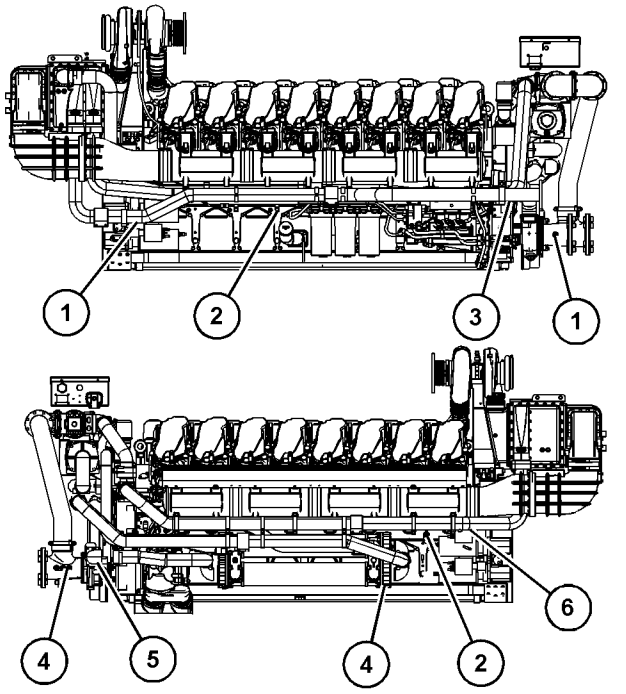

Illustration 58 g06631692

Locations of the drain plugs

(1) SCAC drain
(2) Engine block drain
(3) SCAC sample
(4) Jacket water drain plug
(5) Jacket water sampling valve
(6) Jacket water drain plug

3. Open the cooling system drain valves (if equipped). If the cooling system is not equipped with drain valves, remove drain plugs (1), (2), and (4). Allow the coolant to drain.

4. Ensure that the jacket water drain valve is in the CLOSED position before removing drain plug (6). Remove jacket water drain plug (6). Remove the O-ring seal. Install a new O-ring seal and a connector.

5. Attach a hose adapter and a hose with an inner diameter of 25 mm (1 inch).

6. Open the drain valve and allow the coolant to drain away from the electrical panel.

NOTICE
Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

Radiator Equipped Generator Sets

1. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Ensure that the engine will not start when the cooling system is drained.

2. Loosen the radiator filler cap (7) slowly to relieve any pressure. Remove the radiator filler cap.

3. Open the radiator drain plugs (8). Allow the coolant to drain.

Note: Your radiator may appear differently than the radiator in figure.

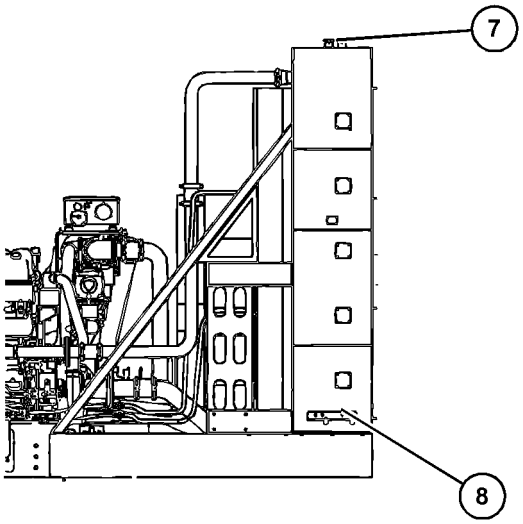

Illustration 59 g06631709

Typical radiator for a C175 Generator Set

NOTICE
Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

For information regarding the disposal, recycling, and the parts required to drain the coolant, consult yourCat dealer, or Dealer Service Tools Group:

Outside Illinois 1-800-542-TOOL
Inside Illinois 1-800-541-TOOL
Canada 1-800-523-TOOL

Clean the Cooling System

1. After the cooling system has been drained, flush the cooling system with clean water to remove any debris.

2. Close the cooling system drain valves (if equipped). Clean the drain plugs and install the drain plugs.

NOTICE
Use of commercially available cooling system cleaners may cause damage to cooling system components. Use only cooling system cleaners that are approved for Caterpillar engines.

3. Fill the cooling system with a mixture of clean water and Cat Fast Acting Cooling System Cleaner. Add .5 L (1 pt) of cleaner per 15 L (4 US gal) of the cooling system capacity. Install the cooling system filler cap.

4. Start the engine. Operate the engine for a minimum of 30 minutes with a coolant temperature of at least 82 °C (180 °F).

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly to relieve any pressure. Remove the cooling system filler cap. Open the cooling system drain valves (if equipped) or remove the drain plugs.

NOTICE
Improper or incomplete rinsing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

6. Allow the water to drain. Flush the cooling system with clean water until the water that drains are clean. Close the cooling system drain valves (if equipped). Clean the drain plugs and install the drain plugs.

Cleaning a Cooling System that has Heavy Deposits or Plugging

Note: For the following procedure to be effective, there must be an active flow through the cooling system components.

1. After the cooling system has been drained, flush the cooling system with clean water to remove any debris.

2. Close the cooling system drain valves (if equipped). Clean drain plugs and install the drain plugs .

3. Fill the cooling system with a mixture of clean water and Cat Fast Acting Cooling System Cleaner. Add .5 L (1 pt) of cleaner per 3.8 to 7.6 L (1 to 2 US gal) of the cooling system capacity. Install the cooling system filler cap.

4. Start the engine. Operate the engine for a minimum of 90 minutes with a coolant temperature of at least 82 °C (180 °F).

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly to relieve any pressure. Remove the cooling system filler cap. Open the cooling system drain valves (if equipped) or remove the drain plugs. Allow the water to drain.

NOTICE
Improper or incomplete rinsing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

6. Flush the cooling system with clean water until the water that drains are clean. Close the cooling system drain valves (if equipped). Clean the drain plugs and install the drain plugs.

Fill the Cooling System

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

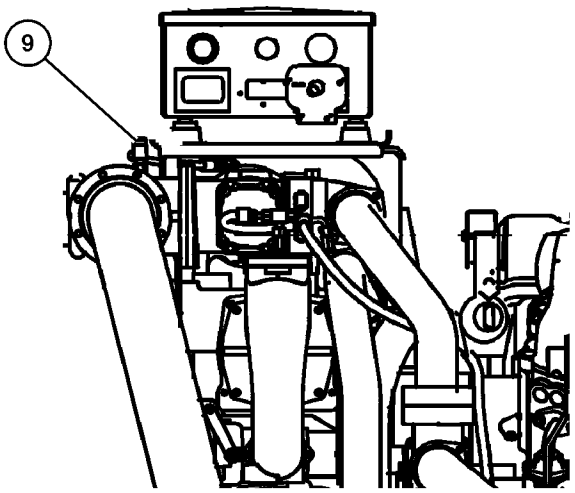

Illustration 60 g06631718
C175 16 and 20 cylinder
(9) Jacket water vent

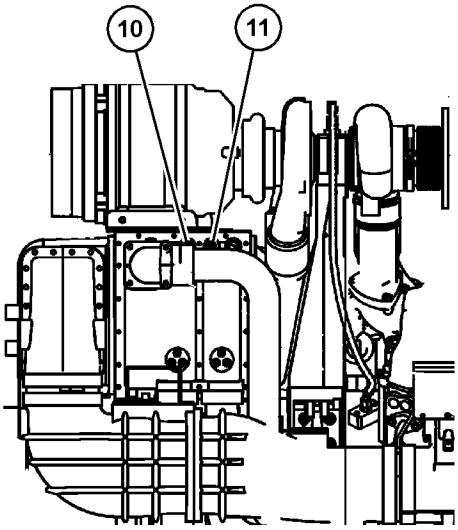

Illustration 61 g06631720
C175 20 cylinder 50 Hz and C175 16 cylinder
(10) SCAC vent
(11) Jacket water vent

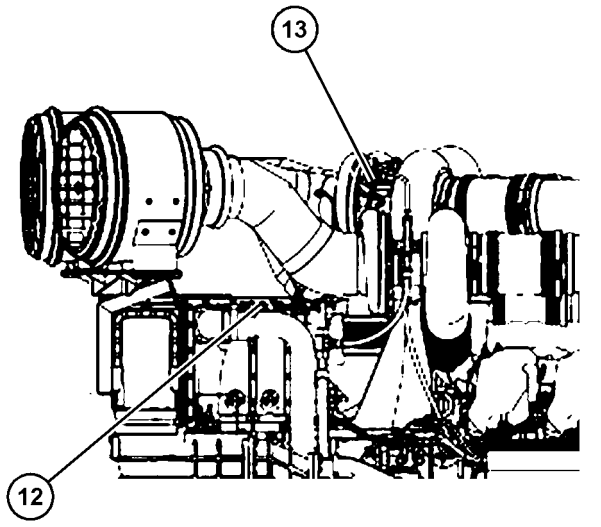

Illustration 62 g06631725

C175 20 cylinder 60 Hz (water-cooled turbochargers)

(12) SCAC vent
(13) Jacket water vent

Note: For information about the proper coolant to use and the capacity of the cooling system, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” (Maintenance Section).

1. Ensure that an active vent is installed on the front vent port at the coolant bypass line for the Jacket Water system (2).

2. Ensure that the SCAC vent plugs (1) and the jacket water vent plugs (2) are loosened prior to filling.

3. Fill the cooling system with an antifreeze/coolant solution. Do not install the cooling system filler cap.

4. Tighten the vent plugs after air has been purged from the cooling system.

5. Start the engine and allow to run for 5 minutes at rated speed to ensure that all air is purged from the cooling system.

6. Check the coolant level. Maintain the coolant to the proper level on the sight gauge (if equipped). If a sight gauge is not equipped, maintain the coolant within 13 mm (0.5 inch) below the bottom of the filler pipe. Refer to Operation and Maintenance Manual, “Coolant Level - Check”.

7. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets of the cooling system filler cap are damaged, discard the old cooling system filler cap and install a new cap. If the gaskets of the cooling system filler cap are not damaged, use a 9S-8140 Pressurizing Pump to test the cap. The correct pressure is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not maintain the correct pressure, install a new cooling system filler cap.

8. Inspect the cooling system for leaks and for proper operating temperature.

Manual Vent Valve Procedure

1. Rotate manual vent valve to vent the cooling system after cooling system fill and maintenance. Venting will ensure that air is purged from the cooling system.

2. Rotate vent valve counter-clockwise to the ON “I” position.

3. Fill the cooling system.

4. Start the engine and operate the engine to vent air from the cooling system.

5. After air has been purged from the system, rotate vent valve to the OFF “O” position.

6. Check the coolant level and add coolant as needed.

7. Ensure that the valve is in the OFF position during engine operation.

i08335569

Coolant (ELC) - Change

SMCS Code: 1350-070; 1395-044

Clean the cooling system before the recommended maintenance interval if the following conditions exist:

- The engine overheats frequently.
- Foaming is observed.
- Oil has entered the cooling system and the coolant is contaminated.
- Fuel has entered the cooling system and the coolant is contaminated.

Drain the Cooling System

1. Drain the Cooling System

2. Loosen the cooling system filler cap slowly to relieve any pressure. Remove the cooling system filler cap.

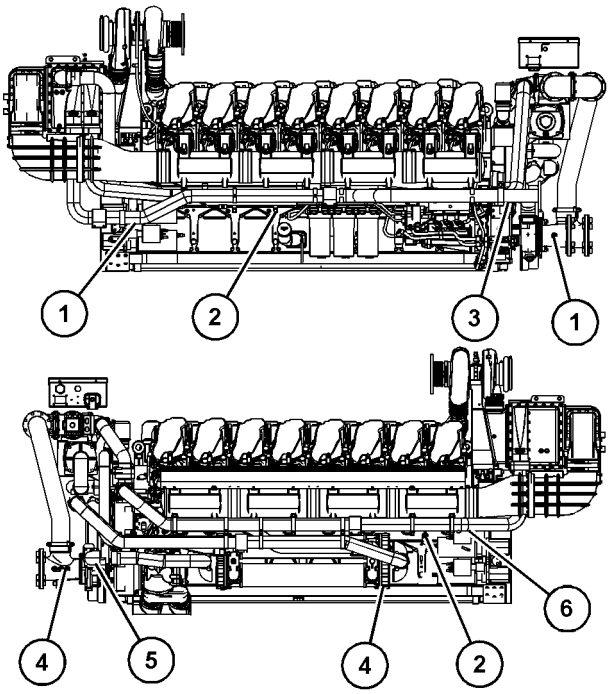

Illustration 63 g06631692

Locations of the drain plugs

(1) SCAC drain
(2) Engine block drain
(3) SCAC sample
(4) Jacket water drain plug
(5) Jacket water sampling valve
(6) Jacket water drain plug

3. Open the cooling system drain valves (if equipped). If the cooling system is not equipped with drain valves, remove drain plugs (1), (2), and (4). Allow the coolant to drain.

4. Ensure that the jacket water drain valve is in the CLOSED position before removing drain plug (6). Remove jacket water drain plug (6). Remove the O-ring seal. Install a new O-ring seal and a connector.

5. Attach a hose adapter and a hose with an inner diameter of 25 mm (1 inch).

6. Open the drain valve and allow the coolant to drain away from the electrical panel.

NOTICE
Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

Radiator Equipped Generator Sets

1. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Ensure that the engine will not start when the cooling system is drained.

2. Loosen the radiator filler cap (7) slowly to relieve any pressure. Remove the radiator filler cap.

3. Open the radiator drain plugs (8). Allow the coolant to drain.

Note: Your radiator may appear differently than the radiator in figure.

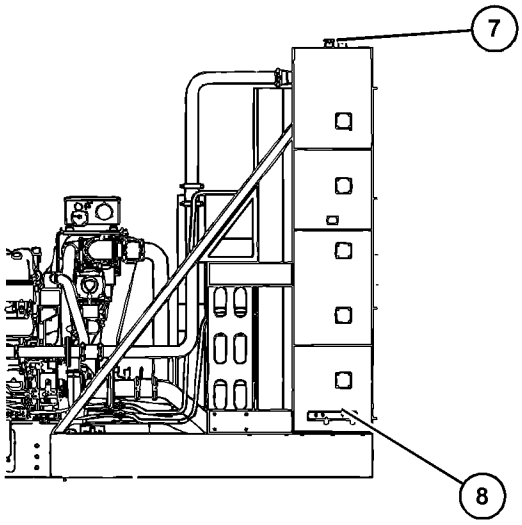

Illustration 64 g06631709

Typical radiator for a C175 Generator Set

NOTICE
Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

For information regarding the disposal, recycling, and the parts required to drain the coolant, consult yourCat dealer, or Dealer Service Tools Group:

Outside Illinois 1-800-542-TOOL
Inside Illinois 1-800-541-TOOL
Canada 1-800-523-TOOL

Clean the Cooling System

1. After the cooling system has been drained, flush the cooling system with clean water to remove any debris.
2. Close the cooling system drain valves (if equipped). Clean the drain plugs and install the drain plugs.

NOTICE
Use of commercially available cooling system cleaners may cause damage to cooling system components. Use only cooling system cleaners that are approved for Caterpillar engines.

3. Fill the cooling system with a mixture of clean water and Cat Fast Acting Cooling System Cleaner. Add .5 L (1 pt) of cleaner per 15 L (4 US gal) of the cooling system capacity. Install the cooling system filler cap.
4. Start the engine. Operate the engine for a minimum of 30 minutes with a coolant temperature of at least 82 °C (180 °F).
5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly to relieve any pressure. Remove the cooling system filler cap. Open the cooling system drain valves (if equipped) or remove the drain plugs.

NOTICE
Improper or incomplete rinsing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

6. Allow the water to drain. Flush the cooling system with clean water until the water that drains are clean. Close the cooling system drain valves (if equipped). Clean the drain plugs and install the drain plugs.

Cleaning a Cooling System that has Heavy Deposits or Plugging

Note: For the following procedure to be effective, there must be an active flow through the cooling system components.

1. After the cooling system has been drained, flush the cooling system with clean water to remove any debris.
2. Close the cooling system drain valves (if equipped). Clean drain plugs and install the drain plugs .
3. Fill the cooling system with a mixture of clean water and Cat Fast Acting Cooling System Cleaner. Add .5 L (1 pt) of cleaner per 3.8 to 7.6 L (1 to 2 US gal) of the cooling system capacity. Install the cooling system filler cap.
4. Start the engine. Operate the engine for a minimum of 90 minutes with a coolant temperature of at least 82 °C (180 °F).
5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly to relieve any pressure. Remove the cooling system filler cap. Open the cooling system drain valves (if equipped) or remove the drain plugs. Allow the water to drain.

NOTICE
Improper or incomplete rinsing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

6. Flush the cooling system with clean water until the water that drains are clean. Close the cooling system drain valves (if equipped). Clean the drain plugs and install the drain plugs.

Fill the Cooling System

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

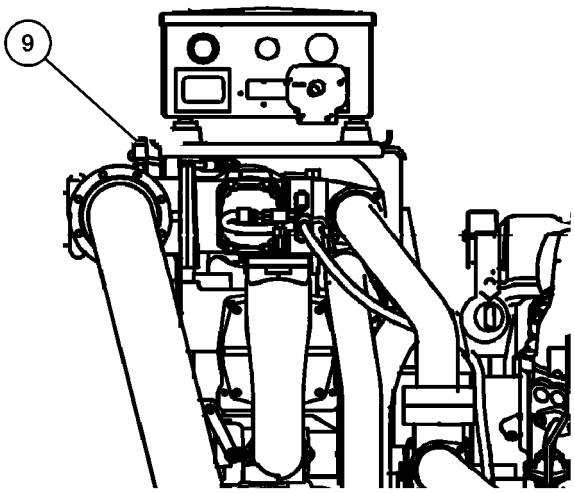

Illustration 65 g06631718

C175 16 and 20 cylinder

(9) Jacket water vent

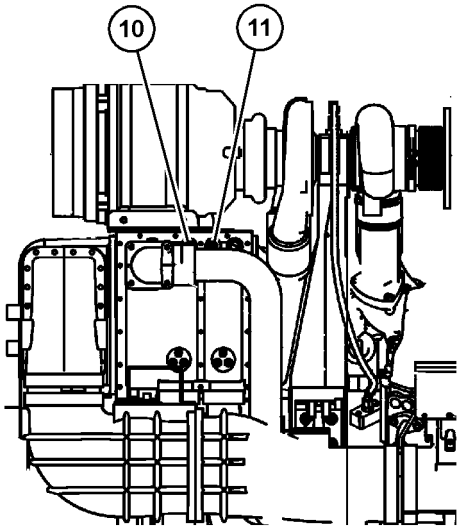

Illustration 66 g06631720

C175 20 cylinder 50 Hz and C175 16 cylinder

(10) SCAC vent
(11) Jacket water vent

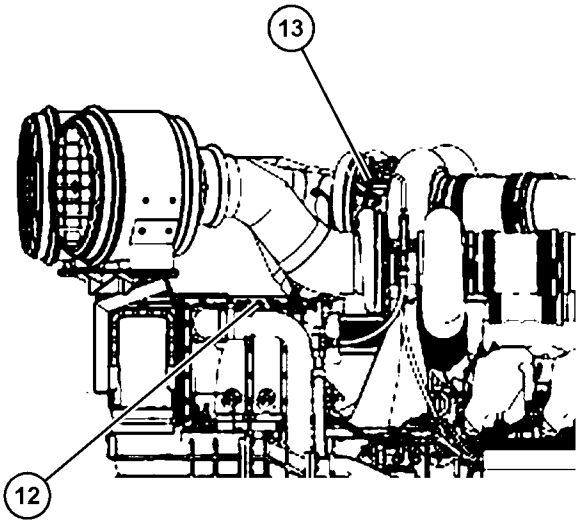

Illustration 67 g06631725

C175 20 cylinder 60 Hz (water-cooled turbochargers)

(12) SCAC vent
(13) Jacket water vent

Note: For information about the proper coolant to use and the capacity of the cooling system, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” (Maintenance Section).

1. Ensure that an active vent is installed on the front vent port at the coolant bypass line for the Jacket Water system (2).
2. Ensure that the SCAC vent plugs (1) and the jacket water vent plugs (2) are loosened prior to filling.
3. Fill the cooling system with an antifreeze/coolant solution. Do not install the cooling system filler cap.
4. Tighten the vent plugs after air has been purged from the cooling system.
5. Start the engine and allow to run for 5 minutes at rated speed to ensure that all air is purged from the cooling system.
6. Check the coolant level. Maintain the coolant to the proper level on the sight gauge (if equipped). If a sight gauge is not equipped, maintain the coolant within 13 mm (0.5 inch) below the bottom of the filler pipe. Refer to Operation and Maintenance Manual, “Coolant Level - Check”.

7. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets of the cooling system filler cap are damaged, discard the old cooling system filler cap and install a new cap. If the gaskets of the cooling system filler cap are not damaged, use a 9S-8140 Pressurizing Pump to test the cap. The correct pressure is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not maintain the correct pressure, install a new cooling system filler cap.
8. Inspect the cooling system for leaks and for proper operating temperature.

Manual Vent Valve Procedure

1. Rotate manual vent valve to vent the cooling system after cooling system fill and maintenance. Venting will ensure that air is purged from the cooling system.
2. Rotate vent valve counter-clockwise to the ON “I” position.
3. Fill the cooling system.
4. Start the engine and operate the engine to vent air from the cooling system.
5. After air has been purged from the system, rotate vent valve to the OFF “O” position.
6. Check the coolant level and add coolant as needed.
7. Ensure that the valve is in the OFF position during engine operation.

i08232554

Coolant Extender (ELC) - Add

SMCS Code: 1352-544-NL

Cat ELC (Extended Life Coolant) does not require the frequent additions of any supplemental cooling additives which are associated with the present conventional coolants. Add the Cat ELC Extender once.

NOTICE
Use only Cat Extended Life Coolant (ELC) Extender with Cat ELC.

Do NOT use conventional supplemental coolant additive (SCA) with Cat ELC. Mixing Cat ELC with conventional coolants and/or conventional SCA reduces the Cat ELC service life.

Check the cooling system only when the engine is stopped and cool.

⚠ WARNING

Personal injury can result from hot coolant, steam and alkali.

At operating temperature, engine coolant is hot and under pressure. The radiator and all lines to heaters or the engine contain hot coolant or steam. Any contact can cause severe burns.

Remove cooling system pressure cap slowly to relieve pressure only when engine is stopped and cooling system pressure cap is cool enough to touch with your bare hand.

Do not attempt to tighten hose connections when the coolant is hot, the hose can come off causing burns.

Cooling System Coolant Additive contains alkali. Avoid contact with skin and eyes.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, PERJ1017, “Dealer Service Tool Catalog” for tools and supplies suitable to collect and contain fluids on Cat ® products.

Dispose of all fluids according to local regulations and mandates.

1. Loosen the cooling system filler cap slowly to relieve pressure. Remove the cooling system filler cap.
2. Draining an amount of coolant from the cooling system to add the Cat ELC Extender may be required.
3. Add Cat ELC Extender according to the requirements for your engine cooling system capacity. Refer to the Operation and Maintenance Manual, “Refill Capacities and Recommendations” article for more information.
4. Clean the cooling system filler cap. Inspect the gaskets on the cooling system filler cap. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.

i08287090

Coolant Level - Check

SMCS Code: 1395-082

Check the coolant level when the engine is stopped and cool.

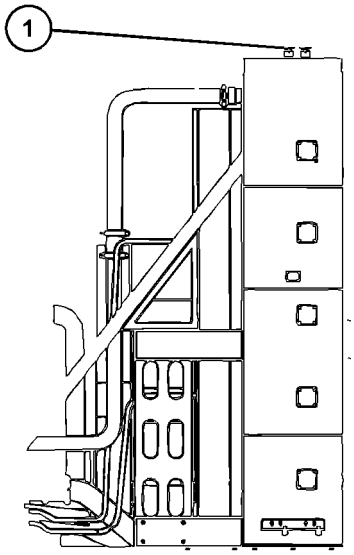

Illustration 68 g06612058

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Remove the cooling system filler cap (1) slowly to relieve pressure.
2. Maintain the coolant level within 13 mm (0.5 inch) of the bottom of the filler pipe. If the engine is equipped with a sight glass, maintain the coolant level to the proper level in the sight glass.

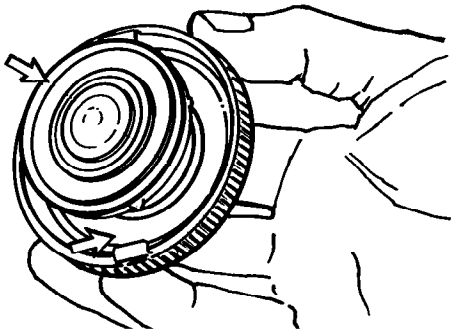

Illustration 69 g00103639

Typical filler cap gaskets

3. Clean the cooling system filler cap and check the condition of the filler cap gaskets. Replace the cooling system filler cap if the filler cap gaskets are damaged. Reinstall the cooling system filler cap.
4. Inspect the cooling system for leaks.

i08331135

Coolant Sample (Level 1) - Obtain

SMCS Code: 1350-008; 1395-008; 1395-554; 7542

Note: Obtaining a Coolant Sample (Level 1) is optional if the cooling system is filled with Cat ELC (Extended Life Coolant). Cooling systems that are filled with Cat ELC should have a Coolant Sample (Level 2) obtained at the recommended interval.

Note: Obtain a Coolant Sample (Level 1) if the cooling system is filled with any other coolant instead of Cat ELC. Other coolants include the following types of coolants:

- Commercial long life coolants that meet the Cat Engine Coolant Specification -1 (Caterpillar EC-1)
- Cat DEAC (Diesel Engine Antifreeze/Coolant)
- Commercial heavy-duty coolant/antifreeze

Table 31

Recommended Interval		
Type of Coolant	Level 1	Level 2

(continued)

(Table 31, contd)

Cat DEAC	Every 250 Hours(1)	Yearly(1) (2)
Cat ELC	Optional(2)	Yearly(2)

(1) This interval is the recommended interval for coolant samples for all conventional heavy-duty coolant/antifreeze. This interval is also the recommended interval for coolant samples of commercial coolants that meet the Cat EC-1 specification for engine coolant.
(2) The Level 2 Coolant Analysis should be performed sooner if a problem is suspected or identified.

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

Note: Level 1 results may indicate a need for Level 2 Analysis.

Obtain the sample of the coolant as close as possible to the recommended sampling interval. To receive the full effect of S·O·S analysis, a consistent trend of data must be established. To establish a pertinent history of data, perform consistent samplings that are evenly spaced. Supplies for collecting samples can be obtained from your Cat dealer.

Use the following guidelines for proper sampling of the coolant:

- Complete the information on the label for the sampling bottle before you begin to take the samples.
- Keep the unused sampling bottles stored in plastic bags.
- Obtain coolant samples directly from the coolant sample port. You should not obtain the samples from any other location.
- Keep the lids on empty sampling bottles until you are ready to collect the sample.
- Place the sample in the mailing tube immediately after obtaining the sample to avoid contamination.
- Never collect samples from expansion bottles.
- Never collect samples from the drain for a system.

Submit the sample for Level 1 analysis.

For additional information about coolant analysis, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” or consult your Cat dealer.

i08331145

Coolant Sample (Level 2) - Obtain

SMCS Code: 1350-008; 1395-554; 1395-008; 7542

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

Refer to Operation and Maintenance Manual, “Coolant Sample (Level 1) - Obtain” for the guidelines for proper sampling of the coolant.

Submit the sample for Level 2 analysis.

For additional information about coolant analysis, see Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engines Fluids Recommendations” or consult your Cat dealer.

i08312042

Coolant Temperature Regulator - Replace

SMCS Code: 1355-510

Replace the water temperature regulator before the water temperature regulator fails. This procedure is a recommended preventive maintenance practice. Replacing the water temperature regulator reduces the chances for unscheduled downtime. Refer to this Operation and Maintenance Manual, “Maintenance Interval Schedule” for the proper maintenance interval.

A water temperature regulator that fails in a partially opened position can cause overheating or overcooling of the engine.

A water temperature regulator that fails in the closed position can cause excessive overheating. Excessive overheating could result in cracking of the cylinder head or piston seizure problems.

A water temperature regulator that fails in the open position will cause the engine operating temperature to be too low during partial load operation. Low engine operating temperatures during partial loads could cause an excessive carbon buildup inside the cylinders. This excessive carbon buildup could result in an accelerated wear of the piston rings and wear of the cylinder liner.

NOTICE
Failure to replace your water temperature regulator on a regularly scheduled basis could cause severe engine damage.

Cat engines incorporate a shunt bypass design cooling system and require operating the engine with a water temperature regulator installed.

If the water temperature regulator is installed incorrectly, the engine may overheat, causing cylinder head damage. Ensure that the new water temperature regulator is installed in the original position. Ensure that the water temperature regulator vent hole is open.

Do not use liquid gasket material on the gasket or cylinder head surface.

Refer to two articles in the Disassembly and Assembly Manual, “Water Temperature Regulators - Remove and Water Temperature Regulators - Install” for the replacement procedure of the water temperature regulator. For additional information refer to this Operation and Maintenance Manual, “Fluid Recommendations” or consult your Cat dealer.

Note: If only the water temperature regulators are replaced, drain the coolant from the cooling system to a level that is below the water temperature regulator housing.

i08312480

Cooling System Supplemental Coolant Additive (SCA) - Test/Add

SMCS Code: 1352-045; 1395-081

⚠ WARNING

Cooling system coolant additive contains alkali. To help prevent personal injury, avoid contact with the skin and eyes. Do not drink cooling system coolant additive.

NOTICE
Excessive supplemental coolant additive concentration can form deposits on the higher temperature surfaces of the cooling system, reducing the engine's heat transfer characteristics. Reduced heat transfer could cause cracking of the cylinder head and other high temperature components.

Excessive supplemental coolant additive concentration could also result in blockage of the heat exchanger, overheating, and/or accelerated wear of the water pump seal.

Do not exceed the recommended amount of supplemental coolant additive concentration.

This maintenance procedure is required for conventional coolants such as DEAC.**Do not perform this maintenance for cooling systems that are filled with Cat Extended Life Coolant (Cat ELC) or Cat Extended Life Inhibitor (Cat ELI).**

Note: Caterpillar recommends an S·O·S coolant analysis (Level 1).

NOTICE
Do NOT mix brands or types of SCA. Do NOT mix SCAs and extenders.

Failure to follow the recommendations can result in shortened cooling system component life.

NOTICE
Use Only Approved SCAs. Conventional coolants require the maintenance addition of SCA throughout their expected life. Do NOT use an SCA with a coolant unless specifically approved by the coolant supplier for use with their coolant. It is the responsibility of the coolant manufacturer to ensure compatibility and acceptable performance.

Failure to follow the recommendations can result in shortened cooling system component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Cat Dealer Service Tool Catalog” and to Special Publication, GECJ0003, “Cat Shop Supplies and Tools” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to applicable regulations and mandates.

Note: Caterpillar recommends that an S·O·S Coolant Analysis (Level 1) is performed to check the concentration of SCA.

Maintain the Proper Concentration of SCA in the Coolant

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Remove the cooling system filler cap slowly.
2. Test the concentration of the SCA with a 286-2578 Nitrite Test Strip or review the results of the S·O·S Coolant Analysis (Level 1).
3. If necessary, drain some coolant to allow space for the addition of the SCA.
4. Add the amount of SCA required to maintain a concentration of 3 percent to 6 percent SCA in the coolant.
5. Clean the cooling system filler cap. Install the cooling system filler cap.

For further information, refer to Special Publication, SEBU6251, “Cat Commercial Diesel Engine Fluids Recommendations”.

For information on Cat coolant conditioner for aluminum components, refer to Special Instruction, REHS7296, “Instructions for Use of Cat Coolant Conditioner for Aluminum Components”.

i08286686

Crankshaft Vibration Damper - Inspect

SMCS Code: 1205-040

The crankshaft vibration damper limits the torsional vibration of the crankshaft. The visconic damper has a weight that is located inside a fluid filled case.

Damage to the crankshaft vibration damper or failure of the damper can increase torsional vibrations. Torsional vibration can result in damage to the crankshaft and to other engine components. A deteriorating damper can cause excessive gear train noise at variable points in the speed range.

A damper that is hot may be the result of excessive friction. This friction could be due to misalignment. Use an infrared thermometer to monitor the temperature of the damper during operation. If the temperature reaches 93 °C (200 °F), consult your Cat dealer.

Inspect the damper for evidence of dents, cracks, and leaks of the fluid.

If a fluid leak is found, determine the type of fluid. The fluid in the damper is silicone. Silicone has the following characteristics: transparent, viscous, and smooth.

If the fluid leak is oil, inspect the crankshaft seals for leaks. If a leak is observed, replace all seals.

Inspect the damper and repair or replace the damper for any of the following reasons.

- The damper is dented or cracked.
- The paint on the damper is discolored from heat.
- The engine has had a failure because of a broken crankshaft.
- The crankshaft bearings are showing excessive wear.
- There is a large amount of gear train wear that is not caused by a lack of oil.

Dampers With Sampling Ports

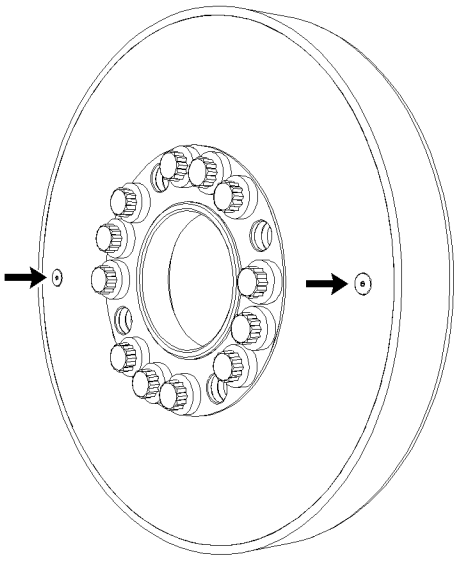

Illustration 70 g01251998

Fluid sampling ports

Some dampers have ports for fluid samples. If the damper has no external damage, collect a 2 to 5 mL sample of the damper fluid. The fluid should be analyzed to check for a loss of viscosity. Use the results of the analysis to determine if the damper should be rebuilt or replaced. Kits for fluid samples are available from the address that follows. Return the kits to the same address for analysis.

Hasse & Wrede GmbH
Mohriner Allee 30-42
D-12347 Berlin
Germany
Phone 49 30 / 70 181 195
Fax 49 30 / 70 09 08-11

Removal and Installation

Refer to the Service Manual or consult your Caterpillar dealer for information about damper replacement.

i08331194

Driven Equipment - Check

SMCS Code: 3279-535

Check the Alignment

Maintain the alignment between the engine and the driven equipment to minimize bearing wear and vibration.

Check the alignment according to the instructions that are provided by the following manufacturers:

- Caterpillar
- OEM of the driven equipment

Torque all fasteners to the proper specifications.

Inspect the Drive Coupling

Inspect the drive coupling according to the instructions that are provided by the OEM of the coupling. For the following service information, see the literature that is provided by the OEM of the coupling:

- Lubrication requirements
- Specifications for the end play
- “Reusability Guidelines”
- Replacement instructions

For additional information, refer to either Special Instructions, REHS 4720 or Special Instructions, REHS 7881 depending on the OEM of the coupling.

Inspect the Radiator Drive Couplings (If equipped)

The radiator that is mounted on the package is driven by a drive shaft that contains rubber drive couplings. Inspect the radiator drive couplings according to the instructions that are provided by the OEM of the coupling.

For additional information, refer to the Special Instructions, REHS 4738.

i08230788

Electrical Connections - Check

SMCS Code: 4459-535

Check all exposed electrical connections for tightness.

Check the following devices for loose mounting or for physical damage:

- transformers
- fuses
- capacitors
- lightning arrestors

Check all lead wires and electrical connections for proper clearance.

i08246334

Engine - Clean

SMCS Code: 1000-070

⚠ WARNING

Personal injury or death can result from high voltage.

Moisture could create paths of electrical conductivity.

Make sure the unit is off line (disconnected from utility and/or other generators), locked out and tagged "Do Not Operate".

NOTICE
Water or condensation can cause damage to generator components. Protect all electrical components from exposure to water.

NOTICE
Accumulated grease and oil on an engine is a fire hazard. Keep the engine clean. Remove debris and fluid spills whenever a significant quantity accumulates on the engine.

Steam cleaning the engine will remove accumulated oil and grease. A clean engine provides the following benefits:

- Easy detection of fluid leaks
- Maximum heat transfer characteristics
- Ease of maintenance

Note: For more information on cleaning and drying electric generators, refer to Special Instruction, SEHS9124, “Cleaning and Drying of Electric Set Generators”.

i08287149

Engine Air Cleaner Element (Dual Element) - Inspect/Clean/Replace
(If Equipped)

SMCS Code: 1051; 1054-510; 1054-040; 1054-070

NOTICE
Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent airborne debris from entering the air inlet.

NOTICE
Never service the air cleaner element with the engine running since this will allow dirt to enter the engine.

Servicing the Air Cleaner Elements

If the air cleaner element becomes plugged, the air can split the material of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear. Your Cat dealer has the proper air cleaner elements for your application. Consult your Cat dealer for the correct air cleaner element.

- Check the precleaner (if equipped) daily for accumulation of dirt and debris. Remove any dirt and debris, as needed.
- Operating conditions (dust, dirt, and debris) may require more frequent service of the air cleaner element.
- The air cleaner element may be cleaned up to six times if the element has been properly cleaned and inspected.
- The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Replace the dirty paper air cleaner elements with clean air cleaner elements. Before installation, check the air cleaner elements thoroughly for tears and/or holes in the filter material. Inspect the gasket or the seal of the air cleaner element for damage. Maintain a supply of suitable air cleaner elements for replacement purposes.

Dual Element Air Cleaners

The dual element air cleaner contains a primary air cleaner element and a secondary air cleaner element. The primary air cleaner element can be used up to six times if the element has been properly cleaned and inspected. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

The secondary air cleaner element is not serviceable or washable. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element. When the engine is operating in environments that are dusty or dirty, air cleaner elements may require more frequent replacement.

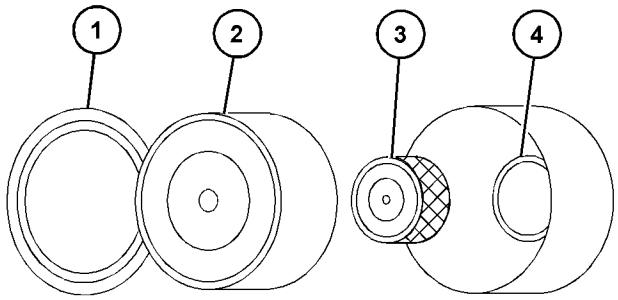

Illustration 71 g06612086

(1) Cover
(2) Primary air cleaner element
(3) Secondary air cleaner element
(4) Air inlet for the turbocharger

1. Remove the cover. Remove the primary air cleaner element.
2. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element.

Note: Refer to “Cleaning the Primary Air Cleaner Elements”.

3. Cover the air inlet to the turbocharger with tape to keep out dirt.

4. Clean inside the air cleaner cover and body with a clean, dry cloth.

5. Remove the tape from the air inlet of the turbocharger. Install the secondary air cleaner element. Install a primary air cleaner element that is new or cleaned.

6. Install the air cleaner cover.

7. Reset the air cleaner service indicator.

Cleaning the Primary Air Cleaner Elements

NOTICE
Caterpillar recommends certified air filter cleaning services that are available at Cat dealers. The Cat cleaning process uses proven procedures to assure consistent quality and sufficient filter life.

Observe the following guidelines if you attempt to clean the filter element:

Do not tap or strike the filter element in order to remove dust.

Do not wash the filter element.

Use low pressure compressed air in order to remove the dust from the filter element. Air pressure must not exceed 207 kPa (30 psi). Direct the air flow up the pleats and down the pleats from the inside of the filter element. Take extreme care in order to avoid damage to the pleats.

Do not use air filters with damaged pleats, gaskets, or seals. Dirt entering the engine will cause damage to engine components.

The primary air cleaner element can be used up to six times if the element has been properly cleaned and inspected. When the primary air cleaner element is cleaned, check for rips or tears in the filter material. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Use clean primary air cleaner elements while dirty elements are being cleaned.

NOTICE
Do not clean the air cleaner elements by bumping or tapping. This could damage the seals. Do not use elements with damaged pleats, gaskets or seals. Damaged elements will allow dirt to pass through. Engine damage could result.

Visually inspect the primary air cleaner elements before cleaning. Inspect the air cleaner elements for damage to the seal, the gaskets, and the outer cover. Discard any damaged air cleaner elements.

There are two common methods that are used to clean primary air cleaner elements:

- Pressurized air
- Vacuum cleaning

Pressurized Air

Pressurized air can be used to clean primary air cleaner elements that have not been cleaned more than two times. Pressurized air will not remove deposits of carbon and oil. Use filtered, dry air with a maximum pressure of 207 kPa (30 psi).

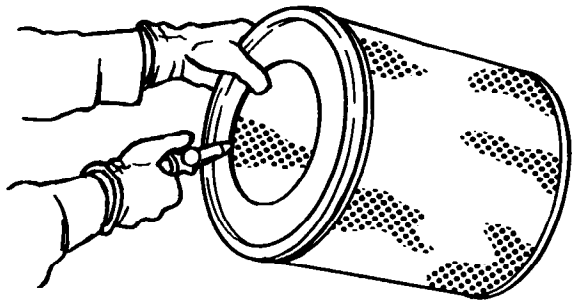

Illustration 72 g00281692

Note: When the primary air cleaner elements are cleaned, always begin with the clean side (inside) to force dirt particles toward the dirty side (outside).

Aim the hose so that the air flows inside the element along the length of the filter to prevent damage to the paper pleats. Do not aim the stream of air directly at the primary air cleaner element. Dirt could be forced further into the pleats.

Note: Refer to “Inspecting the Primary Air Cleaner Elements”.

Vacuum Cleaning

Vacuum cleaning is a good method for cleaning primary air cleaner elements which require daily cleaning because of a dry, dusty environment. Cleaning with pressurized air is recommended prior to vacuum cleaning. Vacuum cleaning will not remove deposits of carbon and oil.

Note: Refer to “Inspecting the Primary Air Cleaner Elements”.

Inspecting the Primary Air Cleaner Elements

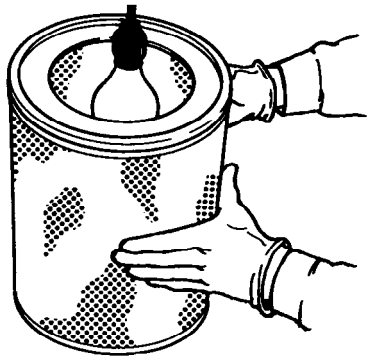

Illustration 73 g00281693

Inspect the clean, dry primary air cleaner element. Use a 60w blue light in a dark room or in a similar facility. Place the blue light in the primary air cleaner element. Rotate the primary air cleaner element. Inspect the primary air cleaner element for tears and/or holes. Inspect the primary air cleaner element for light that may show through the filter material. To confirm the result, compare the primary air cleaner element to a new air cleaner element that has the same part number.

Do not use a primary air cleaner element that has any tears and/or holes in the filter material. Do not use a primary air cleaner element with damaged pleats, gaskets, or seals. Discard damaged primary air cleaner elements.

Storing Primary Air Cleaner Elements

If a primary air cleaner element that passes inspection will not be used, the primary air cleaner element can be stored for future use.

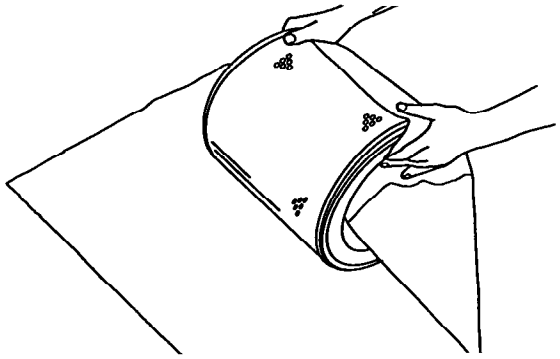

Illustration 74 g00281694

Do not use paint, a waterproof cover, or plastic as a protective covering for storage. An air flow restriction may result. To protect against dirt and damage, wrap the primary air cleaner elements in Volatile Corrosion Inhibited (VCI) paper.

Place the primary air cleaner element into a box for storage. For identification, mark the outside of the box and mark the primary air cleaner element. Include the following information:

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

i08287154

Engine Air Cleaner Element (Single Element) - Inspect/Clean/Replace

SMCS Code: 1051; 1054-040; 1054-070; 1054-510

NOTICE
Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent airborne debris from entering the air inlet.

NOTICE
Never service the air cleaner element with the engine running since this will allow dirt to enter the engine.

Servicing the Air Cleaner Elements

If the air cleaner element becomes plugged, the air can split the material of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear. Your Cat dealer has the proper air cleaner elements for your application. Consult your Cat dealer for the correct air cleaner element.

- Check the precleaner (if equipped) daily for accumulation of dirt and debris. Remove any dirt and debris, as needed.
- Operating conditions (dust, dirt, and debris) may require more frequent service of the air cleaner element.
- The air cleaner element may be cleaned up to three times if the element is properly cleaned and inspected.
- The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Replace the dirty paper air cleaner elements with clean air cleaner elements. Before installation, the air cleaner elements shall be thoroughly checked for tears and/or holes in the filter material. Inspect the gasket or the seal of the air cleaner element for damage. Maintain a supply of suitable air cleaner elements for replacement purposes.

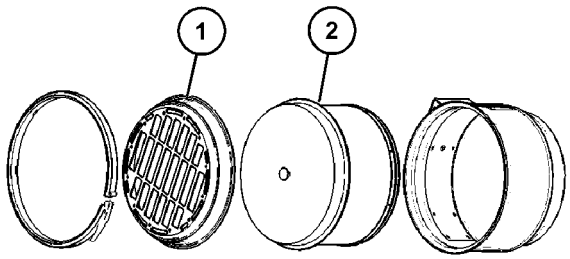

Illustration 75 g06612095

Typical example

(1) Cover
(2) Air cleaner element

1. Remove the air cleaner cover (1). Remove the air cleaner element (2).

Note: Refer to “Cleaning the Air Cleaner Elements”.

2. Cover the air inlet with tape to keep out dirt.

3. Clean inside the air cleaner cover and body with a clean, dry cloth.

4. Remove the tape from the air inlet. Install an air cleaner element that is new or cleaned.

5. Install the air cleaner cover.

6. Install and latch the clamp.

7. Reset the air cleaner service indicator.

Cleaning the Air Cleaner Elements

NOTICE
Caterpillar recommends certified air filter cleaning services that are available at Caterpillar dealers. The Caterpillar cleaning process uses proven procedures to assure consistent quality and sufficient filter life.

Observe the following guidelines if you attempt to clean the filter element:

Do not tap or strike the filter element in order to remove dust.

Do not wash the filter element.

Use low pressure compressed air in order to remove the dust from the filter element. Air pressure must not exceed 207 kPa (30 psi). Direct the air flow into the outlet end of the filter element, keeping the nozzle at least 50 mm (2 inches) away from the outlet face of the filter element.

Do not use air filters with damaged pleats, gaskets, or seals. Dirt entering the engine will cause damage to engine components.

The air cleaner element can be used up to three times if the element is properly cleaned and inspected. When the air cleaner element is cleaned, check for rips or tears in the filter material. The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Use clean air cleaner elements while dirty elements are being cleaned.

NOTICE
Do not clean the air cleaner elements by bumping or tapping. This could damage the seals. Do not use elements with damaged pleats, gaskets or seals. Damaged elements will allow dirt to pass through. Engine damage could result.

Visually inspect the air cleaner elements before cleaning. Inspect the air cleaner elements for damage to the seal, the gaskets, and the outer cover. Discard any damaged air cleaner elements.

Pressurized Air

Pressurized air can be used to clean air cleaner elements up to three times. Pressurized air will not remove deposits of carbon and oil. Use filtered, dry air with a maximum pressure of 207 kPa (30 psi). Keep the air nozzle at least 50 mm (2 inch) away from the face of the filter element.

Note: When the air cleaner elements are cleaned, always apply air pressure to the outlet side of the filter element.

Note: Do not clean air filter elements more than three times before replacing.

Note: Refer to “Inspecting the Air Cleaner Elements”.

Inspecting the Air Cleaner Elements

Inspect the clean, dry air cleaner element. Do not use an air cleaner element that has any tears and/or holes in the filter material. Do not use an air cleaner element with damaged pleats, gaskets, or seals. Discard damaged air cleaner elements.

Storing Air Cleaner Elements

If an air cleaner element that passes inspection will not be used, the air cleaner element can be stored for future use.

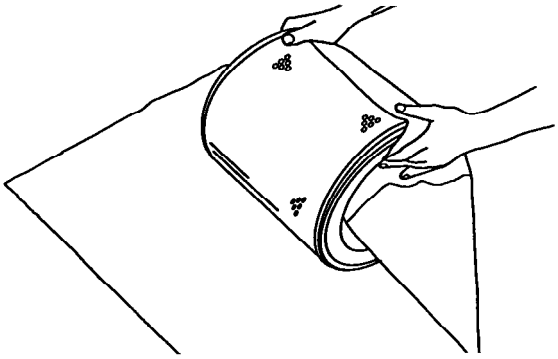

Illustration 76 g00281694

Do not use paint, a waterproof cover, or plastic as a protective covering for storage. An air flow restriction may result. To protect against dirt and damage, wrap the air cleaner elements in Volatile Corrosion Inhibited (VCI) paper.

Place the air cleaner element into a box for storage. For identification, mark the outside of the box and mark the air cleaner element. Include the following information:

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

i06103548

Engine Air Cleaner Service Indicator - Inspect
(If Equipped)

SMCS Code: 7452-040

Some engines may be equipped with a different service indicator.

Some engines are equipped with a differential gauge for inlet air pressure. The differential gauge for inlet air pressure displays the difference in the pressure that is measured before and after the air cleaner element. As the air cleaner element becomes dirty, the pressure differential rises. If your engine is equipped with a different type of service indicator, follow the OEM recommendations in order to service the air cleaner service indicator.

The service indicator may be mounted on the clean side of the air cleaner housing or in a remote location.

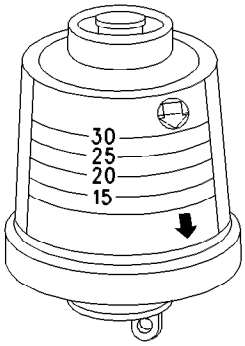

Illustration 77 g00103777
Typical service indicator

Observe the service indicator. The air cleaner element should be cleaned or the air cleaner element should be replaced when one of the following conditions occur:

- The yellow diaphragm enters the red zone.
- The red piston locks in the visible position.

Test the Service Indicator

Service indicators are important instruments.

- Check for ease of resetting. The service indicator should reset in less than three pushes.

- Check the movement of the service indicator core when the engine is run at full load speed. The core should latch approximately at the greatest vacuum that is attained.

If the service indicator does not reset easily, or if the core does not latch at the greatest vacuum, the service indicator should be replaced. If the new service indicator will not reset, the hole for the service indicator may be plugged.

If necessary, replace the service indicator more frequently in environments that are severely dusty. Replace the service indicator annually regardless of the operating conditions. Replace the service indicator when the engine is overhauled, and whenever major engine components are replaced.

Note: When a new service indicator is installed, excessive force may crack the top of the service indicator. Tighten the service indicator to a torque of 2 N·m (18 lb in).

i08287009

Engine Crankcase Breather - Clean

SMCS Code: 1317-070

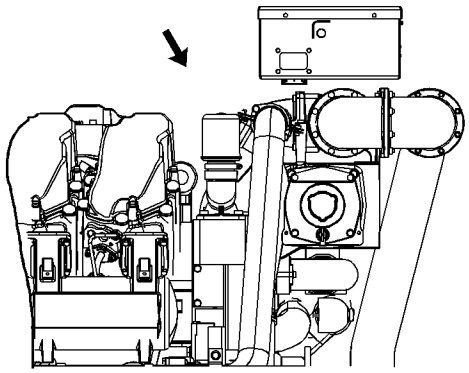

Illustration 78 g01245639

The crankcase breather helps to prevent a buildup of pressure in the crankcase. Some of the oil from the fumes that are produced in the crankcase is collected in the breather elements. The fumes are exhausted into the atmosphere.

If the crankcase breather is not maintained regularly, the crankcase breather will become plugged. A plugged crankcase breather will cause excessive crankcase pressure that may cause crankshaft seal leakage. The breather elements may be cleaned.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Cat Dealer Service Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Cleaning the Crankcase Breathers

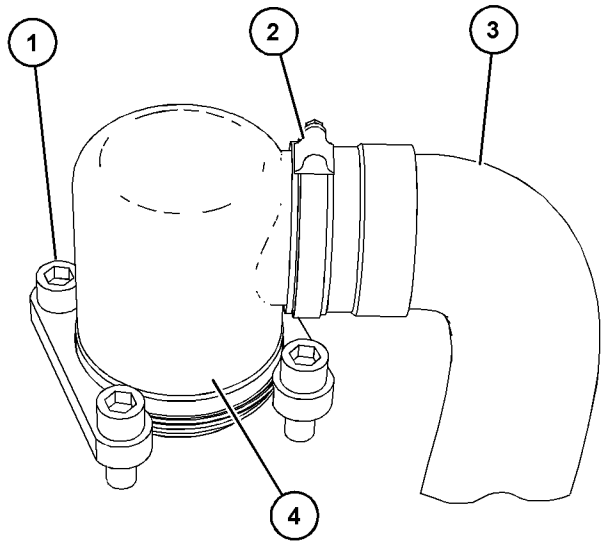

Illustration 79 g06611990

(1) Bolt
(2) Clamp
(3) Tube
(4) Breather

1. Loosen clamp (2). Slide the clamp onto tube (3).

2. Remove bolts (1) and the retainers.

3. Remove the breather.

4. Clean the breather elements with clean, nonflammable solvent.

Turn the breathers upside-down to inspect the condition of the breather elements. If the breather elements remain contaminated after the cleaning, discard the breathers and obtain new breathers. Do not attempt to disassemble the breathers.

Allow the breather elements to dry before installation.

5. The breather has a rubber gasket that is a part of the unit. Coat the gasket with clean engine oil.
6. Reinstall breather (4), the retainers, and bolts (1). For the proper torque, refer to the Service Manual, “Specifications”.
7. Place hose (3) on the breather. Slide the clamp into the proper position and tighten. For the proper torque, refer to the Service Manual, “Specifications”.

i08267181

Engine Mounts - Inspect

SMCS Code: 1152; 1152-040

Misalignment of the engine and the driven equipment will cause extensive damage. Excessive vibration can lead to misalignment. Excessive vibration of the engine and the driven equipment can be caused by the following conditions:

- Improper mounting
- Loose bolts
- Deterioration of the isolators

Ensure that the mounting bolts are tightened to the proper torque. For standard torques, see Specifications, SENR3130, “Torque Specifications”.

Ensure that the isolators are free of oil and contamination. Inspect the isolators for deterioration. Ensure that the bolts for the isolators are tightened to the proper torque.

Replace any isolator that shows deterioration. For more information, see the literature that is provided by the OEM of the isolators. Also see the Application and Installation Guide for the engine. Consult your Cat dealer for assistance.

i08287044

Engine Oil Filter Differential Pressure - Check

SMCS Code: 1308-535

Observe the oil filter differential pressure frequently during engine operation.

Oil Filter Differential Pressure (Restriction) – Indicates the difference in pressure between the inlet side and the outlet side of the engine oil filters. As the oil filter elements become plugged, oil filter differential pressure will increase.

The nominal oil filter differential pressure during normal engine operation is approximately 60 kPa (9 psi).

Replace the oil filter elements when the oil filter differential pressure reaches 152 kPa (22 psi).

For instructions on replacement of the oil filter elements, see this Operation and Maintenance Manual, “Engine Oil and Filter - Change” topic.

i08331187

Engine Oil Level - Check

SMCS Code: 1348-535-FLV

The most accurate check of the engine oil level is obtained when the engine is stopped and the engine oil is cold.

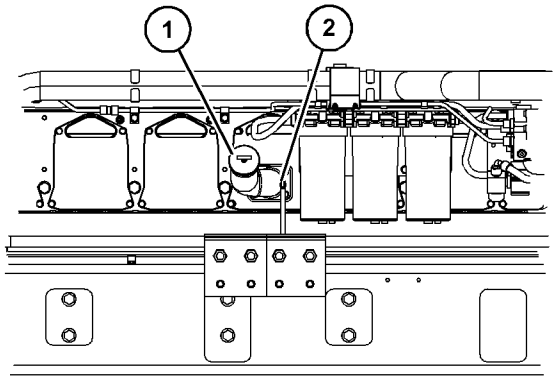

Illustration 80 g06631796

(1) Filler cap
(2) Engine oil level gauge (dipstick)

1. Remove filler cap (1) to ensure that the crankcase pressure is equal to the atmospheric pressure.

   Excess pressure or a slight vacuum will affect engine oil level that is measured.
2. Ensure that engine oil level gauge (2) is seated.

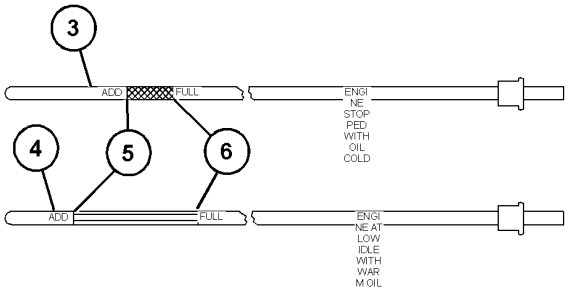

Illustration 81 g06631798

(3) “ENGINE STOPPED WITH OIL COLD” side
(4) “ENGINE AT LOW IDLE WITH WARM OIL” side
(5) “ADD” mark
(6) “FULL” mark

a. If the engine is stopped, remove the engine oil level gauge. Observe the engine oil level on “ENGINE STOPPED WITH OIL COLD” side (3).

b. If the engine is operating, reduce the engine speed to low idle. Remove the engine oil level gauge and observe the engine oil level on “ENGINE AT LOW IDLE WITH WARM OIL” side (4).

The engine oil level should be between “ADD” mark (5) and “FULL” mark (6).

NOTICE
Engine damage can occur if the crankcase is filled above the “FULL” mark on the oil level gauge (dipstick).

An overfull crankcase can cause the crankshaft to dip into the oil. This will reduce the power that is developed and also force air bubbles into the oil. These bubbles (foam) can cause the following problems: reduction of the oil's ability to lubricate, reduction of oil pressure, inadequate cooling, oil blowing out of the crankcase breathers and excessive oil consumption.

Excessive oil consumption will cause deposits to form on the pistons and in the combustion chamber. Deposits in the combustion chamber lead to the following problems: guttering of the valves, packing of carbon under the piston rings and wear of the cylinder liner.

If the oil level is above the “FULL” mark on the oil level gauge, drain some of the oil immediately.

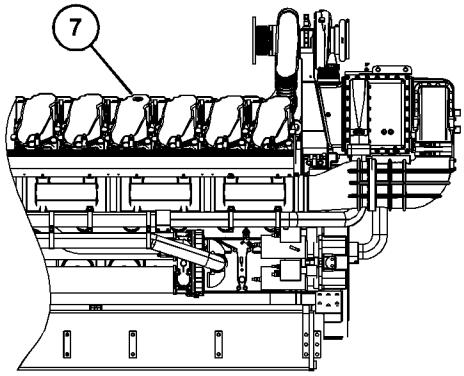

Illustration 82 g06631801

3. If necessary, add engine oil to the make up oil filler (7) that is on one of the valve covers on the engine. Use a stand or a platform to reach the make up oil fill cap. Follow the instructions for mounting the engine that is in the “Mounting and Dismounting” topic. For the correct engine oil to use, refer to this Operation and Maintenance Manual, “Fluid Recommendations” topic (Maintenance Section). Do not fill the crankcase above the “FULL” mark on the engine oil level gauge. Clean the filler cap. Install the filler cap.

4. Record the amount of engine oil that is added. For the next engine oil sample and analysis, include the total amount of engine oil that has been added since the previous oil change. This record will help to provide the most accurate analysis.

i08331150

Engine Oil Sample - Obtain

SMCS Code: 1348-554-SM

In addition to a good preventive maintenance program, Caterpillar recommends using S·O·S oil analysis at regularly scheduled intervals. S·O·S oil analysis provides infrared analysis, which is required for determining nitration and oxidation levels.

Obtain the Sample and the Analysis

⚠ WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Before you take the oil sample, complete the Label, PEEP5031 for identification of the sample. To help obtain the most accurate analysis, provide the following information:

- Engine model
- Service hours on the engine
- The number of hours that have accumulated since the last oil change
- The amount of oil that has been added since the last oil change

To ensure that the sample is representative of the oil in the crankcase, obtain a warm, mixed oil sample.

To avoid contamination of the oil samples, the tools and the supplies that are used for obtaining oil samples must be clean.

Caterpillar recommends using the sampling valve to obtain oil samples. The quality and the consistency of the samples are better when the sampling valve is used. The location of the sampling valve allows oil that is flowing under pressure to be obtained during normal engine operation.

The 169-8373 Fluid Sampling Bottle is recommended for use with the sampling valve. The fluid sampling bottle includes the parts that are needed for obtaining oil samples. Instructions are also provided.

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

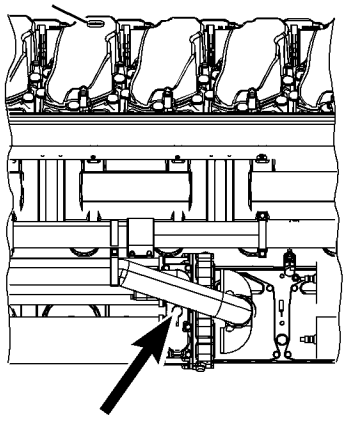

Illustration 83 g02361263
Engine oil sampling port

If the engine is not equipped with a sampling valve, use the 1U-5718 Vacuum Pump. The pump is designed to accept sampling bottles. Disposable tubing must be attached to the pump for insertion into the sump.

For instructions, see Special Publication, PEGJ0047, “How To Take A Good S·O·S Oil Sample”. Consult your Cat dealer for complete information and assistance in establishing an S·O·S program for your engine.

i08331202

Engine Oil and Filter - Change

SMCS Code: 1318-510

⚠ WARNING

Hot oil and components can cause personal injury.

Do not allow hot oil or components to contact skin.

The oil change interval will be affected by the following items:

- Engine application
- Size of the oil sump
- Fuel type
- Oil type
- Ambient air conditions

- Air/fuel ratio

The S·O·S oil analysis program analyzes used oil to determine if the oil change interval is suitable for your specific engine.

Drain the Engine Oil

Do not drain the oil when the engine is cold. As the oil cools, suspended waste particles settle on the bottom of the oil pan. The waste particles are not removed when the cold oil is drained. Drain the crankcase when the oil is warm. This draining method allows the waste particles that are suspended in the oil to be drained properly.

Failure to follow this recommended procedure will allow the waste particles to be recirculated through the engine lubrication system with the new oil.

1. After the engine has been operated at normal operating temperature, STOP the engine.

2. Drain the oil according to the equipment on the engine.

Note: The threads that are provided on the drain valve are metric. Drain the oil into a suitable container. Dispose of the oil according to local regulations.

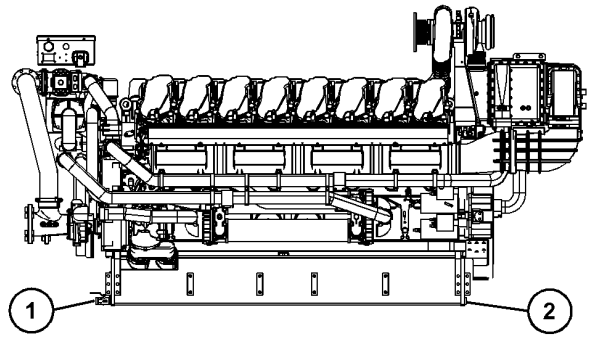

Illustration 84 g06631812

(1) Oil drain valve
(2) Oil drain plug

a. Open oil drain valve (1). Oil drain plug (2) may also be used to drain the oil. After the oil has drained, close the oil drain and/or reinstall the drain plug.

b. If a suction device is inserted into the oil pan, ensure that the suction device is clean. The suction device will prevent dirt from entering into the oil pan. Be careful not to strike the engine oil suction tubes or the piston cooling jets.

c. If a suction device that attaches to the oil drain is used, ensure that the suction device is clean. Attach the suction device to the oil drain. Open the oil drain. After the oil has drained, close the oil drain and remove the suction device.

Replace the Oil Filter Elements

Replace the engine oil filters when either of the following conditions are met:

- Every oil change
- The engine oil filter differential pressure reaches 103 kPa (15 psi).

Service tools are available to aid in the service of oil filters. Consult your Cat dealer for the part names and the part numbers. Follow the instructions that are supplied with the service tools. If the service tools are not used, perform the following appropriate procedure.

Replacing the Engine Oil Filters With the Engine Stopped

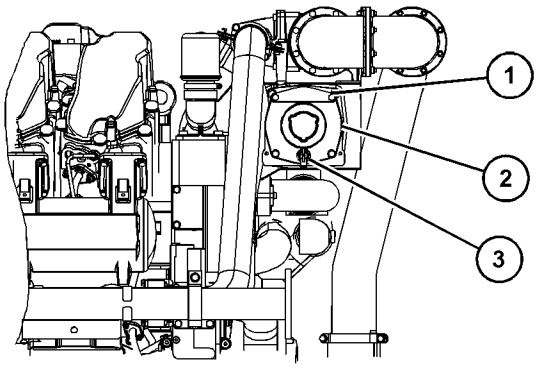

Illustration 85 g06631815

(1) Bolts
(2) Cover
(3) Drain valve

Note: Drain the oil into a suitable container. Dispose of the oil according to local regulations.

1. Connect a hose to drain valve (3). Place the other end of the hose into a suitable container to collect the oil.

2. Open drain valve (3). Allow the oil to drain. Clean the plug and install the plug. Close the drain valve. Remove the hose from the drain.

⚠ WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

Note: Some oil will remain in the housing after the oil has been drained. This oil will pour out of the housing when cover (2) is removed. Prepare to catch the oil in a suitable container. Clean up any spilled oil with rags. DO NOT use absorbent particles to clean up the oil.

3. Be alert to the spring force. Gradually loosen but do not remove bolts (1). Before removing bolts (1), pry the cover (2) loose to relieve any spring pressure. Remove cover (2). Remove the O-ring seal inside the cover.

4. Clean cover (2) and clean the O-ring seal. Clean inside the oil filter housing.

NOTICE
Caterpillar oil filters are built to Caterpillar specifications. Use of an oil filter not recommended by Caterpillar could result in severe engine damage to the engine bearings, crankshaft, etc., as a result of the larger waste particles from unfiltered oil entering the engine lubricating system. Only use oil filters recommended by Caterpillar.

5. Install new oil filter elements.

6. Inspect the O-ring seal. Ensure that the surfaces for the O-ring seal are clean. Install a new O-ring seal if the old O-ring seal is damaged or deteriorated.

7. Install cover (2). Ensure that the springs are seated properly between the cover and the oil filter elements.

Replace the Oil Filter Elements During Engine Operation

⚠ WARNING

Filter contains hot pressurized fluid when engine is running.

Follow instructions on control valve to avoid personal injury.

If rapid air movement exists to blow fluid, Stop the engine to avoid fire.

If replacing the oil filters during engine operation is necessary, perform the following procedure.

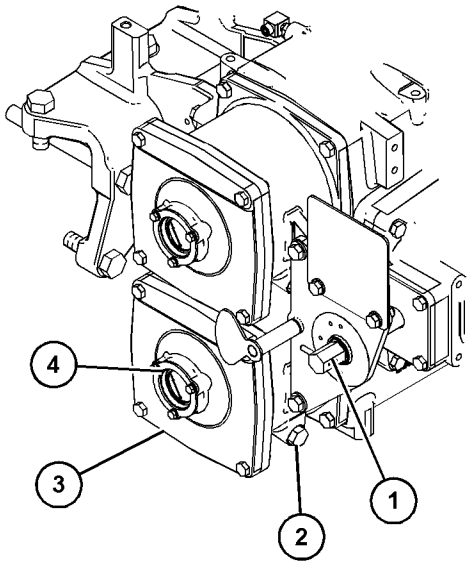

Illustration 86 g06631817

(1) Control valve
(2) Drain
(3) Cover
(4) Pressure gauge

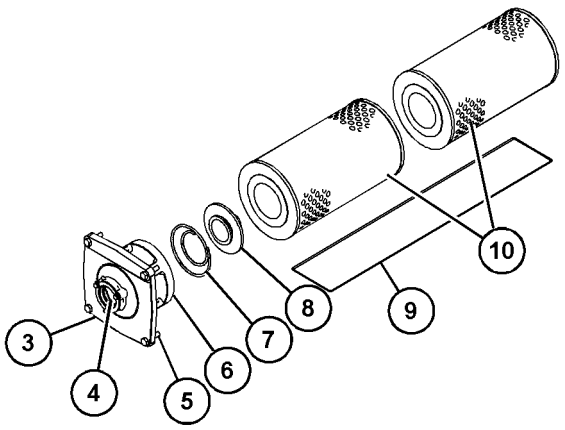

Illustration 87 g06631822

1. Connect a drain tray to the drain valve (2). Use a suitable container to catch the used oil.

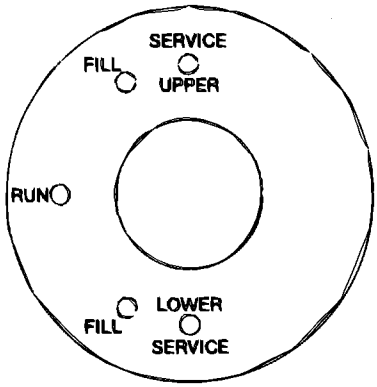

Illustration 88 g03363303

2. Rotate control valve (1) to the “LOWER SERVICE” position.

3. Open drain valve (2) and drain the lower oil filter housing.

4. Observe pressure gauge (4) until the pressure is “0” .

⚠ WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

Note: DO NOT use absorbent particles to clean up the oil.

5. Some oil will remain in the housing after the oil has been drained. Prepare to catch the oil in a suitable container. Clean up any spilled oil with rags. Be alert to the spring force. The cover has a spring (7) with a force up to 240 N (54 lb). Gradually loosen but do not remove the last two bolts (5) or nuts that are at opposite ends of cover (3). Before removing the last two bolts, pry the cover loose or tap the cover with a rubber mallet to relieve any spring pressure.

6. Gradually remove cover and O-ring seal (6).

7. Remove spring (7) and retainer (8).

8. Elements (10) are mounted on wire rack (9) inside the housing. Use a pan to catch the oil that drips when wire rack is removed. Remove wire rack. Remove used elements (10). Clean up any oil that is spilled.

NOTICE
Caterpillar oil filters are built to Caterpillar specifications. Use of an oil filter not recommended by Caterpillar could result in severe engine damage to the engine bearings, crankshaft, etc., as a result of the larger waste particles from unfiltered oil entering the engine lubricating system. Only use oil filters recommended by Caterpillar.

9. Ensure that the new oil filter elements are in good condition. Place the elements on wire rack . Install the wire rack and the elements.

10. Ensure that the surfaces for O-ring seal (6) are clean. Inspect the O-ring seal. If the old O-ring seal is damaged or deteriorated, replace the old O-ring seal with a new O-ring seal. Install the O-ring seal.

11. Install cover (3). Ensure that the spring is seated properly between retainer (8) and cover (3). Close drain valve (2).

12. Rotate control valve (1) to the “LOWER FILL” position. Observe pressure gauge (4). Check cover (3) for leaks.

Note: A hydraulic stop will limit the rotation of the control valve until the oil filter housing is full of oil.

13. After the pressure of the lower oil filter and the upper oil filter are equal, rotate control valve (1) to the “UPPER SERVICE” position. Repeat Step 1 through Step 12 for the upper oil filter.

14. After servicing the oil filters and the pressure of the lower and upper oil filters are equal, rotate control valve (1) to the “RUN” position.

Fill the Crankcase

NOTICE
Only use oils that are recommended by Caterpillar. For the proper oil to use, refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic (Maintenance Section).

NOTICE
If the engine is equipped with an auxiliary oil filter system, extra oil must be added when filling the crankcase. If equipped with an auxiliary oil filter system that is not supplied by Caterpillar, follow the recommendations of the OEM.

NOTICE
Engine damage can occur if the crankcase is filled above the “FULL” mark on the oil level gauge (dipstick).

An overfull crankcase can cause the crankshaft to dip into the oil. This will reduce the power that is developed and also force air bubbles into the oil. These bubbles (foam) can cause the following problems: reduction of the oil's ability to lubricate, reduction of oil pressure, inadequate cooling, oil blowing out of the crankcase breathers and excessive oil consumption.

Excessive oil consumption will cause deposits to form on the pistons and in the combustion chamber. Deposits in the combustion chamber lead to the following problems: guttering of the valves, packing of carbon under the piston rings and wear of the cylinder liner.

If the oil level is above the “FULL” mark on the oil level gauge, drain some of the oil immediately.

Use the following procedure to fill the crankcase if the engine oil filters were replaced with the engine stopped.

1. Remove the oil filler cap. Fill the crankcase through the oil filler tube only. For the amount of oil to use, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic (Maintenance Section). Clean the oil filler cap. Install the oil filler cap.

NOTICE
To prevent engine damage, crank engine with fuel off to fill all filters before starting.

Do Not crank engine for more than 30 seconds.

2. Close the fuel supply line and crank the engine until the oil pressure gauge indicates 70 kPa (10 psi). Open the fuel supply line. Allow the starting motor to cool for 2 minutes before cranking again.

3. Start the engine according to this Operation and Maintenance Manual, “Starting The Engine” procedure (Operation Section). Operate the engine at low idle for 2 minutes. This process will ensure that the lubrication system has oil and that the oil filters are filled with oil. Inspect the engine for oil leaks. Ensure that the oil level is at the “FULL” mark on the “LOW IDLE” side of the oil level gauge.

4. Stop the engine and allow the oil to drain back into the sump for a minimum of 10 minutes.

5. Remove the oil level gauge and check the oil level. Maintain the oil level to the “FULL” mark on the “ENGINE STOPPED” side of the oil level gauge.

Inspect the Used Oil Filter Elements

Cut the used oil filter element open with a utility knife. Remove the metal wrap. Cut the filter element free from the end caps. Spread apart the pleats and inspect the element for metal debris. An excessive amount of debris in the element may indicate early wear or a pending failure.

Use a magnet to differentiate between the ferrous metals and the nonferrous metals that are found in the element. Ferrous metals may indicate wear on the steel and the cast iron parts of the engine. Nonferrous metals may indicate wear on the aluminum parts, the brass parts, or the bronze parts of the engine. Parts that may be affected include the following components: main bearings, rod bearings, turbocharger bearings, and cylinder heads.

Due to normal wear and friction, small amounts of debris may be found in the oil filter element. If an excessive amount of debris is found in the oil filter element, consult your Caterpillar dealer to arrange for further oil analysis.

Drain the Fuel Injection Pump Oil (Wet-Sump Pump)

Note: Perform the following procedure at the same interval as the engine oil and filter change.

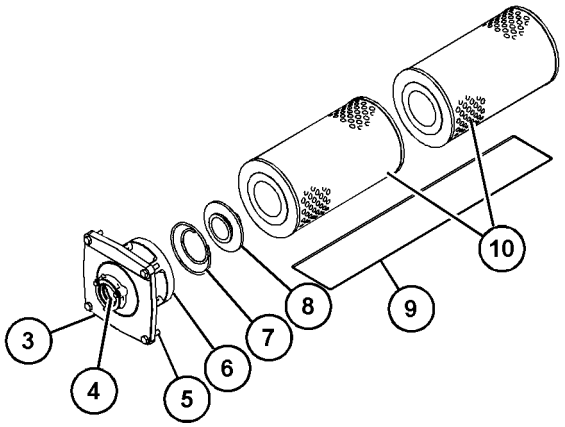

Illustration 89 g06631822

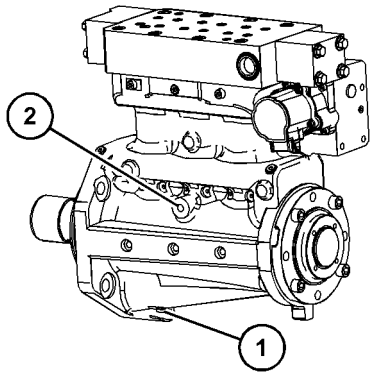

Illustration 90 g06631826

(1) Oil drain plug
(2) Oil fill plug

1. Remove the oil fill plug (2).

Note: An oil fill plug is on each side of the fuel injection pump housing.

2. Remove the oil drain plug (1). Allow the oil to drain into a suitable container.

3. Clean and reinstall the oil drain plug.

4. Utilizing a hand priming pump, fill the pump with oil. For the correct type and amount of oil to use, refer to this Operation and Maintenance Manual (Maintenance Section), “Refill Capacities and Recommendations”.

5. Clean and reinstall the oil fill plug.

i08258801

Engine Protective Devices - Check

SMCS Code: 7400-535

Alarms and shutoffs must function properly. Alarms provide timely warning to the operator. Shutoffs help to prevent damage to the engine. Determining if the engine protective devices are in good working order during normal operation is impossible. Malfunctions must be simulated to test the engine protective devices.

A calibration check of the engine protective devices will ensure that the alarms and shutoffs activate at the setpoints. Ensure that the engine protective devices are functioning properly.

NOTICE
During testing, abnormal operating conditions must be simulated.

The tests must be performed correctly in order to prevent possible damage to the engine.

To prevent damage to the engine, only authorized service personnel or your Cat dealer should perform the tests.

Visual Inspection

Visually check the condition of all gauges, sensors, and wiring. Look for wiring and components that are loose, broken, or damaged. Damaged wiring or components should be repaired or replaced immediately.

i06258980

Engine Valve Lash - Check

SMCS Code: 1105-535

Note: For procedures on adjusting the valve lash, see Testing and Adjusting, “Valve Lash Adjustment”. Consult your Cat dealer for assistance.

Engine Valve Lash

NOTICE
Only qualified service personnel should perform this maintenance. Refer to the Systems Operation/Testing and Adjusting Manual, “Valve Lash and Valve Bridge Adjustment” article or consult your Caterpillar dealer for the complete valve lash adjustment procedure.

Operation of Caterpillar engines with improper valve adjustments can reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component life.

If the valve lash is within the tolerance, an adjustment of the valve lash is NOT necessary.

Perform the valve lash setting when the engine is cold. After the engine has been shut down and the valve covers are removed, the engine is considered cold. Before performing maintenance, prevent the entry of foreign matter into the top of the cylinder head and the valve mechanism. Thoroughly clean the area around the valve mechanism covers.

For the valve lash setting, see Testing and Adjusting , “Valve Lash - Adjust”.

i08272323

Fan Drive Bearing - Lubricate

SMCS Code: 1359-086-BD

Inspect fan drive bearings for wear or damage. If the bearings are loose, replace the bearings and perform an inspection of internal components.

To determine bearing health, refer to Tool Operating Manual, NEHS1302, “469-1621 Vibration Analyzer” and utilize 474 - 9414 Shock Pulse Transducer tool.

Note: Bearings should be replaced at each overhaul interval.

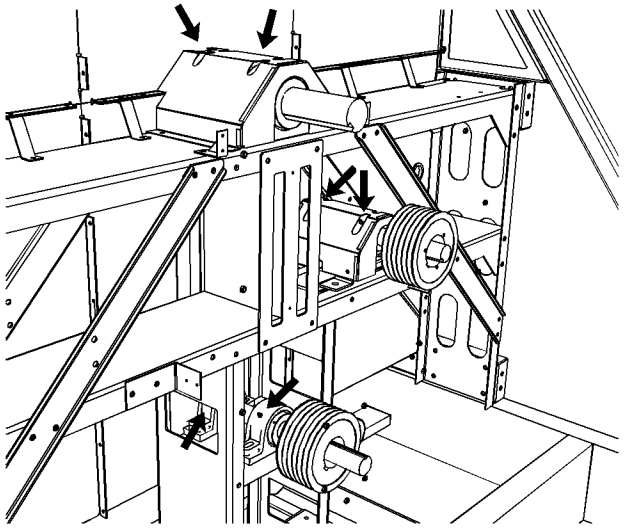

Illustration 91 g01269845

The fan pulley bearings are shown without the belt guard and the fan pulley.

There are six grease fittings on the fan drive system. Lubricate the grease fittings with a Cat NLGI grade 2 lithium based extreme pressure grease or the equivalent.

Inspect the shaft for wear or damage. If a shaft is loose, replace the shaft. Refer to the Service Manual for more information.

i08287045

Fuel System - Prime

SMCS Code: 1250-548; 1258-548

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off, depress the emergency stop button, and turn the battery disconnect switch to the OFF position when changing fuel filters or water separator elements. Clean up fuel spills immediately.

Prime the fuel system to fill the fuel filter, and prime the fuel system to purge trapped air. The fuel system should be primed under the following conditions:

- The injector has been changed.
- The fuel filter has been changed.
- The fuel system is dry.

1. Connect a hose with a quick disconnect to the monoblock and route the hose into a 5 gallon container.

2. Connect a laptop computer that is equipped with Electronic Technician (ET) to the CAN1 service connector.

3. Initiate ET and select an electronic control module (ECM).

4. Enter the configuration mode and select the Electronic Modular Control Panel (EMCP 3).

5. Expand the “Automatic Start/Stop” section from the menu.

6. Scroll to “Fuel Priming Feature Enable Status” . Double-click the value and change “Disabled” to “Enabled” to enable this feature. Refer to table 32 .

Table 32

Description	Value
Automatic Start/Stop	
Engine Operating State Input Configuration	CAN Input
Fuel Priming Feature Enable Status	Disabled
Engine Forced Idle Feature Enable Status	Enabled

7. Scroll to the “Engine Operating State Input Configuration” . Double-click the “Value” field and change “Can Input” to “Hardwired Input” . Refer to table 33 .

Table 33

Description	Value
Automatic Start/Stop	
Engine Operating State Input Configuration	CAN Input
Fuel Priming Feature Enable Status	Enabled
Engine Forced Idle Feature Enable Status	Enabled

8. Access the Electronic Modular Control Panel that is on your engine.

Note: For more information regarding the electronic module control panel, refer to this Operation and Maintenance Manual, “Electronic Module Control Panel 3”.

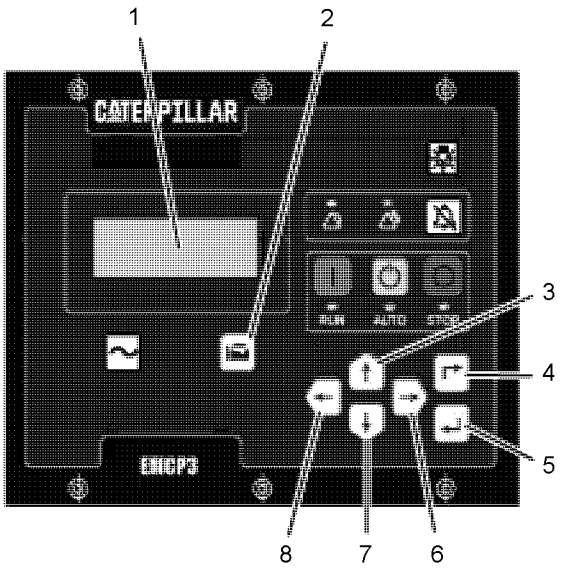

Illustration 92 g01700299

(1) Display Screen
(2) Engine Overview Key
(3) Up Key
(4) Escape Key
(5) Enter Key
(6) Right Key
(7) Down Key
(8) Left Key

9. Press the engine overview key (2). Press and hold the escape key (4).

10. Use the down key (7) to scroll to “Control” . Press the enter key (5).

11. Use the down key (7) to scroll to “Engine Fuel Priming” . Press the enter key(5).

12. Use the right key (6) to select “ON” .

The display screen (1) will indicate “Priming” . A timed countdown will determine the amount of time that is needed to prime the fuel system. The fuel system priming will automatically stop when the timed countdown has expired. Priming may be manually discontinued at any time by pressing the left key. Refer to table 32

13. Confirm that the fuel system is priming.

- The display screen (1) should indicate priming.
- The Relay Output 2 “(RO2)” should be activated.
- The fuel priming pump should be running.

14. Once the priming has been discontinued, the display screen (1) will indicate “OFF” . Press the “Engine Overview” key (2).

15. Return to the ET. Scroll to “Engine Operating State Input Configuration” . Double-click the value and change “Hardwired Input” to “CAN Input” .

16. Scroll to “Fuel Priming Feature Enable Status” . Double-click the value and change “Enabled” to “Disabled” to disable this feature.

17. Remove the hose with a quick disconnect from the monoblock.

18. Exit ET.

i08335378

Fuel System Primary Filter - Clean/Inspect/Replace

SMCS Code: 1260-571; 1260-510

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

Ensure that the engine is stopped before servicing the primary filter.

Replace the primary fuel filter elements whenever the following conditions occur:

- The differential pressure gauge for the fuel filter registers 103 kPa (15 psi).
- The fuel filters have been used for 1200 service hours.
- The inlet pressure to the fuel transfer pump is less than 40 kPa (5.8 psi).

Replacing the Fuel Filter Elements

NOTICE
Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over any disconnected fuel system components.

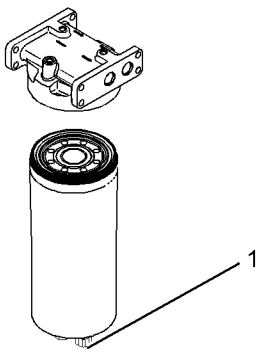

Illustration 93 g01462052
(1) Drain valve

NOTICE
Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

1. Open drain valve(1) and drain the fuel from the filter into a suitable container.

2. Remove the old filter.

3. Apply clean diesel fuel to the new fuel filter gasket.

NOTICE
Do not fill the fuel filters with fuel before installing the fuel filters. The fuel will not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

4. Spin the new fuel filter into the fuel filter base until the gasket contacts the base. Tighten the fuel filter by hand by one full turn. Do not overtighten the fuel filter. Use the rotation index marks that are on the fuel filter as a guide for proper tightening.

i08287029

Fuel System Primary Filter/ Water Separator - Drain

SMCS Code: 1260-543; 1263-543

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

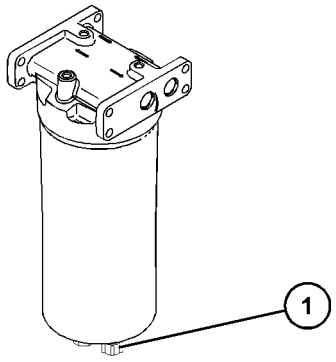

Illustration 94 g06611998

(1) Drain

1. Open drain (1). Catch the draining water in a suitable container. Dispose of the water properly.

2. Close drain (1).

NOTICE
The water separator is under suction during normal engine operation. Ensure that the drain valve is tightened securely to help prevent air from entering the fuel system.

i08335366

Fuel System Secondary Filter - Replace

SMCS Code: 1261-510-SE

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

Note: Refer to Testing and Adjusting Manual, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

NOTICE
Ensure that the engine is stopped before any servicing or repair is performed.

NOTICE
Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over any disconnected fuel system components.

Replace the secondary fuel filter elements whenever the following conditions occur:

- The differential pressure gauge registers 103 kPa (15 psi).
- The fuel filters have been used for 1200 service hours.

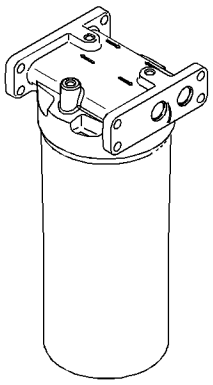

Illustration 95 g01948301

NOTICE
Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

1. Remove the old filter.

2. Apply clean diesel fuel to the new fuel filter gasket.

NOTICE
Do not fill the fuel filters with fuel before installing the fuel filters. The fuel will not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

3. Spin the new fuel filter into the fuel filter base until the gasket contacts the base. Tighten the fuel filter by hand by one full turn. Do not overtighten the fuel filter. Use the rotation index marks that are on the fuel filter as a guide for proper tightening.

Note: Your product may have an additional secondary filter. Follow the above procedure to change the additional secondary filter.

i08312524

Fuel Tank Water and Sediment - Drain

SMCS Code: 1273-543-M&S

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Fuel Tank

Fuel quality is critical to the performance and to the service life of the engine. Water in the fuel can cause excessive wear to the fuel system. Condensation occurs during the heating and cooling of fuel. The condensation occurs as the fuel passes through the fuel system and the fuel returns to the fuel tank. This causes water to accumulate in fuel tanks. Draining the fuel tank regularly and obtaining fuel from reliable sources can help to eliminate water in the fuel. The fuel tank utilizes a fuel tank vent to prevent an air lock or vacuum. Ensure that the vent is free of debris and not damaged.

Drain the Water and the Sediment

Fuel tanks should contain some provision for draining water and draining sediment from the bottom of the fuel tanks.

Prepare to catch water and sediment in an appropriate container. Connect a hose (if necessary) to the valve prior to opening the valve.

Open the drain valve on the bottom of the fuel tank to drain the water and the sediment. Close the drain valve.

Note: Failure to close the drain properly could result in fuel leakage, which could have detrimental results to performance.

Check the fuel daily. Drain the water and sediment from the fuel tank after operating the engine. Drain the water and sediment from the fuel tank after the fuel tank has been filled. Allow 5 to 10 minutes before performing this procedure.

Fill the fuel tank after operating the engine to drive out moist air. This procedure will help prevent condensation. Do not fill the tank to the top. The fuel expands as the fuel gets warm. The tank may overflow.

Some fuel tanks use stand pipes that allow water and sediment to settle below the end of the fuel stand pipe. Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

Fuel Storage Tanks

Drain the water and the sediment from the fuel storage tank during the following conditions:

- Weekly
- Refill of the tank

This procedure will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank. A four micron(c) absolute filter for the breather vent on the fuel tank is also recommended.

If a bulk storage tank has been refilled or moved recently, allow adequate time for the sediment to settle before filling the engine fuel tank. Internal baffles in the bulk storage tank will also help trap sediment. Filtering fuel that is pumped from the storage tank helps to ensure the quality of the fuel. When possible, water separators should be used.

i08287069

Generator - Dry

SMCS Code: 4450-569

NOTICE
Do not operate the generator if the windings are wet. If the generator is operated when the windings are wet, damage can occur due to insulation breakdown.

When moisture is present or when moisture is suspected in a generator, the generator must be dried before being energized.

If the drying procedure does not restore the insulation resistance to an acceptable value, the winding should be reconditioned.

Note: For additional information, refer to Special Instruction, SEHS9124 .

Drying Methods

The following methods can be used for drying a generator:

- Self-circulating air method
- Oven method

NOTICE
Do not allow the winding temperature to exceed 85 °C (185.0 °F). Temperatures that are greater than 85 °C (185.0 °F) will damage the winding insulation.

Self-Circulating Air Method

Note: Disable the excitation before using this method.

Run the engine and disconnect the generator load. This action will help circulate air. Operate the generator space heaters.

Oven Method

Place the entire generator inside a forced air drying oven for 4 hours at 65 °C (149 °F).

NOTICE
Use a forced air type oven rather than a radiant type oven.

Radiant type ovens can cause localized overheating.

i08336866

Generator - Inspect

SMCS Code: 4450-040

⚠ WARNING

Personal injury or death can result from improper troubleshooting and repair procedures.

The following troubleshooting and repair procedures should only be performed by qualified personnel familiar with this equipment.

⚠ WARNING

The high voltage that is produced by an operating generator set can cause severe injury or death. Before performing any maintenance or repairs, ensure that the generator will not start.

Place the engine control switch in the "OFF" position. Attach "DO NOT OPERATE" tags to all starting controls. Disconnect the batteries or disable the starting system. Lock out all switchgear and automatic transfer switches that are associated with the generator.

Refer to Safety Section, "Generator Isolating for Maintenance" for information regarding the procedure to isolate the generator safely.

Proper maintenance of electrical equipment requires periodic visual examination of the generator and periodic visual examination of the windings. Proper maintenance of electrical equipment also requires appropriate electrical checks and appropriate thermal checks. Insulation material should be examined for cracks. The insulation material should be examined for accumulations of dirt and dust. If there is an insulation resistance value that is below normal, a conductive path may be present. This conductive path may be made of one of the following materials:

- Carbon
- Salt
- Metal dust
- Dirt that is saturated with moisture

These contaminants will develop a conductive path which may produce shorts. Cleaning is advisable if heavy accumulations of dirt can be seen or if heavy accumulations of dust can be seen. If excess dirt is the cause of a restriction in the ventilation, cleaning is also advisable. Restricted ventilation will cause excessive heating.

NOTICE
To avoid the possibility of deterioration to the generator windings, do not clean the generator unless there is visual, electrical, or thermal evidence that dirt is present.

If harmful dirt accumulations are present, various cleaning techniques are available. The cleaning procedure that is used may be determined by one of the items on the following list:

- The extent of the cleaning procedure that is being attempted
- The type of enclosure of the generator
- The voltage rating of the generator
- The type of dirt that is being removed

Cleaning (Assembled Generators)

NOTICE
Do not use water to clean the generator.

NOTICE
Do not use trichloroethane, perchloroethylene, trichloroethane, or any alkaline products to clean the generator.

Cleaning may be required at the point of installation. Complete disassembly of the generator may not be necessary or feasible. In this case, a vacuum cleaner should be used to pick up the following items: dry dirt, dust, and carbon. Cleaning the generator will prevent the spreading of these contaminants.

A small nonconductive tube may need to be connected to the vacuum cleaner. The small nonconductive tube will allow the vacuum cleaner to clean the surfaces that are not exposed. After dust is removed, use a small brush attached to the vacuum hose to remove dirt that is firmly attached to the surface.

After the initial cleaning with a vacuum, compressed air may be used to remove the remaining dust and dirt. Compressed air that is used for cleaning should be free of moisture and free of oil. Air pressure should be a maximum of 210 kPa (30 psi) to prevent mechanical damage to the insulation. If the above cleaning procedures are not effective, consult a Caterpillar dealer.

Cleaning (Disassembled Generators)

NOTICE
Do not use water to clean the generator.

NOTICE
Do not use trichloroethane, perchloroethylene, trichloroethane, or any alkaline products to clean the generator.

An initial insulation resistance check should be made on the generator to confirm electrical integrity. A minimum reading of 1megohm would be expected with severely contaminated generators. A zero megohm reading may indicate an insulation breakdown. An insulation breakdown requires more than cleaning. An insulation breakdown requires repair.

Use the following for cleaning the stator, the rotor, the exciter, and the diode bridge:

- Toluene
- Benzene
- Cyclohexane

Avoid permitting the solvent to run into the slots. Apply the solvent with a brush. Use a sponge on the windings frequently to remove the debris. Dry the winding with a dry cloth. Allow the solvent to evaporate before reassembling the generator.

Allow the generator to dry at room temperature. Check the insulation resistance. The insulation resistance should now be normal. If the insulation resistance is not normal, repeat the procedure.

Note: For more information on drying methods, refer to Special Instructions, SEHS9124, “Cleaning and Drying of Electric Set Generators”.

Note: For installation and maintenance of M17XXL4, M22XXL4, and M27XXL4 frames (If equipped) refer to Special Instruction, UENR8811, “Caterpillar M17XXL4, M22XXL4, M27XXL4 Low Voltage Alternator 4 Pole”.

i08254035

Generator Bearing Temperature - Test/Record

SMCS Code: 4471-081-TA

The monitoring of bearing temperature may prevent premature bearing failure. A generator set should never operate above the recommended set points. Keep records to monitor the changes in the temperature of the bearing.

Note: Measure the bearing temperature after the generator reaches normal operating temperature.

Resistive Temperature Detectors (RTDs)

Cat Generators may be equipped with resistance temperature detectors for generator bearings. These detectors are 100 ohm resistance temperature detectors. A resistance temperature detector may be monitored by the optional monitor for the EMCP resistance temperature detector. A resistance temperature detector may be monitored by equipment that is provided by the customer. Consult with your Cat dealer about other methods of measuring the bearing temperature.

The EMCP may be configured to “ALARM” or the EMCP may be configured to “SHUTDOWN” . An alarm is activated if the temperature of the bearing reaches 85 °C (185 °F). A shutdown occurs if the temperature of the bearing reaches 95 °C (203 °F).

Infrared Thermometers

Bearing temperatures can also be recorded with the use of an infrared thermometer. Refer to Special Publication, NENG2500, “Cat Dealer Service Tools Catalog” for various infrared thermometers. Follow the instructions that come with your infrared thermometer.

i08286680

Generator Load - Check

SMCS Code: 4450-535-LA

⚠ WARNING

Personal injury or death can result from high voltage.

When power generation equipment must be in operation to make tests and/or adjustments, high voltage and current are present.

Improper test equipment can fail and present a high voltage shock hazard to its user.

Make sure the testing equipment is designed for and correctly operated for high voltage and current tests being made.

During normal operation, monitor the power factor and monitor generator loading.

When a three-phase generator is installed, ensure that the total current in any one phase does not exceed the nameplate rating. Or, when a three-phase generator is reconnected, ensure that the total current in any one phase does not exceed the nameplate rating. Each phase should carry the same load. Carrying the same load allows the three-phase generator to work at the rated capacity. If one-phase current exceeds the nameplate amperage, an electrical imbalance will occur. An electrical imbalance can result in an electrical overload and an electrical imbalance can result in overheating on three-phase generators. This imbalance is not applicable to single-phase generators.

The power factor can be referred to as the efficiency of the load. This power factor can be expressed as the ratio of kVA to actual kW. The power factor can be calculated by dividing kW by kVA. Power factor is expressed as a decimal. Power factor is used to mean the portion of current that is supplied to a system that is doing useful work. The portion of the current that is not doing useful work is absorbed in maintaining the magnetic field in motors. This current (reactive load) can be maintained without engine power.

i08286685

Generator Set - Test

SMCS Code: 4450-081

⚠ DANGER

DANGER: Shock/Electrocution Hazard-Do not operate this equipment or work on this equipment unless you have read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings will result in serious injury or death.

⚠ WARNING

Personal injury or death can result from high voltage.

When power generation equipment must be in operation to make tests and/or adjustments, high voltage and current are present.

Improper test equipment can fail and present a high voltage shock hazard to its user.

Make sure the testing equipment is designed for and correctly operated for high voltage and current tests being made.

When servicing or repairing electric power generation equipment:

- **Make sure the unit is off-line (disconnected from utility and/or other generators power service), and either locked out or tagged DO NOT OPERATE.**
- **Make sure the generator engine is stopped.**
- **Make sure all batteries are disconnected.**
- **Make sure all capacitors are discharged.**

Table 34

Tools Needed		
Part Number	**Part**	**Quantity**
237-5130	Digital Multimeter	1
	12 VDC battery	1
	Potential Transformer	1

The generator set functional test is a simplified test that can be performed to determine if the generator is functional. The generator set functional test should be performed on a generator set that is under load.

The generator set functional test determines if the following statements happen:

- A phase voltage is being generated.
- The phase voltages are balanced.
- The phase voltages change relative to engine speed.

The generator set functional test consists of the following steps:

1. Stop the generator. Connect the potential transformer high voltage winding to the generator terminals (T1) and (T2). Connect the voltmeter to the low voltage winding. If two transformers are available, connect the high voltage winding of the second transformer to the generator terminals (T1) and (T3). Connect the secondary terminals that correspond to generator terminal (T2) of both transformers together.

2. Disconnect wires “E+” and “E-” from the voltage regulator. Disconnect the generator from the load.

3. Connect a 12 VDC automotive battery to wires “E +” and “E-” .

4. Measure the AC voltage across the low voltage terminals of the transformer that correspond to the following generator terminals: “T1” and “T2” , “T2” , and “T3” and “T3” and “T1” . Record the voltages.

i08286683

Generator Set Vibration - Inspect

SMCS Code: 4450-040-VI

Excessive vibration will indicate a problem with the generator set. The vibration may be caused by the following:

- Misalignment of the coupling between the engine and the generator
- Faulty mounting or play in the coupling
- Incorrect balancing of the generator shaft or engine crankshaft
- A three-phase generator has too much load on a single phase.
- There is a short circuit in the stator.

Check for vibration damage. Vibration may cause the following problems:

- loose fittings
- loose bolts
- excessive noise
- cracked insulation

The following areas are susceptible to vibration damage:

- stator output leads
- protective sleeving
- insulation
- exposed electrical connections
- transformers
- fuses
- capacitors

Check the generator set vibration level by using a broad spectrum analyzer.

i08287076

Generator Winding Insulation - Test

SMCS Code: 4453-081; 4454-081; 4457-081; 4470-081

Recommended Periodic Insulation Tests

⚠ WARNING

The high voltage that is produced by an operating generator set can cause severe injury or death. Before performing any maintenance or repairs, ensure that the generator will not start.

Place the engine control switch in the "OFF" position. Attach "DO NOT OPERATE" tags to all starting controls. Disconnect the batteries or disable the starting system. Lock out all switchgear and automatic transfer switches that are associated with the generator.

Table 35

Tools Needed		
Part Number	**Part Name**	**Quantity**
300-8648	Insulation Testing Gp	1

Periodically, use an insulation tester to check the insulation resistance of the generator main stator winding. The frequency of this test is determined by the generator environment. Previous insulation tester readings will also determine the frequency of this test.

Test the main stator windings with an insulation tester in the following situations:

- The generator set is started for the first time.
- The generator set is removed from storage.
- The generator set is operating in a humid environment. Test every 3 months.
- The generator set is not protected from the elements in an enclosed area. Test every 3 months.
- The generator set is installed in an enclosed area. This area needs to be low in humidity and this area needs to have steady temperatures. Test every 12 months (minimum).
- The generator set has not been run under load for 3 months. Test the generator set weekly. Use space heaters around the generator set if the generator is exposed to a sea water environment or if the humidity is above 75 percent. Also use space heaters if a test result was below 3 megohms.

Space heaters must be used whenever the generator set is not under load. Space heaters must be used whenever salt is present or whenever high humidity is present. Using a space heater in this fashion is the only way to maintain insulation tester readings above 1 megohm. Use space heaters only when the generator is not running.

For additional information, refer to Special Instruction, SEHS9124, "Cleaning and Drying of Electric Set Generators".

Recommended Procedure for the Insulation Test

⚠ WARNING

Personal injury or death can result from electrocution.

The megohmmeter is applying a high voltage to the circuit.

To avoid electrocution, do not touch the instrument leads without first discharging them. When finished testing also discharge the generator windings.

1. Take the generator out of service.
2. Visually inspect the generator for moisture. If moisture exists, do not perform this insulation test. Dry the unit first. Refer to Special Instruction, SEHS9124, "Cleaning and Drying of Electric Set Generators".
3. Inspect the installation. Determine the equipment that will be tested by the insulation tester.
4. Discharge the capacitance of the windings.
5. Disconnect "T0" from ground.
6. Disconnect the sensing lead wires for the regulator by unplugging the harness connectors.
7. Disconnect the PT leads of the load share module.
8. Connect the black lead insulation tester to ground.
9. Connect the red lead of the insulation tester to "T0" .
10. Set the voltage to the rated voltage of the generator.

11. Use the 30/60 Time Resistance Method:

a. Apply voltage.

b. Observe the readings at 30 seconds. Observe the readings at 60 seconds.

c. Record the 60 second reading. This reading must be corrected for temperature.

d. Record temperature.

e. Record humidity.

f. Remove voltage.

12. Evaluate the readings. The actual value of the resistance may vary greatly between generators. For this reason, the insulation condition must be evaluated. Base this evaluation on the comparison between the 60 second resistance readings and the readings that were taken on previous dates. These two readings must be taken under similar conditions. If a 60 second resistance reading has a 50 percent reduction from the previous reading, the insulation may have absorbed too much moisture.

Switch the insulation tester to the “OFF” position. This procedure will discharge the insulation tester leads. Disconnect the insulation tester leads.

Note: The results from the insulation resistance checks indicate when cleaning and/or repairing is becoming critical. Generally, insulation resistance will vary greatly with temperature. Therefore, always test at the same temperature and humidity. Refer to Illustration 96 .

Engine Serial Number_____

Serial Number for the Generator_____

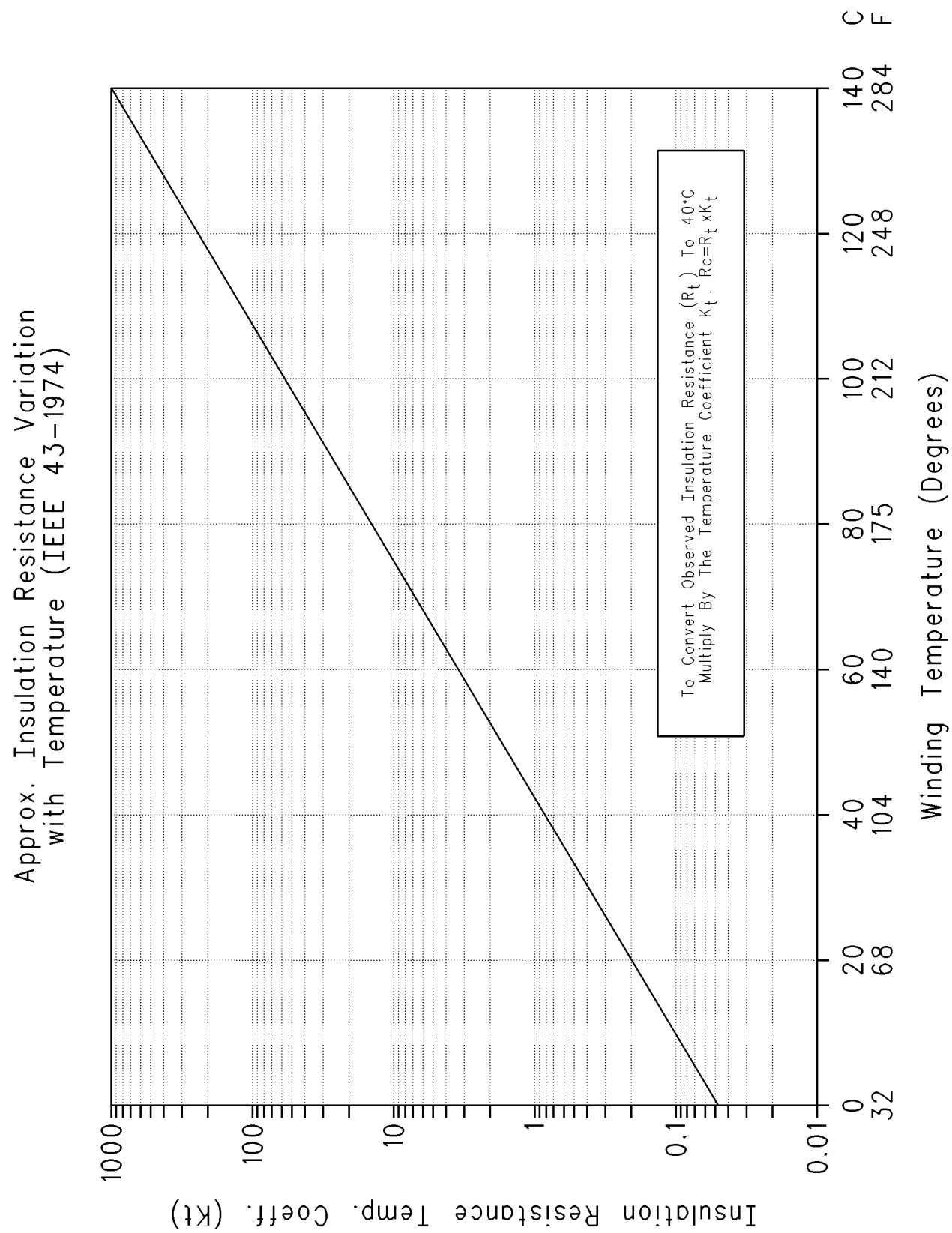
Approx. Insulation Resistance Variation
with Temperature (IEEE 43-1974)
Insulation Resistance Temp. Coeff. (Kt)
1000
100
10
1
0.1
0.01
0
32
20
68
40
104
60
140
80
175
100
212
120
248
140
284
C
F
Winding Temperature (Degrees)
To Convert Observed Insulation Resistance (Rt) To 40°C
Multiply By The Temperature Coefficient Kt. Rc=Rt xKt

Illustration 96 g00633226

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Hoses and Clamps - Inspect/ Replace

SMCS Code: 7554-040; 7554-510

Hoses and clamps must be inspected periodically and replaced at the recommended interval to ensure safe and continuous operation of the engine. Failure to replace a fuel hose at the recommended change interval may result in a hazardous situation. Take proper safety precautions before inspecting or replacing hoses and clamps.

Note: Always use a board or cardboard when the engine components are checked for leaks. Leaking fluid that is under pressure can cause serious injury or possible death. Leaks that are the size of a pin hole are included. Refer to Operation and Maintenance Manual, “General Hazard Information” for more information.

Note: Ensure that the hose is compatible with the application.

Inspect Tubes, Hoses, Bellows, and Clamps

Inspect all tubes and hoses for leaks that are caused by the following conditions. Replace any tube or hose which exhibits any of the following conditions. Failure to replace a tube or hose which exhibits any of the following conditions may result in a hazardous situation.

- Hoses which are cracked
- Hoses which are soft
- Outer covering that is chafed or cut
- Exposed wire that is used for reinforcement
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering
- Exhaust bellows for leaks or damage
- Hoses which exhibit signs of leakage which are not the result of loose couplings or clamps

Inspect all clamps for the following conditions. Replace any clamp which exhibits signs of any of the following conditions.

- Cracking
- Looseness
- Damage

Inspect all couplings for leaks. Replace any coupling which exhibits signs of leaks.

Each installation application can be different. The differences depend on the following factors:

- Type of hose
- Type of fitting material
- Anticipated expansion and contraction of the hose
- Anticipated expansion and contraction of the fittings

Due to extreme temperature changes, the hose will heat set. Heat setting causes hose clamps to loosen which can result in leaks. A constant torque hose clamp will help to prevent loose hose clamps.

Replace hoses that are cracked or soft. Replace hoses that show signs of leakage. Replace hoses that show signs of damage. Replace hose clamps that are cracked or damaged. Tighten or replace hose clamps which are loose.

Replace the Hoses and the Clamps

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Cooling System

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

⚠ WARNING

Personal injury can result from removing hoses or fittings in a pressure system.

Failure to relieve pressure can cause personal injury.

Do not disconnect or remove hoses or fittings until all pressure in the system has been relieved.

1. Stop the engine.

2. Allow the engine to cool.

3. Before servicing a coolant hose, slowly loosen the filler cap for the cooling system to relieve any pressure.

4. Remove the filler cap for the cooling system.

5. Drain the coolant from the cooling system to a level that is below the hose that is being replaced. Drain the coolant into a suitable clean container. The coolant can be reused.

6. Remove the hose clamps.

7. Disconnect the old hose.

8. Replace the old hose with a new hose.

9. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, “Torque Specifications” “Hose Clamps” for information about selecting and installing the proper hose clamps.

10. Refill the cooling system.

11. Clean the coolant filler cap. Inspect the gaskets on the filler cap. Inspect the gasket seat. Inspect the vacuum valve and seat for debris or damage. Replace the filler cap if the gaskets are damaged. Install the filler cap.

12. Start the engine. Inspect the cooling system for leaks.

Fuel System

⚠ WARNING

Personal injury can result from removing hoses or fittings in a pressure system.

Failure to relieve pressure can cause personal injury.

Do not disconnect or remove hoses or fittings until all pressure in the system has been relieved.

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

NOTICE
Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses. Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires. Inspect all lines, tubes and hoses carefully. Tighten all connections to the recommended torque.

NOTICE
Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over any disconnected fuel system components.

Note: High-pressure fuel lines may be installed between the high-pressure fuel pump and the fuel injectors. High-pressure fuel lines are constantly charged with high pressure. Do not check the high-pressure fuel lines with the engine or the starting motor in operation. Wait for 10 minutes after the engine stops before you perform any service or repair on high-pressure fuel lines. Waiting for 10 minutes will allow the pressure to be purged.

1. Drain the fuel from the fuel system to a level that is below the hose that is being replaced.

2. Remove the hose clamps.

3. Disconnect the old hose.

Note: When servicing fuel system, use cap/s or cover/s as required to protect the system and maintain fuel system cleanliness.

4. Replace the old hose with a new hose.

5. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, “Torque Specifications” “Hose Clamps” for information about selecting and installing the proper hose clamps.

6. Carefully inspect the engine for any spilled fuel. Make sure that no fuel remains on or close to the engine.

Note: Fuel must be added to the fuel system ahead of the fuel filter.

7. Refill the fuel system. Refer to this Operation and Maintenance Manual, “Fuel System - Prime” for information about priming the engine with fuel.

8. Start the engine. Inspect the fuel system for leaks.

Lubrication System

⚠ WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

1. Drain the oil from the lubrication system to a level that is below the hose that is being replaced.

2. Remove the hose clamps.

3. Disconnect the old hose.

4. Replace the old hose with a new hose.

5. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, “Torque Specifications” “Hose Clamps” for information about selecting and installing the proper hose clamps.

6. Refill the lubrication system. Refer to this Operation and Maintenance Manual, “Engine Oil Level - Check” to ensure that the lubrication system is filled with the proper amount of engine oil.

7. Start the engine. Inspect the lubrication system for leaks.

Air System

1. Remove the hose clamps.

2. Disconnect the old hose.

3. Replace the old hose with a new hose.

4. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, “Torque Specifications” “Hose Clamps” for information about selecting and installing the proper hose clamps.

Note: The bellows and the V-clamps that are used on the exhaust bellows should never be reused.

5. Start the engine. Inspect the air lines for leaks.

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Jacket Water Heater - Check (Standby Generator Sets (If Equipped))

SMCS Code: 1383-535

Jacket water heaters help to improve startability in ambient temperatures that are below 21 °C (70 °F). All installations that require automatic starting should have jacket water heaters.

Check the operation of the jacket water heater. For an ambient temperature of 0 °C (32 °F), the heater should maintain the jacket water coolant temperature at approximately 32 °C (90 °F).

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Jacket Water Heater Contactor - Replace

SMCS Code: 1383-510

The Jacket Water Heater Contactor must be replaced at regular intervals. The contactor is rated for 100,000 cycles. Refer to Special Instruction, M0096795, “Procedure for Reworking the Jacket Water Heater Contactor on Certain C27, C32, 3400, 3500, and C175 Generator Set Engines” for instructions.

i08335374

Maintenance Recommendations

SMCS Code: 1000

Service Hours and Fuel Consumption

Experience has shown that maintenance intervals are most accurately based on fuel consumption. Fuel consumption corresponds more accurately to the engine load. Table 36 and table 37 lists average ranges of fuel consumption and service hours of a load factor of approximately 60 percent. Use the range of fuel consumption and service hours as a guideline.

Table 36

Maintenance Intervals for Overhaul Service hours for the C175-16 engine(1)			
Interval	**Rated Up To 1300 RPM**	**Rated 1301 To 1600 RPM**	**Rated 1601 To 1800 RPM**
Top End Overhaul	16500 service hours	13500 service hours	11000 service hours
	4164000 L (1100000 US gal)		
Major overhaul	33000 service hours	27000 service hours	22000 service hours
	8327900 L (2200000 US gal)		

(1) Fuel consumption is based on a load factor of approximately 60 percent of the continuous rating.

Table 37

Maintenance Intervals for Overhaul Service hours for the C175-20 engine(1)			
Interval	**Rated Up To 1200 RPM**	**Rated 1201 To 1500 RPM**	**Rated 1501 To 1800 RPM**
Top End Overhaul	16500 service hours	13500 service hours	11000 service hours
	5204939 L (1375000 US gal)		
Major overhaul	33000 service hours	27000 service hours	22000 service hours
	10409878 L (2750000 US gal)		

(1) Fuel consumption is based on a load factor of approximately 60 percent of the continuous rating.

Severe Operation

Severe operation is the use of an engine that exceeds current published standards for that engine. Caterpillar maintains standards for the following engine parameters:

- Horsepower
- Range of rpm
- Fuel consumption
- Fuel quality
- Altitude
- Maintenance intervals
- Selection of oil
- Selection of coolant
- Environmental qualities
- Installation

Refer to the standards for your engine or consult your Cat dealer to determine if your engine is operating within the defined parameters.

Severe operation can accelerate component wear. Engines that are operating under severe conditions may need more frequent maintenance intervals for the following reasons:

- Maximum reliability
- Retention of full service life

Because of individual applications, identifying all factors which can contribute to severe operation is not possible. Consult your Cat dealer about the maintenance that is needed for your specific engine.

The following factors can contribute to severe operation: environment, improper operating procedures, and improper maintenance practices.

Environmental Factors

Extreme Ambient Temperatures

Extended operation in environments that are cold or hot can damage components. Valve components can be damaged by carbon buildup if the engine is frequently started and stopped in cold temperatures. Hot inlet air reduces the performance capabilities of the engine.

Note: See this Operation and Maintenance Manual, “Cold-Weather Operation” topic (Operation Section), or see Special Publication, SEBU5898, “Cold-Weather Recommendations”.

Cleanliness

Unless the equipment is cleaned regularly, extended operation in a dirty environment and in a dusty environment can damage components. Built up mud, dirt, and dust can encase components. This condition can make maintenance difficult. The buildup can contain corrosive chemicals. Corrosive chemicals and salt can damage some components.

The high-pressure fuel system is sensitive to debris. The debris can lead to early erosion and replacement for many of the high-pressure fuel system components and lack of performance. Caution should be taken by covering any fuel system opening during maintenance with a CLEAN cover. Refer to Special Instruction, SEBF9107, “CR1100 Fuel System Flushing Procedure” and Special Instruction, SEBF9109, “CR1100 Fuel System Assembly and Handling Guidelines” for information on handling and assembling fuel system components.

Improper Operating Procedures

- Extended operation at low idle
- Minimum cool down periods after high load factor operation
- Operating the engine beyond the guidelines for the engine rating
- Operating the engine at loads that are greater than the rated load
- Operating the engine at speeds that are greater than the rated speed
- Use of the engine for an application that is not approved

Improper Maintenance Practices

- Extension of maintenance intervals
- Not using recommended fuel, lubricants, and coolant/antifreeze

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Overhaul (Major)

SMCS Code: 7595-020-MJ

The need for a major overhaul is determined by several factors.

- An increase of oil consumption
- An increase of crankcase blowby
- The total amount of fuel consumption
- The service hours of the engine
- The wear metal analysis of the lube oil
- An increase in the levels of noise and vibration

An increase of wear metals in the lube oil indicates that the bearings and the surfaces that wear may need serviced. An increase in the levels of noise and vibration indicates that rotating parts require service.

Note: Oil analysis may indicate a decrease of wear metals in the lube oil. The cylinder liners may be worn so that polishing of the bore occurs. Also, the increased use of lube oil will dilute the wear metals.

Monitor the engine as the engine accumulates service hours. Consult your Caterpillar dealer about scheduling a major overhaul.

Note: The driven equipment may also require service when the engine is overhauled. Refer to the literature that is provided by the OEM of the driven equipment.

A major overhaul includes all work that is done for the top end overhaul. A major overhaul includes additional parts and labor. Additional parts and labor are required to rebuild the engine.

For the major overhaul, all bearings, seals, gaskets, and components that wear are disassembled. The parts are cleaned and inspected. If necessary, the parts are replaced. The crankshaft is measured for wear. The crankshaft may require regrinding. Alternatively, the crankshaft may be replaced with a Caterpillar replacement part.

Your Caterpillar dealer can provide these services and components. Your Caterpillar dealer can ensure that the components are operating within the appropriate specifications.

The following definitions explain the terminology for the services that are performed during an overhaul:

Exchange – Your Caterpillar dealer will exchange your worn parts for parts that conform to original functional specifications.

Inspect – Inspect the components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, “Index of Publications on Reusability or Salvage of Used Parts”. The guidelines were developed to help Caterpillar dealers and customers to avoid unnecessary expenditures. New parts are not required if the existing parts can still be used, reconditioned, or repaired. If the components are not in the reusability guidelines, refer to the Service Manual, “Specifications” module.

Install New – The service life of the part is exhausted. The part cannot be reconditioned. Used parts are not appropriate. A new part must be installed.

Rebuild – The component can be reconditioned to comply with reusability guidelines.

Replace – The service life of the part is exhausted. The part must be replaced with a part that meets functional specifications. The replacement part may be a new part, a rebuilt part, or a used part.

If you elect to perform an overhaul without the services of a Caterpillar dealer, be aware of the recommendations in Table 38 . Your Caterpillar dealer can provide these services and components.

Table 38

Major Overhaul Instructions [1]	
Clean	Oil suction screen
Clean Inspect Test	Aftercooler core [2]
Inspect	Alternator
	Camshafts
	Camshaft thrust washers
	Cylinder block
	Crankshaft vibration damper
	Driven equipment (alignment)
	Electronic control module (ECM) [3]
	Engine mounts
	Engine wiring harness
	Flywheel
	Front gear train (gears)
	Lifters
	Rear gear train (gears)
Inspect Rebuild	Rocker arms
Inspect Rebuild Exchange	Connecting rods
	Engine oil pump
	Fuel priming pump
	Fuel transfer pump
	Jacket water pump
	Prelube pump
	SCAC pump
	Starting motor
	Turbochargers
Inspect Rebuild Replace	Camshaft bearings
	Crankshaft thrust plates
	Electronic thermostat (If Equipped)
	Oil cooler core
	Piston pins

(continued)

(Table 38, contd)

Major Overhaul Instructions [1]	
	Software [4]
	Timing gears
Inspect Exchange	Crankshaft
	Cylinder liners
	Pistons (Crowns and Skirts)
Inspect Replace Install new	Fuel pressure regulating valve
	high-pressure fuel rail
	Pushrods
	Quill tubes
Replace	Alternator Belt
	Connecting rod bearings
	Coolant temperature regulator
	Cylinder head assemblies
	Exhaust manifold (seals and bellows)
	high-pressure fuel pump
	Inlet manifold (gaskets and seals)
	Main bearings
	Piston rings
Exchange Install new	Fuel injectors

(1) For instructions on removal and installation of components, see the Service Manual, “Disassembly and Assembly” module.
(2) For instructions on cleaning the core, see this Operation and Maintenance Manual, “Aftercooler Core - Clean/Test” topic.
(3) Check for damage.
(4) Install new software when a new ECM is installed.

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Overhaul (Top End)

SMCS Code: 7595-020-TE

A top end overhaul involves the removal, the inspection, and the rework of the cylinder head components. Some additional components are replaced and serviced.

Your Cat dealer can provide these services and components. Your Cat dealer can ensure that the components are operating within the appropriate specifications.

Note: The driven equipment may also require service when the engine is overhauled. Refer to the literature that is provided by the OEM of the driven equipment.

The following definitions explain the terminology for the services that are performed during an overhaul:

Exchange – Your Cat dealer will exchange your worn parts for parts that conform to original functional specifications.

Inspect – Inspect the components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, “Index of Publications on Reusability or Salvage of Used Parts”. The guidelines were developed to help Cat dealers and customers to avoid unnecessary expenditures. New parts are not required if the existing parts can still be used, reconditioned, or repaired. If the components are not in the reusability guidelines, refer to the Service Manual, “Specifications” module.

Install New – The service life of the part is exhausted. The part cannot be reconditioned. The replacement part must be a new part.

Rebuild – The component is reconditioned to comply with reusability guidelines.

Replace – The service life of the part is exhausted. The part must be replaced with a part that meets functional specifications. The replacement part may be a new part, a rebuilt part, or a used part.

If you elect to perform an overhaul without the services of a Cat dealer.

Table 39

Top End Overhaul (1)	
Clean	Oil suction screen Drain screen for turbocharger oil (2)
Clean Inspect Pressure test	Aftercooler core (3)
Inspect Exchange	Lifters
Inspect Rebuild Exchange	Cylinder head assemblies
	Electronic Fluid Temperature Control (ESTAT)
	Fuel priming pump
	Fuel transfer pump
	Prelube pump
Inspect Replace	Crankshaft thrust plates
	Fuel pressure regulating valve
	Fuel injectors
	High-pressure fuel rail
	Pushrods

(continued)

(Table 39, contd)

	Quill tubes
Inspect Rebuild	Rocker arms
Install new	Air inlet manifold (gaskets and seals)
	Exhaust manifold (seals and bellows)
	Coolant temperature regulator
Rebuild Exchange	Turbochargers
Replace	High-pressure fuel pump

(1) For instructions on removal and installation of components, see the Service Manual, “Disassembly and Assembly” module.
(2) The screen is located in the turbocharger support.
(3) For instructions on cleaning the core, see this Operation and Maintenance Manual, “Aftercooler Core - Inspect/Clean” topic.

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Overhaul Considerations

SMCS Code: 7595-043

Severe Operation

Severe operation is the use of an engine that exceeds current published standards for that engine. Caterpillar maintains standards for the following engine parameters:

- Horsepower
- Range of rpm
- Fuel consumption
- Fuel quality
- Altitude
- Maintenance intervals
- Selection of oil
- Selection of coolant
- Environmental qualities
- Installation

Refer to the standards for your engine or consult your Cat dealer to determine if your engine is operating within the defined parameters.

Severe operation can accelerate component wear. Engines that are operating under severe conditions may need more frequent maintenance intervals for the following reasons:

- Maximum reliability
- Retention of full service life

Because of individual applications, identifying all factors which can contribute to severe operation. Consult your Cat dealer about the maintenance that is needed for your specific engine.

The following factors can contribute to severe operation: environment, improper operating procedures, and improper maintenance practices.

Environmental Factors

Extreme Ambient Temperatures

Extended operation in environments that are cold or hot can damage components. Valve components can be damaged by carbon buildup if the engine is frequently started and stopped in cold temperatures. Hot inlet air reduces the performance capabilities of the engine.

Note: See this Operation and Maintenance Manual, “Cold-Weather Operation” topic (Operation Section), or see Special Publication, SEBU5898, “Cold-Weather Recommendations”.

Cleanliness

Unless the equipment is cleaned regularly, extended operation in a dirty environment and in a dusty environment can damage components. Built up mud, dirt, and dust can encase components. The buildup can contain corrosive chemicals. Corrosive chemicals and salt can damage some components.

Improper Operating Procedures

- Extended operation at low idle
- Minimum cool down periods after high load factor operation
- Operating the engine beyond the guidelines for the engine rating

- Operating the engine at loads that are greater than the rated load
- Operating the engine at speeds that are greater than the rated speed
- Use of the engine for an application that is not approved

Improper Maintenance Practices

- Extension of maintenance intervals
- Not using recommended fuel, lubricants, and coolant/antifreeze

Overhaul Information

An overhaul is replacing the major worn components of the engine. An overhaul interval is a maintenance interval that is planned. The engine is rebuilt with parts that have been rebuilt or new parts that replace worn parts.

An overhaul also includes the following maintenance:

- Inspection of all the parts that are visible during the disassembly
- Replacement of the seals and gaskets that are removed
- Cleaning of the internal passages of the engine and the engine block

Most owners will save money by overhauling the engine at the intervals that are recommended in this Operation and Maintenance Manual. Consider the graph in Illustration 97 .

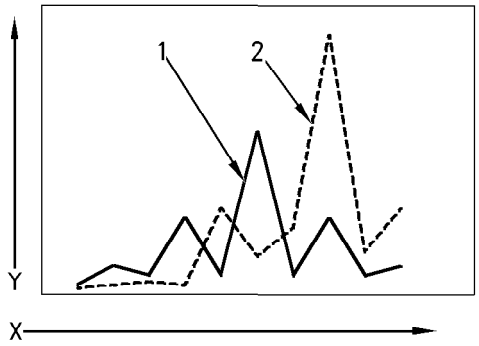

Illustration 97 g00745964

(Y) Cost
(X) Time
(1) Cost of maintenance and repair that is planned
(2) Cost of maintenance and repair that is not planned

In Illustration 97 , line (1) represents the maintenance and repair costs for an owner that followed the recommendations for inspection, maintenance, and repair. The peaks represent overhauls.

Line (2) represents the maintenance and repair costs for an owner that chose to operate beyond the recommended intervals. The initial cost of the “repair-after-failure” philosophy is lower. Also, the first overhaul was delayed. However, the peaks are higher than the peaks for the customer that used the “repair-before-failure” philosophy .

The higher peaks result from two key factors:

- Delaying an overhaul until a breakdown increases the chance of a catastrophic failure. This type of failure requires more parts, labor, and cleanup.
- Excessive wear means that fewer components will be reusable. More labor may be required for salvage or repair of the components.

When all costs are considered, “repair-before-failure” is the least expensive alternative for most components and engines.

Waiting until the engine exhibits symptoms of excessive wear or failure may be difficult. Waiting is not less costly. A planned overhaul before failure may be the best value for the following reasons:

- Costly unplanned downtime can be avoided.
- Many original parts can be reused according to the guidelines for reusable parts.
- The service life of the engine can be extended without the risk of a major catastrophe due to engine failure.
- Achieve the best cost/value relationship per hour of extended service life.

Overhaul Intervals

Some factors that are important for determining the overhaul intervals include the following considerations:

- Performance of preventive maintenance
- Use of recommended lubricants
- Use of recommended coolants
- Use of recommended fuels
- Proper installation
- Operating conditions
- Operation within acceptable limits
- Engine load

- Engine speed

Generally, engines that are operated at a reduced load and/or speed achieve more service life before an overhaul. However, this service life is for engines that are properly operated and maintained.

Other factors must be considered for determining a major overhaul:

- The total amount of fuel consumption
- The service hours of the engine
- An increase of oil consumption
- An increase of crankcase blowby
- The wear metal analysis of the lube oil
- An increase in the levels of noise and vibration

An increase of wear metals in the lube oil indicates that the bearings and the surfaces that wear may need to be serviced. An increase in the levels of noise and vibration indicates that rotating parts require service.

Note: Oil analysis can indicate a decrease of wear metals in the lube oil. The cylinder liners may be worn so that polishing of the bore occurs. Also, the increased use of lube oil will dilute the wear metals.

Monitor the engine as the engine accumulates service hours. Consult your Cat dealer about scheduling a major overhaul.

Note: The driven equipment may also require service when the engine is overhauled. Refer to the literature that is provided by the OEM of the driven equipment.

Using Fuel Consumption For Calculating the Overhaul Intervals

Table 40

Equation For Calculating Overhaul Intervals
F/R = H
“F” is the estimated total amount of fuel consumption of the engine.
“R” is the rate of fuel consumption in liters per hour or gallons per hour.
“H” is the number of estimated hours until the overhaul interval.

Use the actual records of fuel consumption, when possible. If the actual records are not available, use the following procedure to estimate the fuel consumption.

1. Estimate the average percent of the load for the operation of the engine.

2. Refer to the fuel consumption data in the Technical Marketing Information (TMI) for your engine. This information will determine the fuel consumption for the percent of the load that was estimated in Step 1. Use this figure as variable “F” for the equation in Table 40 . For more information about the Technical Marketing Information (TMI) for your engine, consult your Caterpillar dealer.

Oil Consumption as an Overhaul Indicator

Oil consumption, fuel consumption, and maintenance information can be used to estimate the total operating cost for your Caterpillar engine. Oil consumption can also be used to estimate the required capacity of a makeup oil tank that is suitable for the maintenance intervals.

Oil consumption is in proportion to the percentage of the rated engine load. As the percentage of the engine load is increased, the amount of oil that is consumed per hour also increases.

The oil consumption rate (brake-specific oil consumption) is measured in grams per kW/h (lb per bhp). The brake-specific oil consumption (BSOC) depends on the engine load. Consult your Caterpillar dealer for assistance in determining the typical oil consumption rate for your engine.

When an engine oil consumption has risen to three times the original oil consumption rate due to normal wear, an engine overhaul should be scheduled. There may be a corresponding increase in blowby and a slight increase in fuel consumption.

Overhaul Inspection

Refer to the applicable Disassembly and Assembly manual for procedures that are necessary to perform the required maintenance on the items that are listed. Consult your Cat dealer for assistance.

To determine the reusability publications that are needed to inspect the engine, refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, “Index of Publications on Reusability or Salvage of Used Parts”.

The Guidelines For Reusable Parts and Salvage Operations is part of an established Cat parts reusability program. These guidelines were developed to assist Cat dealers and customers reduce costs by avoiding unnecessary expenditures for new parts. If the engine parts comply with the established inspection specifications, the parts can be reused.

The use of out-of-spec parts could result in unscheduled downtime and/or costly repairs. The use of out-of-spec parts can also contribute to increased fuel consumption and reduction of engine efficiency. New parts are not necessary if the old parts can be reused, repaired, or salvaged. Otherwise, the old parts can be replaced or exchanged.

Your Cat dealer can provide the parts that are needed to rebuild the engine at the least possible cost.

Overhaul Programs

An economical way to obtain most of the parts that are needed for overhauls is to use Cat remanufactured parts. Cat remanufactured parts are available at a fraction of the cost of new parts. These parts have been rebuilt by Caterpillar and certified for use. The following components are examples of the remanufactured parts:

- Cylinder heads
- High-pressure fuel pumps
- Oil pumps
- Turbochargers
- Water pumps

Consult your Caterpillar dealer for details and for a list of the remanufactured parts that are available.

Your Caterpillar dealer may be offering various overhaul options.

A Flat Rate Overhaul guarantees the maximum price that you will pay for an overhaul. Flat rate prices on preventive maintenance programs or major repair options are available from many servicing dealers for all Caterpillar Engines. Consult your Caterpillar dealer to schedule a before failure overhaul.

Overhaul Recommendation

Caterpillar recommends a scheduled overhaul to minimize downtime. A scheduled overhaul will provide the lowest cost and the greatest value. Schedule an overhaul with your Cat dealer.

Overhaul programs vary between dealers. To obtain specific information about the types of overhaul programs and services, consult your Cat dealer.

i08173122

Power Factor - Check

SMCS Code: 4450-535-PWR

The power factor of a system can be determined by a power factor meter or by calculations. The power factor can be calculated by dividing kW by kVA. Power factor is expressed as a decimal.

i08286678

Prelube Pump - Inspect

SMCS Code: 1319-040

Inspect the prelube pump for the following conditions:

- Cracks
- Pin holes
- Proper operation
- Wear

Inspect the prelube pump for leaks. Replace all seals if a leak is observed.

Inspect the wiring for the following conditions:

- Damage
- Fraying

Ensure that the wiring is in good condition.

Inspect the electrical connections. Ensure that the electrical connections are secure.

If repair or replacement is necessary, refer to the applicable Disassembly and Assembly manual. Consult your Cat dealer for assistance.

Air Prelube Pump

Inspect all components in the air circuit for the prelube pump. Inspect all air lines and connections for leaks. Ensure that the components in the air circuit are in good condition.

Electric Prelube Pump

Inspect the brushes. Replace the brushes, if necessary.

i08143327

Radiator - Clean

SMCS Code: 1353-070

Note: Adjust the frequency of cleaning according to the effects of the operating environment.

A dirty radiator will not be able to transfer heat efficiently. A dirty radiator can lead to overheating of the engine. Clean the radiator according to the instructions that are provided by the OEM of the radiator.

i08265777

Rotating Rectifier - Check

SMCS Code: 4465-535

Check the exciter armature. Ensure that the rotating rectifier is tight. If a failure of a rectifier is suspected, proceed to the “Testing a Three-Diode Rectifier Block” section.

Testing a Three-Diode Rectifier Block

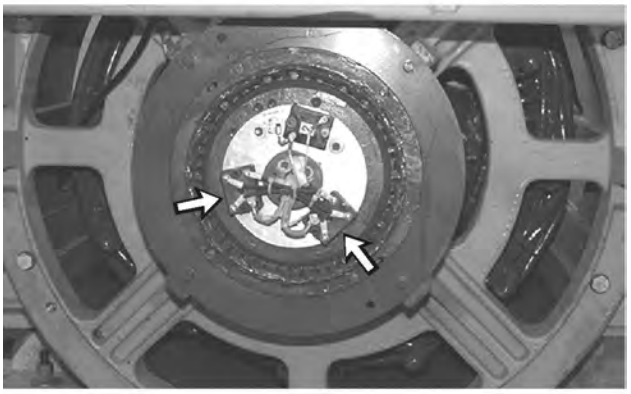

Illustration 98 g00610240

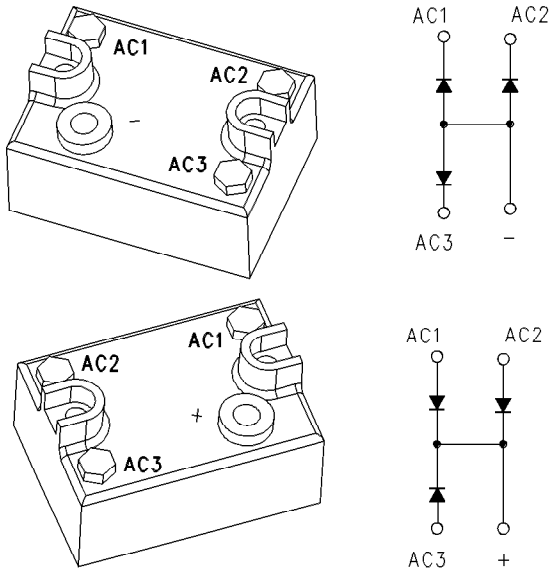

Illustration 99 g00613971

Three-Diode Rectifier Block (two pieces)

The following procedure tests all three diodes within a block. Check the positive rectifier block and the negative rectifier block. If any meter reading does not fall within the given ranges, replace the rectifier block.

1. Set the digital multimeter on the diode range. Remove all leads from the rectifier block.

2. To test the negative rectifier block, follow these steps:

a. Place the red test lead on the negative “-” terminal. Place the black test lead on the following rectifier terminals: “AC1” (3), “AC2” (4), and “AC3” (5). All readings on the meter should be between 0.4 and 1.0.

b. Place the black test lead on the negative “-” terminal. Place the red test lead on the following rectifier terminals: “AC1” (3), “AC2” (4), and “AC3” (5). In all cases, the meter should read “OL” (overload).

3. To test the positive rectifier block, follow these steps:

a. Place the red test lead on the positive “+” rectifier terminal. Place the black test lead on the following rectifier terminals: “AC1” (3), “AC2” (4), and “AC3” (5). In all cases, the meter should read “OL” (overload).

b. Place the black test lead on the positive “+” rectifier terminal. Place the red test lead on the following rectifier terminals: “AC1” (3), “AC2” (4), and “AC3” (5). All readings on the meter should be between 0.4 and 1.0.

Note: A shorted diode can damage the exciter rotor. If a diode is shorted, check the exciter rotor. Refer to the Testing and Adjusting, “Winding - Test” and Testing and Adjusting, “Insulation - Test”. Perform these tests.

Note: This rectifier block also contains varistor “CR7” . “CR7” can be checked by measuring the resistance between the positive “+” rectifier terminal and the negative “-” rectifier terminal. The resistance should be a minimum of 15000 ohms.

i08312035

Rotating Rectifier - Inspect/ Test

SMCS Code: 4465-040; 4465-081

Testing A Brushless Exciter Rotating Rectifier With An Ohmmeter

Table 41

Tools Needed		
Part Number	**Part Name**	**Quantity**
237-5130	Digital Multimeter	1
257-9140	Multimeter	1
146-4080	Digital Multimeter (RS-232)	1
7X-1710	Multimeter Probe Group	1

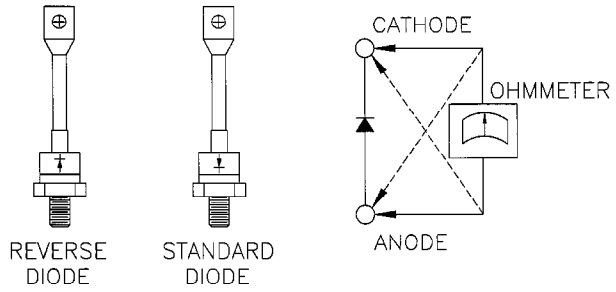

Illustration 100 g00555106

If the failure of a rectifier is suspected, use the following procedure.

1. Remove the cover from the exciter.

2. Remove the nut that secures the rectifier to the heat sink.

3. Remove the diode lead.

4. Lift the rectifier from the heat sink.

5. Refer to Illustration 100 . Connect the ohmmeter leads across the rectifier. Note the meter reading.

6. Reverse the ohmmeter leads. Note the meter reading.

The ohmmeter should indicate a low resistance when the ohmmeter leads are across the rectifier in one direction. The ohmmeter should indicate a high resistance when the leads are reversed.

If the ohmmeter indicates a low resistance in both directions, the rectifier is shorted. A high resistance in both directions indicates an open rectifier.

Replace any faulty rectifiers with rectifiers that have comparable operating characteristics. Include the following information when a rectifier is being ordered for replacement:

- Part Number of the rectifier
- Model number of the exciter
- Type of the exciter
- Serial number of the generator

Testing a Brushless Exciter Rotating Rectifier With A Test Light

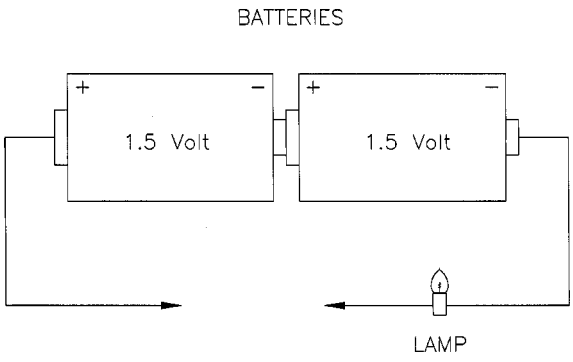

Illustration 101 g00555113

Test Light

If an ohmmeter is not available, a rectifier can be tested by using a test light. A test light consists of two standard flashlight batteries and a flashlight bulb. Refer to Illustration 101 .

If the failure of a rectifier is suspected, use the following procedure.

1. Remove the cover from the exciter.

2. Remove the nut that secures the rectifier to the heat sink.

3. Remove the diode lead.

4. Lift the rectifier from the heat sink.

5. Connect the leads of the test light across the rectifier. Notice if the bulb is illuminated.

6. Reverse the leads of the test light across the rectifier. Notice if the bulb is illuminated.

The bulb should be illuminated when the leads of the test light are across the rectifier in one direction. The bulb should not light when the leads are reversed.

If the bulb is illuminated in both directions, the rectifier is shorted. If the bulb is not illuminated in either direction, the rectifier is open.

Replace any faulty rectifiers with rectifiers that have comparable operating characteristics. Include the following information when a rectifier is being ordered for replacement:

- Part Number of the rectifier
- Model number of the exciter
- Type of the exciter
- Serial number of the generator

i08331146

Space Heater - Test

SMCS Code: 4450-081-HTR

A Cat generator can be operated in high humidity conditions without problems. However, problems can occur when the generator is idle and the surrounding air is warmer than the generator. Moisture can form on the windings that will result in poor performance from the windings. Moisture can also result in damage to the windings. Whenever the generator is not active, ensure that the space heaters are in operation.

Table 42

Tools Needed		
Part Number	**Part**	**Quantity**
237-5130	Digital Multimeter	1

1. Stop the generator set.

2. Remove the panels to allow access to the regulator and control terminal strips. Locate terminal strip “TS1” .

3. For 240 V systems, use the multimeter to measure the voltage between terminal “H1” and terminal “H4” . If voltage is not present, disconnect the power source to terminal “H1” and terminal “H4” , and check for 3 to 12 ohms resistance. If there is no resistance, check the generator service manual for further information. For 120 V systems, use the multimeter to measure the voltage between terminal “H1” and terminal “H2” . If voltage is not present, disconnect the power source to the following terminals: “H1” , “H2” , “H3” and “H4” , and check for 3 to 12 ohms resistance. If there is no resistance, check the generator service manual for further information.

i08335577

Speed Sensor - Clean/Inspect

SMCS Code: 1907-040; 1907-070

The C175 Generator Set has three different speed sensors.

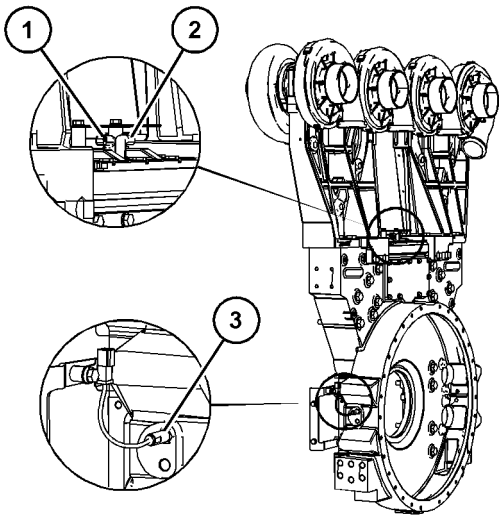

Illustration 102 g06632209

(1) Secondary speed sensor (camshaft)
(2) Third speed sensor (camshaft)
(3) Magnetic pickup for the EMCP (flywheel)

The primary speed sensors and secondary speed sensors are mounted in the top of the flywheel housing. Both of these sensors are pulled into position by a bolt.

1. Remove the speed sensors from the housing. Check the condition of the plastic end of the speed sensors for wear and/or contaminants.

2. Clean the metal shavings and other debris from the face of the speed sensors. Use the procedure in the Service Manual to calibrate the speed sensors.

The third speed sensor has a threaded end, and screws directly into the flywheel housing.

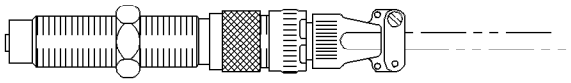

Illustration 103 g00293337

Typical engine speed/timing sensor

1. Remove the engine speed/timing sensor from the flywheel housing. Check the condition of the end of the engine speed/timing sensor. Check for signs of wear and contaminants.

2. Clean the metal shavings and other debris from the face of the magnet.

3. Install the engine speed/timing sensor according to the information in the Service Manual, “Specifications”.

i08259043

Standby Generator Set Maintenance Recommendations

SMCS Code: 4450-041

A standby generator set may be intermittently used. However, the generator set is needed for operation in an emergency situation. Maintenance of the standby generator set is important for the following reasons:

- The generator set must always be in excellent operating condition.
- The generator set must be ready to work under load at any time.

Establishing a Preventive Maintenance Program will provide these benefits:

- Maximum availability of the standby generator set

- Longer service life for the generator set
- Minimum of expensive repairs

Your Cat dealer can help you to establish an effective Preventive Maintenance Program for your generator set. Consult your Cat dealer for details.

Maintenance and Operation Procedures

⚠ WARNING

The high voltage that is produced by an operating generator set can cause severe injury or death. Before performing any maintenance or repairs, ensure that the generator will not start.

Place the engine control switch in the "OFF" position. Attach "DO NOT OPERATE" tags to all starting controls. Disconnect the batteries or disable the starting system. Lock out all switchgear and automatic transfer switches that are associated with the generator.

The recommended maintenance for the generator set is listed in this Operation and Maintenance Manual, "Maintenance Interval Schedule (Standby Generator Sets)" (Maintenance Section).

Maintenance and Repair

The maintenance that is recommended for Every Week can be performed by an authorized operator. The maintenance that is recommended for the subsequent maintenance intervals must be performed by an authorized service technician or by your Cat dealer.

Unless other instructions are provided, perform maintenance and repairs under the following conditions:

- The engine is stopped.
- The starting system is disabled.
- The generator does not pose an electrical shock hazard.
- The generator is disconnected from the load.

Operation

To ensure proper operation, the generator set must be exercised regularly. For instructions on operating the generator set, see the Operation and Maintenance Manual for the generator set control panel.

For these operation procedures, follow the instructions that are provided in this Operation and Maintenance Manual, "Operation Section": starting the engine, engine operation and stopping the engine.

Record Keeping

Maintain a record to document these items: gauge readings, maintenance that is performed, problems, and repairs.

Space Heaters

Moisture can damage generators and other electrical equipment. Make every effort to keep the generator set as dry as possible.

Generators can operate without problems in humid environments. However, problems can occur when the generator is inactive. Moisture can condense on the windings. This condition can result in poor performance. Also, damage to the windings can occur.

Use space heaters to help keep the windings dry. When the generator is not active, ensure that the space heaters are operating. When the generator is operating, turn OFF the space heaters.

i08287059

Starting Motor - Inspect (If equipped)

SMCS Code: 1451-040; 1453-040

Air Starting Motor

If the starting motor fails, the engine may not start in an emergency situation. A scheduled inspection of the starting motor is recommended.

The starting motor pinion and the flywheel ring gear must be in good condition for the engine to start properly. The engine will not start if the starting motor pinion does not engage the flywheel ring gear. The teeth of the starting motor pinion and the flywheel ring gear can be damaged because of irregular engagement.

Inspect the starting motor for proper operation. Listen for grinding when the engine is started. Inspect the teeth of the starting motor pinion and the flywheel ring gear. Look for patterns of wear on the teeth. Look for teeth that are broken or chipped. If damaged teeth are found, the starting motor pinion and the flywheel ring gear must be replaced.

⚠ WARNING

Personal injury or death can result from improperly checking for a leak.

Always use a board or cardboard when checking for a leak. Escaping air or fluid under pressure, even a pin-hole size leak, can penetrate body tissue causing serious injury, and possible death.

If fluid is injected into your skin, it must be treated immediately by a doctor familiar with this type of injury.

Inspect all components in the air circuit for the starting motor. Inspect all air lines and connections for leaks.

If damaged teeth are found, the air circuit for the starting motor must be examined to determine the cause of the problem.

Servicing the Air Inlet Screen

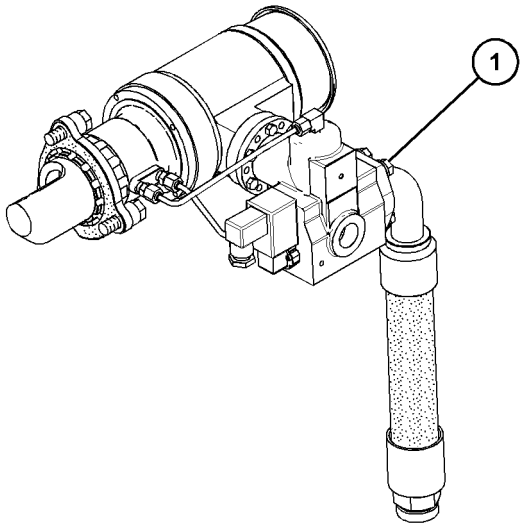

Illustration 104 g06612016

⚠ WARNING

Do not disconnect the air lines until the air pressure in the system is at zero. If hose is disconnected under pressure it can cause personal injury.

Note: Ensure that the air system is not pressurized.

1. Disconnect inlet air line to the starting motor (1).

2. Remove the retaining ring.

3. Remove the screen and clean the screen.

4. Reinstall the screen.

5. Reinstall the retaining ring.

6. Connect the inlet air line to the starting motor.

Removal and Installation of the Starting Motor

Refer to the Service Manual, “Disassembly and Assembly” module for information on removing the starting motor and installing the starting motor.

Consult your Cat dealer for assistance and/or for options on replacement of the starting motor.

i08265790

Stator Lead - Check

SMCS Code: 4459-535

Ensure that the stator output leads are routed out of the generator in a manner that prevents the leads from rubbing against metal objects.

Visually inspect the following areas for cracking and physical damage:

- stator output leads
- protective sleeving
- insulation

i08312312

Stator Winding Temperature - Test

SMCS Code: 4453-081-TA

Some generators are provided with optional 100 Ohm Resistance Temperature Detectors (RTD). When the temperature of the stator winding is suspected to be high, measure the temperature. If the generator is furnished with Resistance Temperature Detectors, the detectors are installed in the slots of the main armature (stator). The detectors are used with equipment that is available from the factory. This equipment is used to measure the main armature winding temperature.

i08335586

Thermostatic Valve - Inspect (If Equipped)

SMCS Code: 135V-040

Perform the following procedure:

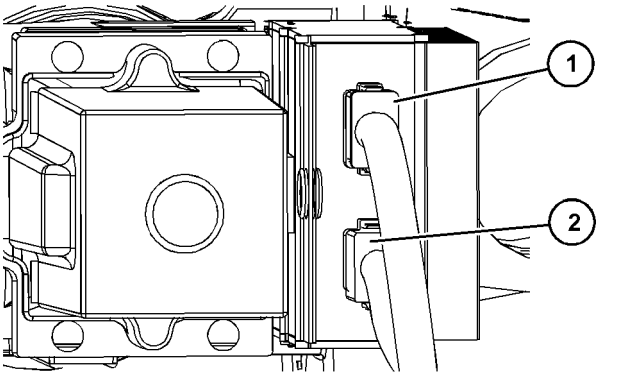

Illustration 105 g06632214

1. Prior to inspecting the electronic thermostat, remove connector (2) to disconnect power to the controller module.

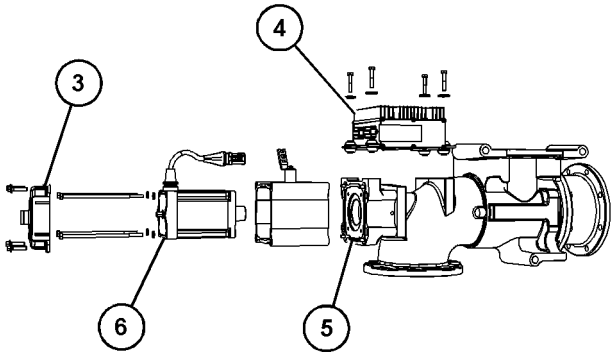

Illustration 106 g06632218

Component breakdown for inspection of the electronic thermostat for moisture entry

(3) Motor cover
(4) Control module
(5) Motor group
(6) Motor mount assembly

2. Remove the four bolts from motor cover (3). Remove the cover from the motor group.

3. Disconnect the connector from control module (4). Remove the mounting bolts, washers, and spacers from the control module. Remove the control module from the electronic thermostat.

4. Remove the four bolts and washers from motor (5). Remove the motor from motor mount assembly (6).

5. Visually inspect the motor housing for moisture entry, corrosion, and rust. Turn the armature of the motor to ensure that the motor turns freely.

If moisture entry, corrosion, or rust is found inside the motor housing, or if the motor does not turn freely, replace the motor.

Note: For additional information, refer to Special Instructions, REHS7404.

6. Perform steps 4 through 2 to assemble the electronic thermostat and motor assembly.

i08009185

Turbocharger - Inspect

SMCS Code: 1052-040

Periodic inspection and cleaning are recommended for the turbocharger compressor housing (inlet side).

Fouling of the compressor can contribute to loss of engine power, increased black smoke and overall loss of engine efficiency.

If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel could allow parts from the compressor wheel to enter an engine cylinder. This condition could damage the pistons, the valves, and the cylinder head.

NOTICE
Failure of turbocharger bearings and seals can cause large quantities of oil to enter the air inlet and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of a turbocharger housing under extended low idle operation should not cause problems as long as a turbocharger bearing failure has not occurred.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine rpm up at no load), do not continue engine operation until the turbocharger is repaired or replaced.

NOTICE
Failure to perform a maintenance inspection at less than the recommended 4500 hours will not void the emissions-related warranty.

An inspection of the turbocharger can minimize unscheduled downtime. An inspection of the turbocharger can also reduce the chance for potential damage to other engine parts.

Note: Turbocharger components require clearances that are precise. The turbocharger cartridge must be balanced due to high rpm. Severe service applications can accelerate the wear of the components. Severe service applications may require more frequent inspections of the turbocharger.

Removal and Installation

For options regarding the removal, installation, repair, and replacement, consult your Cat dealer. Refer to the Service Manual for this engine or consult your Cat dealer for the procedure and specifications.

Cleaning and Inspecting

1. Remove the exhaust outlet piping and remove the air inlet piping from the turbocharger. Visually inspect the piping for the presence of oil.

Illustration 107 g06504979

Polish or striping is visible on compressor housing, no scratches can be felt with O-ring pick. No material has been removed or scratches present below the surrounding surface of compressor housing. No displaced material or wear on compressor wheel blades is present. **Component can remain in service.**

Illustration 108 g06504985

Polished area in center of housing is bordered by areas of light corrosion. No displaced material or wear on compressor wheel blades is present. No material has been removed or scratches present below the surrounding surface of compressor housing. **Component can remain in service.**

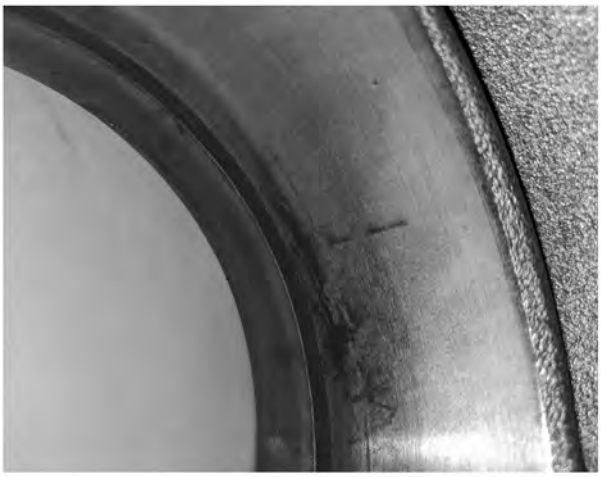

Illustration 109 g06504989

Compressor housing has been removed for clarity. Deposit build-up is present on compressor housing. Material can be easily removed with solvent or light scraping. **Component can remain in service.**

Illustration 110 g06505027

Compressor wheel blades are missing material due to wear and contact with housing. Material has been removed and chatter/scratches are present on compressor housing. **Component should be replaced immediately.**

Illustration 111 g06505032

No displaced material, burrs, or wear on compressor wheel blades is present. Radial scratch is present below the surrounding surface of compressor housing. Scratch can be felt with O-ring pick. **Component should be replaced immediately.**

2. Turn the compressor wheel and the turbine by hand. The assembly should turn freely. Inspect the compressor wheel and the turbine wheel for contact with the turbocharger housings. Compressor housing polishing and deposit buildup can often appear as rubs. To confirm that a rub is present, inspect for displaced material and scratches that are below the surrounding area. Compressor wheel blades that show displaced material resulting in burrs on trailing edges or visible blade wear should be replaced. If deposit buildup is present and can be manipulated or removed easily with solvent, a soft bristle brush or smooth scraper are acceptable for use. See images that follow for reference. If evidence of compressor wheel rub is present, consult your Cat dealer. More disassembly and inspection may be required to evaluate any concerns.

3. Check the compressor wheel for cleanliness. If only the blade side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system. If oil is found only on the back side of the wheel, there is a possibility of a failed turbocharger oil seal.

   The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the inlet air (plugged air filters). This condition would cause the turbocharger to slobber.

4. Inspect the bore of the turbine housing for corrosion.

5. Clean the turbocharger housing with standard shop solvents and a soft bristle brush.

6. Fasten the air inlet piping and the exhaust outlet piping to the turbocharger housing.

i08246338

Varistor - Check

SMCS Code: 4466-535

The varistor must be checked at regular intervals. Refer to Systems Operation/Testing and Adjusting, KENR5284, “Varistor - Test” for instructions.

i08331148

Varistor - Inspect

SMCS Code: 4466-040

The varistor must be inspected at regular intervals. Physical signs of failure indicate that replacement of the varistor is necessary.

i08286677

Voltage and Frequency - Check

SMCS Code: 4450-535-EL

Check for the proper voltage setting and check for the proper frequency setting. Check for stability.

For the correct voltage and frequency, refer to the generator set serial number plate.

i08286689

Walk-Around Inspection

SMCS Code: 1000-040

Inspect the Generator Set for Leaks and for Loose Connections

A walk-around inspection should only take a few minutes. When the time is taken to perform these checks, costly repairs and accidents can be avoided.

For maximum engine service life, make a thorough inspection of the engine before starting. Look for items such as oil leaks or coolant leaks, loose bolts, worn belts, loose connections, and trash buildup. Make repairs, as needed:

- The guards must be in the proper place. Repair damaged guards or replace missing guards.
- Ensure that the areas around the rotating parts are clear.
- Wipe all caps and plugs before the engine is serviced to reduce the chance of system contamination.

NOTICE
For any type of leak (coolant, lube, or fuel) clean up the fluid. If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more often than recommended until the leak is found or fixed, or until the suspicion of a leak is proved to be unwarranted.

NOTICE
Accumulated grease and/or oil on an engine or deck is a fire hazard. Remove this debris with steam cleaning or high pressure water.

Air Inlet and Exhaust System

- Inspect the piping for the air inlet and exhaust system and the elbows for cracks.
- Ensure that the air filters are in place.
- Ensure that all clamps and connections are secure.
- Observe the air cleaner service indicator. Service the air cleaner when the yellow diaphragm enters the red zone, or when the red piston locks in the visible position.

Cooling System

- Inspect the cooling system for leaks or loose connections.
- Inspect the cooling system hoses for cracks and for loose clamps.
- Inspect the water pumps for evidence of leaks.
- Inspect the fan drive belts for cracks and for deterioration.
- Check the coolant level. Add coolant, if necessary. For information on the proper coolant to use, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations”.

Note: The water pump seal is lubricated by coolant in the cooling system. A small amount of leakage to occur as the engine cools down and the parts contract is normal.

Excessive coolant leakage may indicate the need to replace the water pump seal. For the removal of the water pump and the installation of the water pump and seals, refer to the Service Manual . For more information consult your Cat dealer.

Driven Equipment

- Perform any maintenance that is required for the driven equipment. Refer to the Operation and Maintenance Manual for the generator.
- Ensure that the main circuit breaker is open.

Electrical System

Inspect the wiring for the following conditions:

- Loose connections
- Wiring that is worn or frayed
- Inspect the alternator belt for cracks and for deterioration.
- Inspect the ground strap for a good connection and for good condition.
- Inspect the engine-to-frame ground strap for a good connection and for good condition.

Fuel System

The high-pressure fuel system is sensitive to debris. The debris can lead to early erosion and replacement for many of the high-pressure fuel system components and lack of performance. Caution should be taken by covering any fuel system opening during maintenance with a CLEAN cover. Refer to Special Instruction, SEBF9107, “CR1100 Fuel System Flushing Procedure” and Special Instruction, SEBF9109, “CR1100 Fuel System Assembly and Handling Guidelines” for information on handling and assembling fuel system components.

NOTICE
All valves in the fuel return line must be open before and during engine operation to help prevent high fuel pressure. High fuel pressure may cause filter housing failure or other damage.

- Inspect the fuel lines for loose fittings and leaks. Ensure that the fuel lines are properly clamped.
- Ensure that the fuel is supplied to the engine.
- Drain the water and the sediment from fuel tanks daily to ensure that only clean fuel enters the fuel system.

If the engine has not been started for several weeks, fuel may have drained from the fuel system. Air may have entered the filter housing. Also, when fuel filters have been changed, some air space will be left in the housing. In these instances, prime the fuel system. See this Operation and Maintenance Manual (Maintenance Section), “Fuel System-Prime” for information on priming the fuel system.

Lubrication System

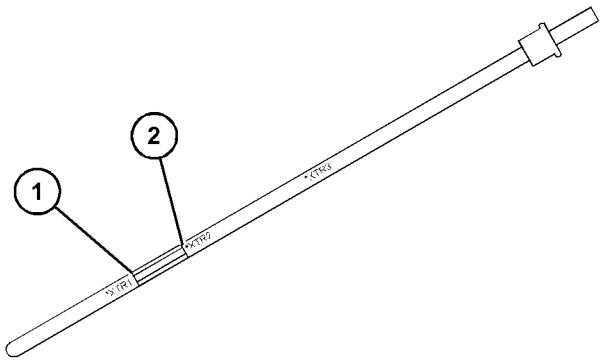

Illustration 112 g06611624

Oil level gauge

(1) “ADD” mark
(2) “FULL” mark

- Check the engine crankcase oil level. Maintain the oil level between the “ADD” and “FULL” marks on the “ENGINE STOPPED” side of the oil level gauge. For information on the proper oil to use, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations”.
- Check for leaks at the following components: crankshaft seals, crankcase, oil filters, oil gallery plugs, sensors, and valve covers.
- Inspect the tubes, tee pieces, and clamps on the crankcase breathers.

Starting System

- Disconnect any battery chargers that are not protected against the high current drain that is created when the electric starting motor is engaged.
- Inspect the battery cables for good connections and for corrosion.
- Inspect the gauges and/or the control panel for good condition.
- Reset the shutoff and alarm components.

i08187477

Water Pump - Inspect

SMCS Code: 1361-040

Failure of a water pump might cause severe overheating. Overheating could result in the following:

- Cracks in the cylinder head
- Damage to the oil coolers
- Piston seizure
- Other potential engine damage

Visually inspect the water pump for leaks. The engine may be equipped with more than one water pump.

If a continuous drip is found coming from the water pump weep hole when the engine is off, replace the seals or replace the pump. Also, if a constant stream is observed when the engine is running, replace the seals or replace the pump.

Evidence of dried coolant around the weep hole can be an indication of intermittent dripping that is part of the normal operation of the pump. Frequent observation is recommended to determine the type of water pump leak.

For more information on cooling system troubleshooting, refer to the applicable Troubleshooting manual.

For the replacement of the water pump or the water pump seals, refer to the applicable Disassembly and Assembly manual.

Consult with your Cat dealer for more information on water pump leaks or cooling system issues.

Warranty Section

Warranty Information

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Warranty Information

SMCS Code: 1000

Engine Protection Plans

Extended Warranties and Service Contracts

A wide variety of protection plans are available for Cat Engines. Consult your Cat dealer for detailed information on the specific programs and coverages that are available.

Consult your Cat dealer for information on a plan that is tailored to fit your requirements.

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Emissions Warranty Information

SMCS Code: 1000

This engine may be certified to comply with exhaust emission standards and the engine may be covered by an Emissions Warranty. A detailed explanation of the Emissions Warranty that is applicable to emissions certified engines is found in Supplement, SMBU6981, “Federal Emissions Control Warranty Information For U.S., Canada, and California”. Consult your Cat dealer to determine if your engine is emissions certified and if the engine is subject to an Emissions Warranty.

Reference Information Section

Engine Ratings

i08231173

Engine Rating Conditions

SMCS Code: 1000

All engine ratings are in compliance with the following standard ambient air conditions of “SAE J1349”:

- 100 kPa (29.61 inches of Hg)
- A temperature of 25 °C (77 °F)

The following standard conditions of “ISO3046/1”, “DIN6271”, and “BS5514” are also applicable:

- 100 kPa (29.61 inches of Hg)
- Relative humidity of 60 percent

The ratings are also valid for the following parameters:

- Air temperature (air cleaner) of 50 °C (122 °F) or less
- Sea water temperature (sea level) of 42 °C (108 °F) or less

Fuel consumption is based on the following specifications:

- Low heat value (LHV) of the fuel of 42 780 kJ/kg (18,390 Btu/lb) at 29 °C (84 °F)
- Gravity (API) of 35 degrees at 15 °C (60 °F)
- Specific gravity of .849 at 15 °C (60 °F)
- Density of 850 kg/m^3 (7.085 lb/US gal)

The engine ratings are gross output ratings.

Gross Output Ratings – The total output capability of the engine that is equipped with standard accessories.

Standard accessories include the following components:

- Oil pumps
- Fuel transfer pumps
- Water pumps

Subtract the power that is required to drive auxiliary components from the gross output. This process will produce the net power that is available for the external load (flywheel).

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Engine Rating Definitions

SMCS Code: 1000

Table 43

	Power Rating			
	Emergency Standby Power (ESP)(1)	Standby(1)	Prime	Continuous
Average power output	70% of ESP rating	70% of standby power	70% of prime power rating	70% to 100% of continuous power rating
Load(2)	Varying	Varying	Varying	Non-varying
Typical hours per year	50	200	Unlimited	Unlimited
Maximum expected usage (hours per year)	200	500	n/a	n/a
Typical peak demand	n/a	n/a	100% of prime rated ekW with 10% overload capability for emergency use for a maximum of 1 hour in 12. The generator set cannot be operated at overload for more than 25 hours per year.	100% of continuous rated ekW for 100% of operating hours.
Typical application	Building service standby	Standby	Industrial, pumping, construction, rental generator set, or cogeneration	Base load, utility, or cogeneration

(1) Power is available during an emergency outage.
(2) The typical load factor is the sum of the loads divided by the number of hours the generator set operates under those loads. Extended idling time does not enter into the calculation for the load factor. Time that the generator set is not operating does not enter into the calculation for the load factor.

Operating units above these rating definitions results in a shorter life before an overhaul.

Customer Service

i08234815

Customer Assistance

SMCS Code: 1000; 4450

USA and Canada

If a problem arises concerning the operation or service of an engine, the problem will be managed by the dealer in your area.

Your satisfaction is a primary concern to Caterpillar and to Cat dealers. If you have a problem that has not been handled to your complete satisfaction, follow these steps:

1. Discuss your problem with a manager from the dealership.

2. If your problem cannot be resolved at the dealer without additional assistance, use the phone number below to talk with a Field Service Coordinator:

1-800-447-4986

The normal hours are from 8:00 to 4:30 Monday through Friday Central Standard Time.

3. If your needs have not been met still, submit the matter in writing to the following address:

Caterpillar Inc.
Electric Power North America
Attn: Product Support Manager
AC 6109
Mossville, Illinois 61552

Keep in mind: probably, your problem will ultimately be solved at the dealership, using the dealership facilities, equipment, and personnel. Therefore, follow the steps in sequence when a problem is experienced.

Outside of USA and of Canada

If a problem arises outside of USA and outside Canada, and if the problem cannot be resolved at the dealer level, consult the appropriate Caterpillar office.

Latin America, Mexico, Carribean
Caterpillar Americas Co.
701 Waterford Way, Suite 200
Miami, FL 33126-4670
USA
Phone: 305-476-6800
Fax: 305-476-6801

Europe, Africa, and Middle East
Caterpillar Overseas S.A.
76 Route de Frontenex
P.O. Box 6000
CH-1211 Geneva 6
Switzerland
Phone: 22-849-4444
Fax: 22-849-4544

Far East
Caterpillar Asia Pte. Ltd.
7 Tractor Road
Jurong, Singapore 627968
Republic of Singapore
Phone: 65-662-8333
Fax: 65-662-8302

China
Caterpillar China Ltd.
37/F., The Lee Gardens
33 Hysan Avenue
Causeway Bay
G.P.O. Box 3069
Hong Kong
Phone: 852-2848-0333
Fax: 852-2848-0440

Japan
Caterpillar Japan Ltd.
SBS Tower
10-1, Yoga 4-Chome
Setagaya-Ku, Tokyo 158-8530
Japan
Phone: 81-3-5717-1150
Fax: 81-3-5717-1177

Australia and New Zealand
Caterpillar of Australia Ltd.
1 Caterpillar Drive
Private Mail Bag 4
Tullamarine, Victoria 3043
Australia
Phone: 03-9953-9333
Fax: 03-9335-3366

i08292376

Ordering Replacement Parts

SMCS Code: 4450; 7567

⚠ WARNING

When replacement parts are required for this product Caterpillar recommends using Caterpillar replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.

Failure to heed this warning can lead to premature failures, product damage, personal injury or death.

Quality Cat replacement parts are available from Cat dealers throughout the world. Cat dealer parts inventories are up to date. The parts stocks include all the parts that are normally needed to protect your Cat engine investment.

When you order parts, specify the following information:

- Part number
- Part name
- Quantity

If there is a question concerning the part number, provide your dealer with a complete description of the needed item.

When a Cat engine requires maintenance and/or repair, provide the dealer with all the information that is stamped on the Information Plate. This information is described in this Operation and Maintenance Manual (Product Information Section).

Discuss the problem with the dealer. Inform the dealer about the conditions of the problem and the nature of the problem. Inform the dealer about when the problem occurs. This information will help the dealer in troubleshooting the problem and solving the problem faster.

Reference Materials

i08160279

Maintenance Records

SMCS Code: 1000; 4450

Caterpillar recommends the retention of accurate maintenance records. Accurate maintenance records can be used for the following purposes:

- Determine operating costs.
- Establish maintenance schedules for other engines that are operated in the same environment.
- Show compliance with the required maintenance practices and maintenance intervals.

Maintenance records can be used for various other business decisions that are related to engine maintenance.

Maintenance records are a key element of a maintenance program that is managed. Accurate maintenance records can help your Cat dealer to fine-tune the recommended maintenance intervals to meet the specific operating situation. These recommendations should result in a lower engine operating cost.

Records should be kept for the following items:

Fuel Consumption – A record of fuel consumption is essential to determine when the load sensitive components should be inspected or repaired. Fuel consumption also determines overhaul intervals.

Service Hours – A record of service hours is essential to determine when the speed sensitive components should be inspected or repaired.

Documents – These items should be easy to obtain, and these items should be kept in the engine history file. All documents should show this information: date, service hours, fuel consumption, unit number, and engine serial number. The following types of documents should be kept as proof of maintenance or repair for warranty:

Keep the following types of documents as proof of maintenance for warranty. Also, keep these types of documents as proof of repair for warranty:

- Dealer work orders and itemized bills
- Owner repair costs
- Owner receipts
- Maintenance log

i08254037

Maintenance Log

SMCS Code: 1000; 4450

Table 44

Engine Model		**Customer Identifier**		
Serial Number		**Arrangement Number**		
Service Hours	**Quantity Of Fuel**	**Service Item**	**Date**	**Authorization**

i08292374

Reference Material

SMCS Code: 1000; 4450

Additional literature regarding your product may be purchased from your local Cat dealer or by visiting publications.cat.com. Use the product name, sales model, and serial number to obtain the correct information for your product.

publications.cat.com

i08312313

Decommissioning and Disposal

SMCS Code: 1000

When the generator set is removed from service, local regulations for the generator set decommissioning will vary. Disposal of the generator set will vary with local regulations. Consult the nearest Cat dealer for additional information.

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Symbols

SMCS Code: 1000; 4450; 4480; 4490

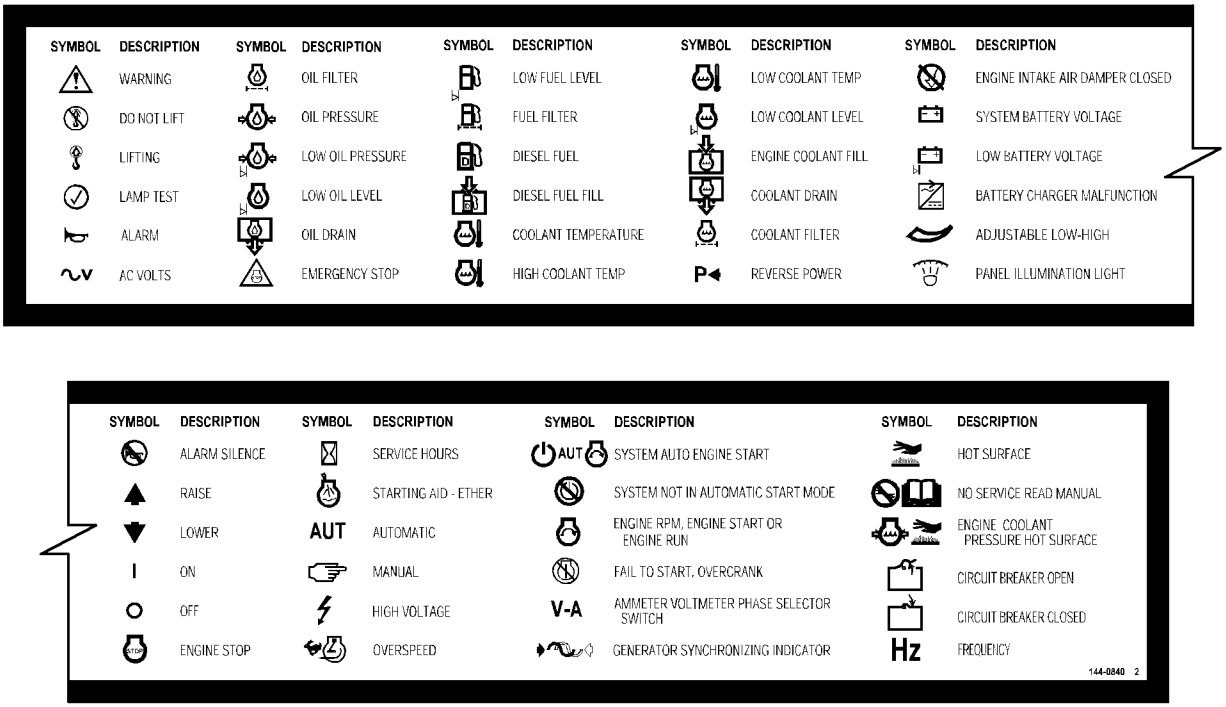

Illustration 113 g01168026

The control panel and modules utilize International Graphic Symbols to identify functions.

A typical list of the symbols that may be used is shown above.

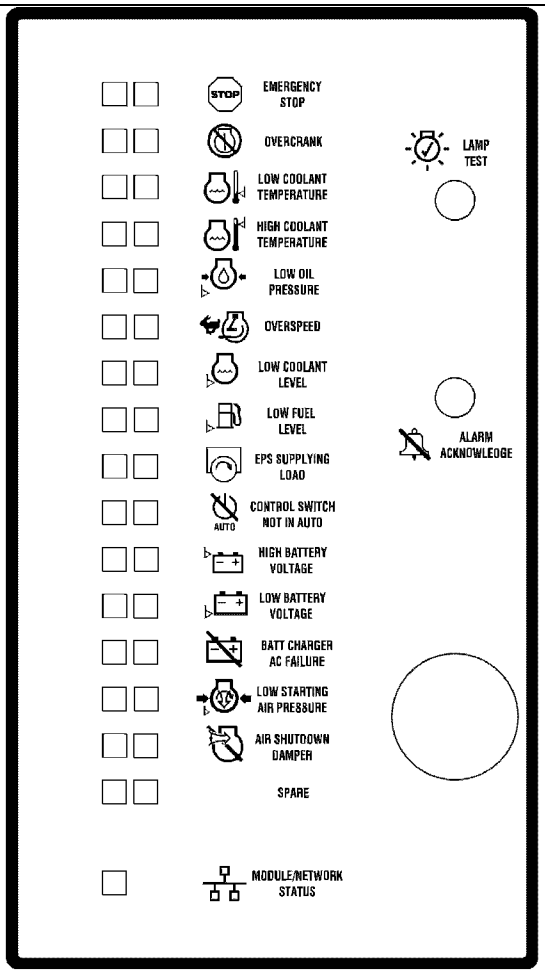

Illustration 114 g01758171

The control panel and modules utilize International Graphic Symbols to identify functions.

A typical list of the symbols that may be used is shown above.

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Glossary

SMCS Code: 4450

Actuate – Actuation relates to putting something in motion.

Alternating Current (AC) – Alternating Current is an electric current that reverses direction at regular intervals (50 times per second in 50 Hz or 60 times per second in 60 Hz).

Anode – An anode is the positive end of a diode or an anode is the positive end of a rectifier.

Blocking Rectifier – A blocking rectifier permits direct current flow in only one direction.

Bolted – A bolted device uses a bolt to hold two or more parts together.

Bridge – A bridge is a circuit that is used to measure small quantities of current, voltage, or resistance.

Bridge Rectifier – A bridge rectifier is a circuit that is used to change alternating current (AC) to direct current (DC).

Buildup – A buildup is a gradual increase in voltage.

Cathode – A cathode is the negative end of a diode or a cathode is the negative end of a rectifier.

Capacitance – Capacitance is the ability to store an electrical charge.

Capacitor – A capacitor is a device that will store an electrical charge.

Circuit Breaker – A circuit breaker is an automatic switch that is used to open a circuit.

Circulating Current – Circulating current is the flow of current between two or more generators that are working in parallel. Circulating current is also the flow of current between two or more generators that are parallel with a utility line.

Conduct – Conducting relates to allowing the flow of current.

Constant Voltage Regulation – Constant Voltage Regulation is one of the two methods of voltage regulation. In order to maintain the line voltage, Constant voltage regulators allow the field to be forced to the saturation point. This allows the engine to be overloaded. On large block load applications, the engine may not recover.

Continuity – Continuity provides a path for current flow.

Control – A control is a device that controls another device. A control is also a circuit that controls a device.

Cross Current Compensation – Cross current compensation is a method that is used for reactive power equalization.

Current Transformer (CT) – A current transformer is used to step down higher line current.

Direct Current (DC) – Direct current is current flow that moves in only one direction in a given circuit.

Damping – Damping refers to decreasing the amplitude of a signal.

De-energized – A de-energized input refers to stopping the current that is going to a component.

Distribution Winding – Distribution windings go from one end of the core to the other end of the core. These windings are arranged in groups that are located in several slots.

Droop – Droop refers to a decrease.

Excitation – Excitation is controlled direct current (DC) that is used to make a magnetic field.

Energized – An energized input refers to activating a device.

Electrostatic Charge – Electrostatic charge is electricity that is caused by induced voltage and stored charge.

Exciter – An exciter supplies direct current (DC) to the field windings of the generator.

Field – A field is a magnetic line of force that surrounds a conductor. This force is caused by current flow in the conductor.

Field Windings – Field windings are many turns of wire that are wrapped around an iron core. When direct current (DC) flows through the field windings, a magnetic field is produced. This magnetic field is comparable to the magnetic field of a bar magnet.

Flashing – Flashing is a process of putting direct current from an external source into the field windings. This process causes the generator to produce an output voltage.

Flux – Flux is magnetic lines of force.

Frequency – Frequency is the number of cycles that are completed in a one second period. The unit of frequency is the Hertz (Hz). One hertz is equal to one cycle per second.

Full-Wave Rectifier – A full-wave rectifier changes the positive phase and the negative phase of alternating current to direct current.

Gain – Gain relates to the ratio of input magnitude to output magnitude.

Gate – A gate is an electronic part of a controlled rectifier (thyristor).

Generate – The production of electricity.

Grounded – A device is grounded by making a connection to ground. A device could also be grounded by making a connection to a component that is connected to ground.

Hertz (Hz) – Hertz is the unit of measurement for frequency. One hertz is equal to one cycle per second.

Humidity – Humidity is the water content that is present in the air.

Impedance – Impedance is the resistance to alternating current.

Impulse Modulation – Impulse modulation changes the following characteristics of a wave: amplitude, frequency and phase. This is accomplished by impressing one wave on another wave that has constant properties.

Induce – This refers to the transfer of power from one device to another device. The transfer is done via a magnetic field or via an electric field.

Interference – Interference is an unwanted mixture of electrical signals. Interference is usually associated with electrical noise.

Instrumentation – Instrumentation is a group of instruments that are used for measuring a system function.

Insulated – An insulated device is a device that is covered with a nonconductive material.

kVA – This is the abbreviation for Kilovolt Amperes. kVA is a term that is used when electrical devices are rated. In order to calculate a device's kVA rating, multiply the rated output (amperes) by the rated operating voltage.

KVAR – Kilovolt Amperes Reactive is abbreviated as KVAR. KVAR is associated with the reactive power that flows in a power system. Reactive power does not load the generator set's engine. Reactive power will cause thermal loss in the generator.

KVAR Regulation – KVAR Regulation is one of the two methods that are used to regulate the reactive power output. Regardless of the generator's real power output, the voltage regulator causes the generator to produce a constant value of KVAR. In this case, the generator's power factor will change when the generator's real power output changes. KVAR regulation is used when the generator is connected in parallel with an infinite bus (utility) and it is not possible to change the system voltage.

Kilowatts (kW) – Kilowatt is the electrical rating of the generator. One kilowatt equals 1000 watts. Actual power is measured in kilowatts.

Lead – A lead is a wire.

Line Voltage – Line voltage is the output voltage of the generator that is measured between the generator leads (phases).

Lock In – Lock in occurs when a contact closes in order to keep a device in an energized state.

Lock Out – Lockout occurs when a contact opens in order to keep a device in a de-energized state.

Magnetic – A magnetic device is a device that has the characteristics of a magnet.

Magnification – Magnification refers to the enlargement of an item.

Module – A module is an assembly of electronic components and electronic circuits.

Moisture – Moisture is the presence of water.

Oscillation – Oscillation is the flow of electricity that periodically changes direction and/or magnitude.

Permanent Magnet (PM) – A permanent magnet supplies the initial magnetism that is required to start a PMPE generator.

Permanent magnet pilot excited (PMPE) – A PMPE generator receives power for the voltage regulator from a pilot exciter. A PMPE generator consists of a permanent magnet and a pilot exciter.

PF Regulation – The PF regulation is one of the two ways to regulate the reactive power output. PF regulation is used when the generator is connected in parallel with an infinite bus (utility) and it is not possible to control the system voltage.

Phase Winding – A phase winding is a group of generator stator coils. Electric power for one phase of the load is induced in the phase winding.

Polarity – Polarity is the positive characteristics or the negative characteristics of two poles.

Power Factor (PF) – Power factor is the ratio of apparent power (kVA) to total power (kW). The power factor represents the portion of the current that is doing useful work. Power factor is expressed as a decimal number between 0 and 1.

Pulsating – Pulsating relates to the characteristics of current that are similar to mechanical vibration.

Radio Suppression – Radio suppression reduces the amplitude of radio frequency interference.

Reactive Droop Compensation – Reactive Droop Compensation is one of the two methods that are

used for reactive power equalization. In reactive droop compensation, the voltage regulator causes an individual generator output to change in proportion to the reactive current. This reactive current is measured with a current transformer.

Reactive Power – Reactive power flows back and forth between the inductive windings of the generator. These windings are part of the electrical load. The reactive power does not perform any useful work in the electrical load. The reactive power only applies load to the generator. This limits the generator's capacity.

Reciprocating – Reciprocating motion is motion that first moves in a straight line in one direction. The direction of this motion then varies by 180 degrees.

Rectifier – A rectifier is a diode circuit that converts alternating current (AC) to direct current (DC).

Regenerative Power – Regenerative power works against primary power.

Reset – A reset returns a switch to a ready condition. In addition, a reset returns a circuit to a ready condition.

Residual Magnetism – Residual magnetism is a small amount of magnetism that is remaining in a device after excitation is removed.

RFA – An RFA is a rotating field assembly.

Rotating Rectifier – A rotating rectifier is mounted to a plate on a generator shaft. This plate then rotates with the generator shaft.

Rotor – A rotor is the rotating windings of a generator.

Saturable Reactor – A saturable reactor has characteristics that are similar to a valve. As the load changes, a valve opens in order to give more current to the output or a valve closes in order to give less current to the output.

Saturated – A device has been saturated when the device has been magnetized in excess. When saturation occurs, a large increase in current results in a small increase in magnetic force.

SCR – An SCR is a silicon controlled rectifier. An SCR is a semiconductor.

SE – An SE generator is a self-excited generator. An SE generator uses a small part of the generator output to provide excitation current back to the generator. An SE generator uses residual magnetic field for start-up.

Semiconductor – A semiconductor is a component such as one of the following components: a transistor, a diode and a thyristor. Semiconductors have electrical characteristics that are between a conductor and insulation.

Series Boost – A series boost is an attachment that allows generator output to continue for a short time during a line failure. This allows the circuit breaker to trip in sequence.

Short – A short is an undesired electrical connection that exists between two or more components.

Shutdown – A shutdown occurs when the engine is stopped. This shutdown can occur manually or this shutdown can occur automatically.

Simultaneous – A simultaneous occurrence refers to two actions that happen at the same time.

Solid-State – A solid-state component is an electrical component that has no moving parts.

Stator – A stator is the windings of a generator that do not rotate.

Surge – A surge is a sudden increase in voltage or current.

Tap – A tap is a connection at the midpoint of a circuit. From this tap, power is taken from the circuit.

Transfer – A transfer refers to moving something from one point to another point. A transfer also refers to converting something from one state to another state.

Transient Peak Voltage – A transient peak voltage is a high voltage condition of limited duration.

Turn-on – When a device is turned on, the device is activated or the device is started.

Varistor – A varistor is a device that loses resistance as voltage increases.

Voltage Droop Resistor – A voltage droop resistor is a variable resistor. This resistor is used to control the change of voltage. This can occur when a generator is paralleled with another generator. This can also occur when the generator is paralleled with a utility.

Voltage Level Rheostat – A voltage level rheostat gives a range of control that is used when the voltage output level is adjusted.

Voltage Regulator – A voltage regulator is a circuit that senses the generator's output voltage. The field coil current is automatically adjusted in order to maintain the desired output.

Voltage Spike – A voltage spike is a brief high voltage.

Volts per Hertz Regulation – Under block loading conditions, the Volts per Hertz Regulation provides fast recovery. This regulation maintains close voltage control over the normal load range. This regulation also produces a rapid response of the generator set. This control is maintained by matching the generator output to the engine performance.

Windings – Windings are layers of wire on a core.

Wiring – Wiring relates to the wires of a circuit.

Wound – Wound refers to being circled.

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Product and Dealer Information

Note: For product identification plate locations, see the section “Product Identification Information” in the Operation and Maintenance Manual.

Delivery Date: _____

Product Information

Model: _____

Product Identification Number: _____

Engine Serial Number: _____

Transmission Serial Number: _____

Generator Serial Number: _____

Attachment Serial Numbers: _____

Attachment Information: _____

Customer Equipment Number: _____

Dealer Equipment Number: _____

Dealer Information

Name: _____ Branch: _____

Address: _____

_____

_____

	Dealer Contact	Phone Number	Hours
Sales:	_____	_____	_____
Parts:	_____	_____	_____
Service:	_____	_____	_____

M0083469 (en-us)
January 2018

Operation and Maintenance Manual

3516E Generator Set

JD7 1-UP (Generator Set)

Important Safety Information

Most accidents that involve product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards, including human factors that can affect safety. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you verify that you are authorized to perform this work, and have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or to other persons.

The hazards are identified by the “Safety Alert Symbol” and followed by a “Signal Word” such as “DANGER”, “WARNING” or “CAUTION”. The Safety Alert “WARNING” label is shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning explains the hazard and can be either written or pictorially presented.

A non-exhaustive list of operations that may cause product damage are identified by “NOTICE” labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. You must not use this product in any manner different from that considered by this manual without first satisfying yourself that you have considered all safety rules and precautions applicable to the operation of the product in the location of use, including site-specific rules and precautions applicable to the worksite. If a tool, procedure, work method or operating technique that is not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that you are authorized to perform this work, and that the product will not be damaged or become unsafe by the operation, lubrication, maintenance or repair procedures that you intend to use.

The information, specifications, and illustrations in this publication are on the basis of information that was available at the time that the publication was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service that is given to the product. Obtain the complete and most current information before you start any job. Cat dealers have the most current information available.

⚠ WARNING

When replacement parts are required for this product Caterpillar recommends using Cat replacement parts.

Failure to follow this warning may lead to premature failures, product damage, personal injury or death.

In the United States, the maintenance, replacement, or repair of the emission control devices and systems may be performed by any repair establishment or individual of the owner's choosing.

Table of Contents

Foreword

Literature Information

This manual contains safety, operation instructions, lubrication and maintenance information. This manual should be stored in or near the engine area in a literature holder or literature storage area. Read, study and keep it with the literature and engine information.

English is the primary language for all Cat publications. The English used facilitates translation and consistency in electronic media delivery.

Some photographs or illustrations in this manual show details or attachments that may be different from your engine. Guards and covers may have been removed for illustrative purposes. Continuing improvement and advancement of product design may have caused changes to your engine which are not included in this manual. Whenever a question arises regarding your engine, or this manual, please consult with your Cat dealer for the latest available information.

Safety

This safety section lists basic safety precautions. In addition, this section identifies hazardous, warning situations. Read and understand the basic precautions listed in the safety section before operating or performing lubrication, maintenance and repair on this product.

Operation

Operating techniques outlined in this manual are basic. They assist with developing the skills and techniques required to operate the engine more efficiently and economically. Skill and techniques develop as the operator gains knowledge of the engine and its capabilities.

The operation section is a reference for operators. Photographs and illustrations guide the operator through procedures of inspecting, starting, operating and stopping the engine. This section also includes a discussion of electronic diagnostic information.

Maintenance

The maintenance section is a guide to engine care. The illustrated, step-by-step instructions are grouped by fuel consumption, service hours and/or calendar time maintenance intervals. Items in the maintenance schedule are referenced to detailed instructions that follow.

Use fuel consumption or service hours to determine intervals. Calendar intervals shown (daily, annually, etc.) may be used instead of service meter intervals if they provide more convenient schedules and approximate the indicated service meter reading.

Recommended service should be performed at the appropriate intervals as indicated in the Maintenance Interval Schedule. The actual operating environment of the engine also governs the Maintenance Interval Schedule. Therefore, under extremely severe, dusty, wet or freezing cold operating conditions, more frequent lubrication and maintenance than is specified in the Maintenance Interval Schedule may be necessary.

The maintenance schedule items are organized for a preventive maintenance management program. If the preventive maintenance program is followed, a periodic tune-up is not required. The implementation of a preventive maintenance management program should minimize operating costs through cost avoidances resulting from reductions in unscheduled downtime and failures.

Maintenance Intervals

Perform maintenance on items at multiples of the original requirement. Each level and/or individual items in each level should be shifted ahead or back depending upon your specific maintenance practices, operation and application. We recommend that the maintenance schedules be reproduced and displayed near the engine as a convenient reminder. We also recommend that a maintenance record be maintained as part of the engine's permanent record.

See the section in the Operation and Maintenance Manual, “Maintenance Records” for information regarding documents that are generally accepted as proof of maintenance or repair. Your authorized Cat dealer can assist you in adjusting your maintenance schedule to meet the needs of your operating environment.

Overhaul

Major engine overhaul details are not covered in the Operation and Maintenance Manual except for the interval and the maintenance items in that interval. Major repairs are best left to trained personnel or an authorized Cat dealer. Your Cat dealer offers a variety of options regarding overhaul programs. If you experience a major engine failure, there are also numerous after failure overhaul options available from your Cat dealer. Consult with your dealer for information regarding these options.

California Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

Battery posts, terminals and related accessories contain lead and lead compounds. **Wash hands after handling.**

Safety Section

i07139643

Safety Messages

SMCS Code: 1000; 7405

There may be several specific safety messages on your engine. The exact location and a description of the safety messages are reviewed in this section. Become familiar with all safety messages.

Ensure that all the safety messages are legible. Clean the safety messages or replace the safety messages if the words cannot be read or if the illustrations are not visible. Use a cloth, water, and soap to clean the safety messages. Do not use solvents, gasoline, or other harsh chemicals. Solvents, gasoline, or harsh chemicals could loosen the adhesive that secures the safety messages. The safety messages that are loosened could drop off the engine.

Replace any safety message that is damaged or missing. If a safety message is attached to a part of the engine that is replaced, install a new safety message on the replacement part. Your Cat dealer can provide new safety messages.

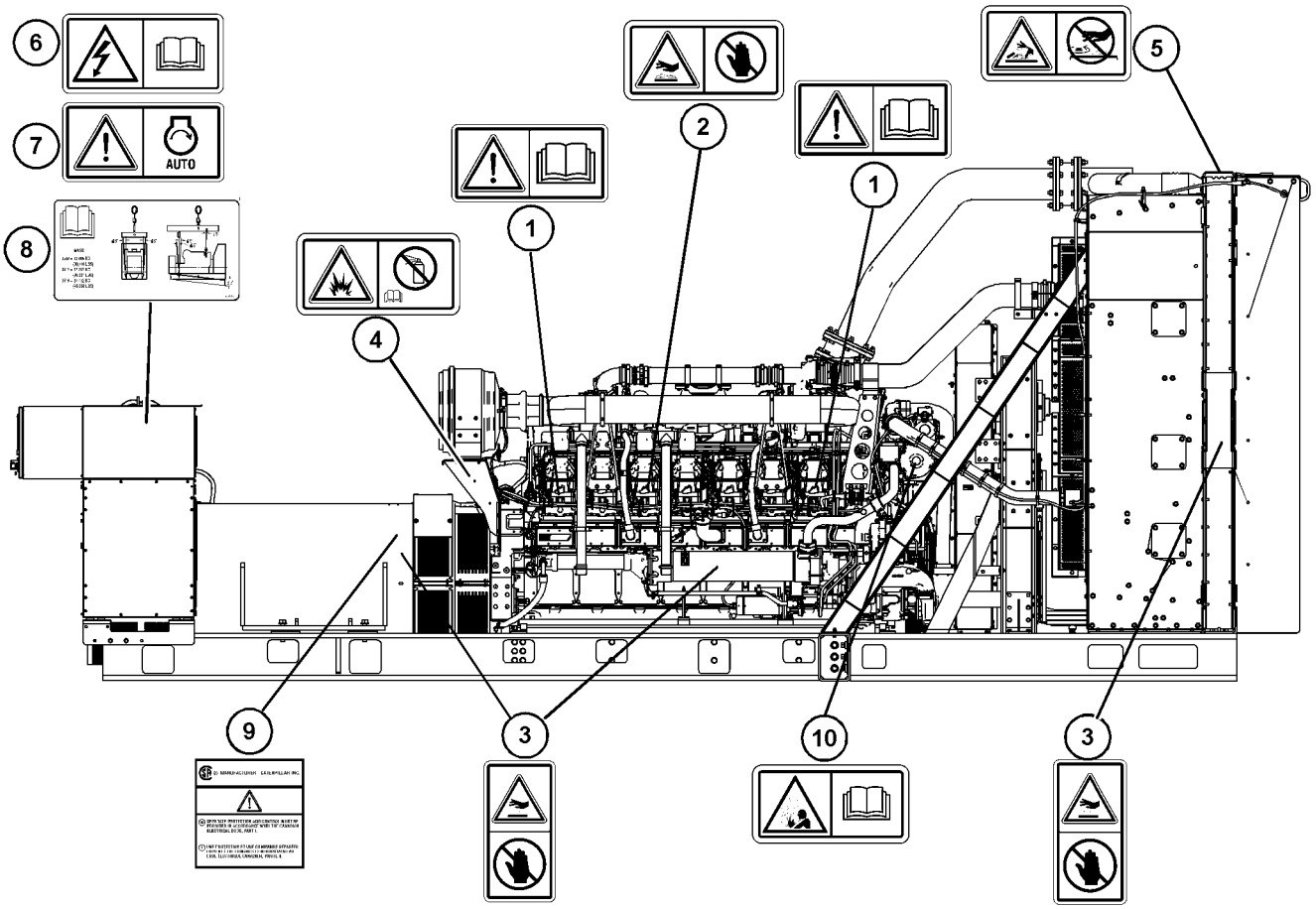

Illustration 1 g06233392

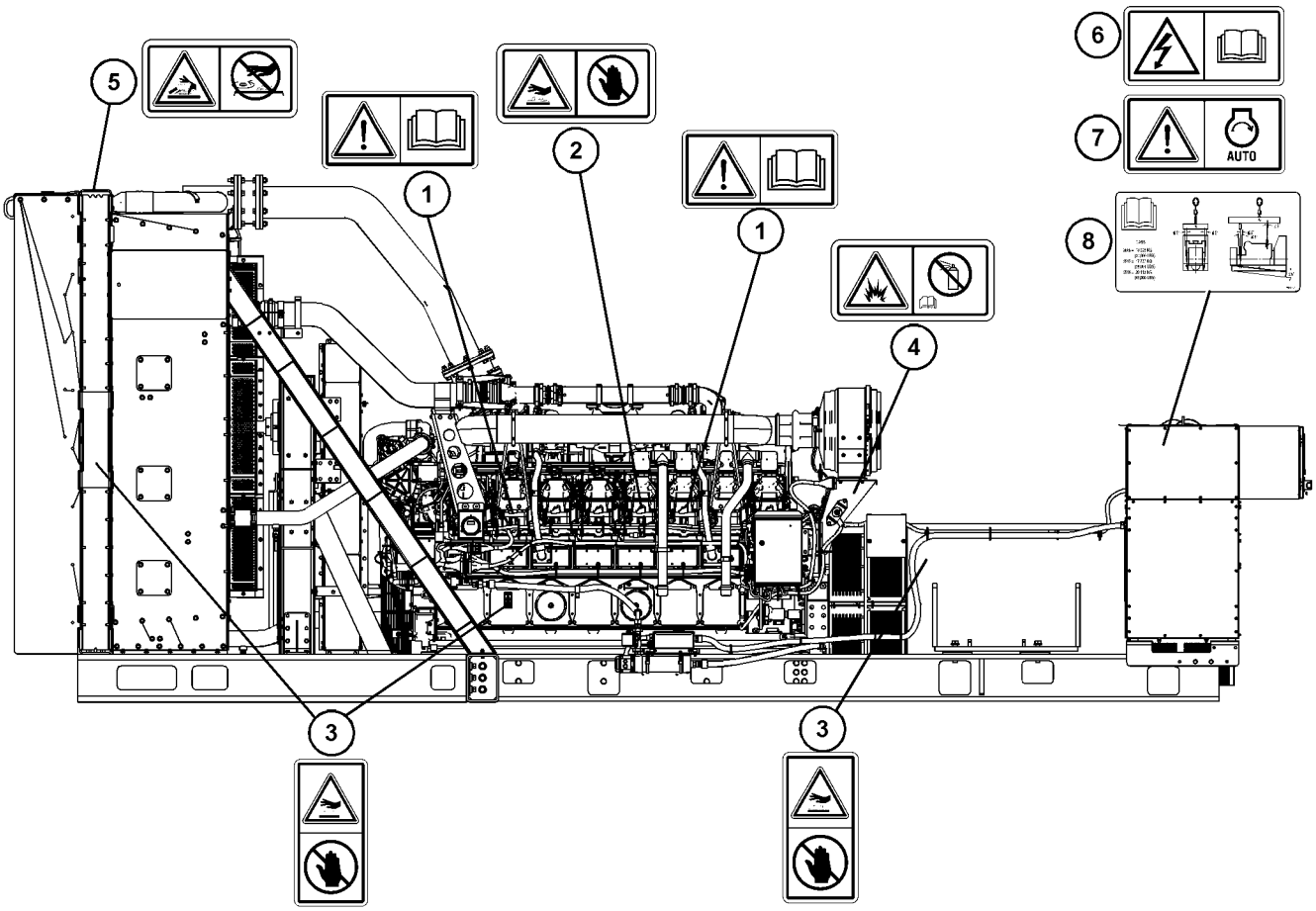

Illustration 2 g06233404

Universal Warning (1)

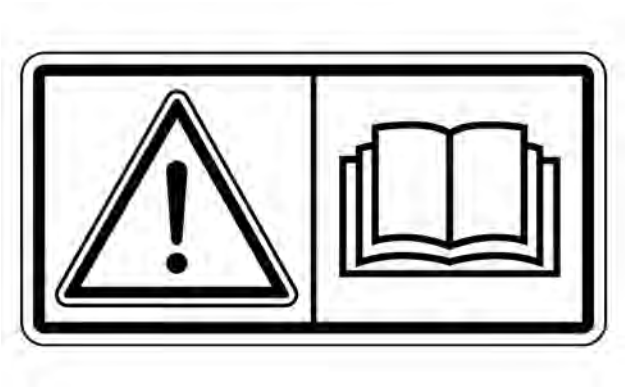

Illustration 3 g01370904

This safety message is on valve cover bases on both sides of the engine.

⚠ WARNING

Do not operate or work on this engine or generator set unless you have read and understand the instructions and warnings in the Operation and Maintenance Manuals.

Failure to follow the warnings and instructions could result in injury or death. Contact any Caterpillar dealer for replacement manuals. Proper care is your responsibility.

Hot Surface (2)

Illustration 4 g01372256

This safety message is on both sides of the engines on valve cover bases.

⚠ WARNING

Hot parts or hot components can cause burns or personal injury. Do not allow hot parts or components to contact your skin. Use protective clothing or protective equipment to protect your skin.

Hot Surface (3)

Illustration 5 g01384734

This safety message is on the oil cooler and both sides of the radiator. The message is also on the crankcase cover on the left side of the engine and on both sides of the barrel of the generator.

⚠ WARNING

Hot parts or hot components can cause burns or personal injury. Do not allow hot parts or components to contact your skin. Use protective clothing or protective equipment to protect your skin.

Explosion Hazard (Ether) (4)

Illustration 6 g01372254

This safety message is on the air cleaner mounting bracket.

⚠ WARNING

Explosion hazard! Do not use ether! This machine is equipped with an air inlet heater. Using ether can create explosions or fires that can cause personal injury or death. Read and follow the starting procedure in the Operation and Maintenance Manual.

Hot Fluid Under Pressure (5)

Illustration 7 g01371640

One safety message is on top of the radiator near the radiator cap.

⚠ WARNING

Pressurized system! Hot coolant can cause serious burns, injury or death. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure. Read and understand the Operation and Maintenance Manual before performing any cooling system maintenance.

Electrocution (6)

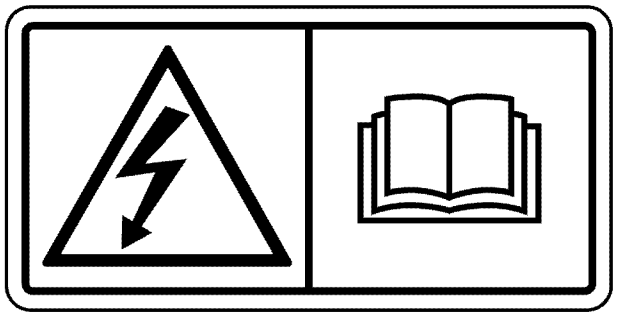

Illustration 8 g03430411

One safety message is on each side of the terminal box.

⚠ DANGER

Do not connect the generator to a utility electrical distribution system unless it is isolated from the system. Electrical feedback into the distribution system can occur and could cause personal injury or death.

Open and secure the main distribution switch, or if the connection is permanent, install a double throw switch to prevent electrical feedback. Some generators are specifically approved by a utility to run in parallel with the distribution system and isolation may not be required. Always check with your utility for the applicable circumstances.

Auto Start (7)

Illustration 9 g01392484

One safety message is on each side of the terminal box.

⚠ WARNING

When the engine is in the AUTOMATIC mode, the engine can start at any moment. To avoid personal injury, always remain clear of the the engine when the engine is in the AUTOMATIC mode.

Lifting the Product (Including the Radiator) (8)

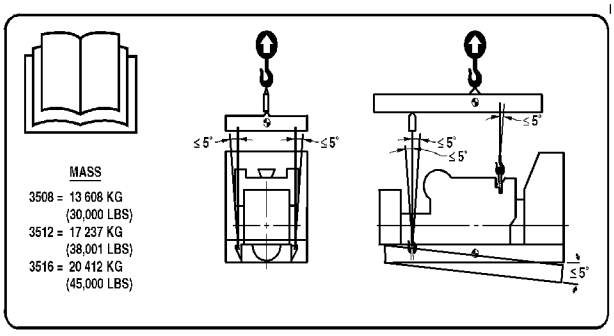

Illustration 10 g01411378

One safety message is on each side of the terminal box.

⚠ WARNING

Before lifting the product, read this Operation and Maintenance Manual, "Product Lifting" in the Operation Section.

If improper equipment is used to lift the product, injury and damage can occur. Use cables which are properly rated for the weight. Use a spreader bar and attach the cables according to the information on the safety message.

Canadian Standards Association (9)

Illustration 11 g01667111

If applicable, this safety message is on the right side on the barrel of the generator.

⚠ WARNING

Separate protection and control must be provided in accordance with the Canadian Electrical Code, part 1.

Vapor Explosion (Oil Filter) (10)

This message is on the end of the oil filter housing.

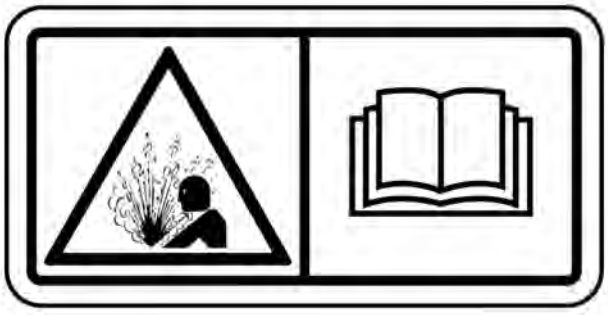

Illustration 12 g01407639

⚠ WARNING

Warning: Vapor Explosion. May cause serious injury or death. Read the Operation and Maintenance Manual before conducting any maintenance on the oil filter.

i06300340

General Hazard Information

SMCS Code: 1000; 4450; 7405

Illustration 13 g03838041

Attach a “Do Not Operate” warning tag to the start switch or controls before the engine is serviced or repaired. These warning tags (Special Instruction, SEHS7332) are available from your Cat dealer. Attach the warning tags to the engine and to each operator control station. When appropriate, disconnect the starting controls.

Do not allow unauthorized personnel on the engine, or around the engine when the engine is being serviced.

Cautiously remove the following parts. To help prevent spraying or splashing of pressurized fluids, hold a rag over the part that is being removed.

- Filler caps
- Grease fittings
- Pressure taps
- Breathers
- Drain plugs

Use caution when cover plates are removed. Gradually loosen, but do not remove the last two bolts or nuts that are located at opposite ends of the cover plate or the device. Before removing the last two bolts or nuts, pry the cover loose in order to relieve any spring pressure or other pressure.

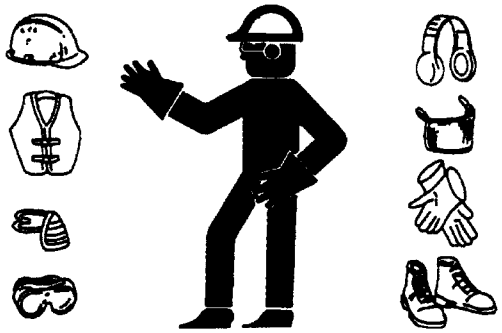

Illustration 14 g00702020

- Wear a hard hat, protective glasses, and other protective equipment, as required.
- When work is performed around an engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.
- Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.
- Ensure that all protective guards and all covers are secured in place on the engine.
- Never put maintenance fluids into glass containers. Glass containers can break.
- Use all cleaning solutions with care.
- Report all necessary repairs.

Unless other instructions are provided, perform the maintenance under the following conditions:

- The engine is stopped. Ensure that the engine cannot be started.

- The protective locks or the controls are in the applied position.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
- When starting a new engine, make provisions to stop the engine if an overspeed occurs. If an engine has not been started since service has been performed, make provisions to stop the engine if an overspeed occurs. Shutting down the engine may be accomplished by shutting off the fuel supply and/or the air supply to the engine.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.
- Start the engine with the operator controls. Never short across the starting motor terminals or the batteries. This method of starting the engine could bypass the engine neutral start system and/or the electrical system could be damaged.

Pressurized Air and Water

Pressurized air and/or water can cause debris and/or hot water to be blown out which could result in personal injury.

The maximum air pressure for cleaning purposes must be reduced to 205 kPa (30 psi) when the air nozzle is deadheaded and used with effective chip guarding (if applicable) and personal protective equipment. The maximum water pressure for cleaning purposes must be below 275 kPa (40 psi).

When pressurized air and/or pressurized water is used for cleaning, wear protective clothing, protective shoes, and eye protection. Eye protection includes goggles or a protective face shield. Always wear eye protection for cleaning the cooling system.

Avoid direct spraying of water on electrical connectors, connections, and components. When using air for cleaning, allow the machine to cool to reduce the possibility of fine debris igniting when redeposited on hot surfaces.

Fluid Penetration

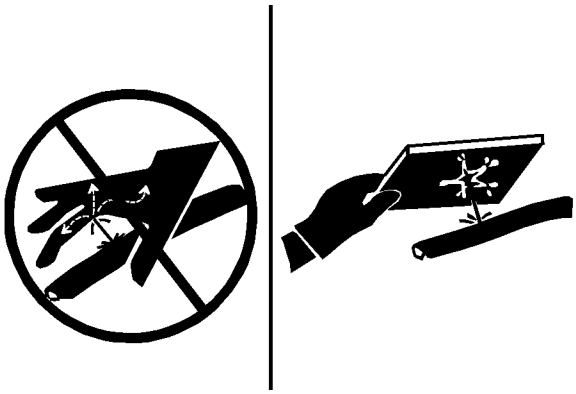

Illustration 15 g00687600

Always use a board or cardboard when you check for a leak. Leaking fluid that is under pressure can penetrate body tissue. Fluid penetration can cause serious injury and possible death. A pin hole leak can cause severe injury. If fluid is injected into your skin, you must get treatment immediately. Seek treatment from a doctor that is familiar with this type of injury.

Containing Fluid Spillage

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Static Electricity Hazard when Fueling with Ultra-low Sulfur Diesel Fuel

The removal of sulfur and other compounds in ultra-low sulfur diesel fuel (ULSD fuel) decreases the conductivity of ULSD and increases the ability of ULSD to store static charge. Refineries may have treated the fuel with a static dissipating additive. Many factors can reduce the effectiveness of the additive over time. Static charges can build up in ULSD fuel while the fuel is flowing through fuel delivery systems. Static electricity discharge when combustible vapors are present could result in a fire or explosion. Ensure that the entire system used to refuel your machine (fuel supply tank, transfer pump, transfer hose, nozzle, and others) is properly grounded and bonded. Consult with your fuel or fuel system supplier to ensure that the delivery system complies with fueling standards for proper grounding and bonding.

⚠ WARNING

Avoid static electricity risk when fueling. Ultra-low sulfur diesel fuel (ULSD fuel) poses a greater static ignition hazard than earlier diesel formulations with a higher sulfur contents. Avoid death or serious injury from fire or explosion. Consult with your fuel or fuel system supplier to ensure the delivery system is in compliance with fueling standards for proper grounding and bonding practices.

Lines, Tubes, and Hoses

Do not bend or strike high-pressure lines. Do not install lines, tubes, or hoses that are damaged.

Repair any fuel lines, oil lines, tubes, or hoses that are loose or damaged. Leaks can cause fires.

Inspect all lines, tubes, and hoses carefully. Do not use bare hands to check for leaks. Always use a board or cardboard for checking engine components for leaks. Tighten all connections to the recommended torque.

Check for the following conditions:

- End fittings that are damaged or leaking
- Outer covering that is chafed or cut
- Wire that is exposed in reinforced hose
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering

Ensure that all of the clamps, the guards, and the heat shields are installed correctly. Correct installation of these components will help to prevent these effects: vibration, rubbing against other parts and excessive heat during operation.

Inhalation

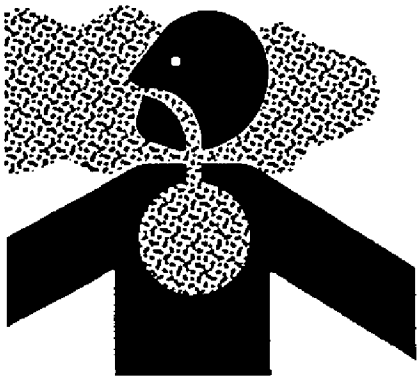

Illustration 16 g02159053

Exhaust

Use caution. Exhaust fumes can be hazardous to your health. If you operate the equipment in an enclosed area, adequate ventilation is necessary.

Asbestos Information

Cat equipment and replacement parts that are shipped from Caterpillar are asbestos free. Caterpillar recommends the use of only genuine Cat replacement parts. Use the following guidelines when you handle any replacement parts that contain asbestos or when you handle asbestos debris.

Use caution. Avoid inhaling dust that might be generated when you handle components that contain asbestos fibers. Inhaling this dust can be hazardous to your health. The components that may contain asbestos fibers are brake pads, brake bands, lining material, clutch plates, and some gaskets. The asbestos that is used in these components is bound in a resin or sealed in some way. Normal handling is not hazardous unless airborne dust that contains asbestos is generated.

If dust that may contain asbestos is present, there are several guidelines that should be followed:

- Never use compressed air for cleaning.
- Avoid brushing materials that contain asbestos.
- Avoid grinding materials that contain asbestos.
- Use a wet method in order to clean up asbestos materials.

- A vacuum cleaner that is equipped with a high efficiency particulate air filter (HEPA) can also be used.
- Use exhaust ventilation on permanent machining jobs.
- Wear an approved respirator if there is no other way to control the dust.
- Comply with applicable rules and regulations for the work place. In the United States, use Occupational Safety and Health Administration (OSHA) requirements. These OSHA requirements can be found in “29 CFR 1910.1001”.
- Obey environmental regulations for the disposal of asbestos.
- Stay away from areas that might have asbestos particles in the air.

Softwrap

Keep the engine room ventilation operating at full capacity. Wear a particulate respirator that has been approved by the National Institute of Occupational Safety and Health (NIOSH). Wear appropriate protective clothing in order to minimize direct contact. Use good hygiene practices and wash hands thoroughly after handling Softwrap material. Do not smoke until washing hands thoroughly after handling Softwrap material. Clean up debris with a vacuum or by wet sweeping. Do not use pressurized air to clean up debris.

Reference: The applicable material safety data sheets can be found at the following web site by searching using part number or the name:

https://catmsds.cat.com/MSDSSearch/servlet/cat.cis.ecs.msdsSearch.controller.UserIdentificationDisplayServlet

Dispose of Waste Properly

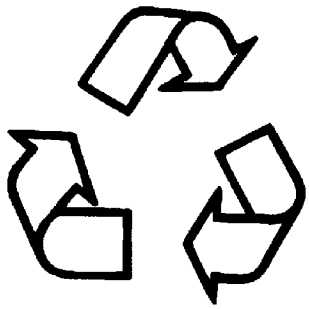

Illustration 17 g00706404

Improperly disposing of waste can threaten the environment. Potentially harmful fluids should be disposed of according to local regulations.

Always use leakproof containers when you drain fluids. Do not pour waste onto the ground, down a drain, or into any source of water.

i02088921

Burn Prevention

SMCS Code: 1000; 4450; 7405

Do not touch any part of an operating engine. Allow the engine to cool before any maintenance is performed on the engine. Relieve all pressure in the appropriate system before any lines, fittings or related items are disconnected.

Coolant

When the engine is at operating temperature, the engine coolant is hot. The coolant is also under pressure. The radiator and all lines to the heaters or to the engine contain hot coolant. Any contact with hot coolant or with steam can cause severe burns. Allow cooling system components to cool before the cooling system is drained.

Check the coolant level after the engine has stopped and the engine has been allowed to cool. Ensure that the filler cap is cool before removing the filler cap. The filler cap must be cool enough to touch with a bare hand. Remove the filler cap slowly in order to relieve pressure.

Cooling system conditioner contains alkali. Alkali can cause personal injury. Do not allow alkali to contact the skin, the eyes, or the mouth.

Oils

Hot oil and hot lubricating components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

If the application has a makeup tank, remove the cap for the makeup tank after the engine has stopped. The filler cap must be cool to the touch.

Batteries

The liquid in a battery is an electrolyte. Electrolyte is an acid that can cause personal injury. Do not allow electrolyte to contact the skin or the eyes.

Do not smoke while checking the battery electrolyte levels. Batteries give off flammable fumes which can explode.

Always wear protective glasses when you work with batteries. Wash hands after touching batteries. The use of gloves is recommended.

i07254650

Fire Prevention and Explosion Prevention

SMCS Code: 1000; 4450; 7405

Illustration 18 g00704000

Use of personal protection equipment (PPE) may be needed.

All fuels, most lubricants, and some coolant mixtures are flammable.

Always perform a Walk-Around Inspection, which may help you identify a fire hazard. Do not operate a product when a fire hazard exists. Contact your Cat dealer for service.

Flammable fluids that are leaking or spilled onto hot surfaces or onto electrical components can cause a fire. Fire may cause personal injury and property damage.

A flash fire may result if the covers for the engine crankcase are removed within 15 minutes after an emergency shutdown.

Determine whether the engine will be operated in an environment that allows combustible gases to be drawn into the air inlet system. These gases could cause the engine to overspeed. Personal injury, property damage, or engine damage could result.

If the application involves the presence of combustible gases, consult your Cat dealer for additional information about suitable protection devices.

Remove all flammable materials such as fuel, oil, and debris from the engine. Do not allow any flammable materials to accumulate on the engine.

All fluids that are captured in the fluid spill containment basin should be cleaned up immediately. Failure to clean up spilled fluids can cause a fire. Fire may cause personal injury and property damage.

Store fuels and lubricants in properly marked containers away from unauthorized persons. Store oily rags and any flammable materials in protective containers. Do not smoke in areas that are used for storing flammable materials.

Do not expose the engine to any flame.

Exhaust shields (if equipped) protect hot exhaust components from oil or fuel spray in a line, a tube, or a seal failure. Exhaust shields must be installed correctly.

Do not weld on lines or tanks that contain flammable fluids. Do not use flame to cut lines or tanks that contain flammable fluid. Clean any such lines or tanks thoroughly with a nonflammable solvent prior to welding or flame cutting.

Wiring must be kept in good condition. Properly route and attach all electrical wires. Check all electrical wires daily. Repair any wires that are loose or frayed before you operate the engine. Clean all electrical connections and tighten all electrical connections.

Eliminate all wiring that is unattached or unnecessary. Do not use any wires or cables that are smaller than the recommended gauge. Do not bypass any fuses and/or circuit breakers.

Arcing or sparking could cause a fire. Secure connections, recommended wiring, and properly maintained battery cables will help to prevent arcing or sparking.

Inspect all lines and hoses for wear or for deterioration. Properly route all hoses. The lines and hoses must have adequate support and secure clamps. Tighten all connections to the recommended torque. Leaks can cause fires.

Properly install all oil filters and fuel filters. The filter housings must be tightened to the proper torque.

Illustration 19 g00704059

Use caution when you are refueling an engine. Do not smoke while you are refueling an engine. Do not refuel an engine near open flames or sparks. Always stop the engine before refueling.

Avoid static electricity risk when fueling. Ultra Low Sulfur Diesel (ULSD) poses a greater static ignition hazard than earlier diesel formulations with a higher Sulfur content. Avoid death or serious injury from fire or explosion. Consult with your fuel or fuel system supplier to ensure that the delivery system is in compliance with fueling standards for proper grounding and bonding practices.

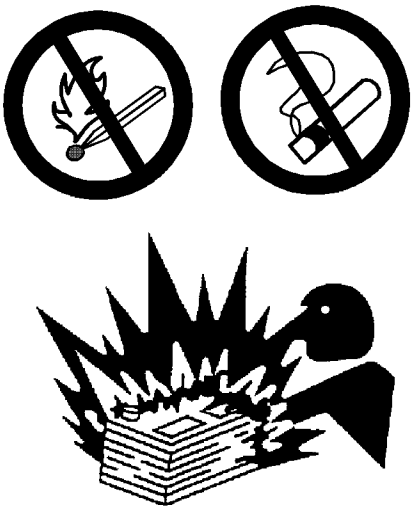

Illustration 20 g02298225

Gases from a battery can explode. Keep any open flames or sparks away from the top of a battery. Do not smoke in battery charging areas.

Never check the battery charge by placing a metal object across the terminal posts. Use a voltmeter or a hydrometer.

Improper jumper cable connections can cause an explosion that can result in injury. Refer to the Operation Section of this manual for specific instructions.

Do not charge a frozen battery. Charging a frozen battery may result in an explosion.

The batteries must be kept clean. The covers (if equipped) must be kept on the cells. Use the recommended cables, connections, and battery box covers when the engine is operated.

Fire Extinguisher

Make sure that a fire extinguisher is available. Be familiar with the operation of the fire extinguisher. Inspect the fire extinguisher and service the fire extinguisher regularly. Obey the recommendations on the instruction plate.

Ether

Ether is flammable and poisonous.

Use ether in ventilated areas. Do not smoke while you are replacing an ether cylinder or while you are using an ether spray.

Do not store ether cylinders in living areas or in the engine compartment. Do not store ether cylinders in direct sunlight or in temperatures above 49 °C (120 °F). Keep ether cylinders away from open flames or sparks.

Dispose of used ether cylinders properly. Do not puncture an ether cylinder. Keep ether cylinders away from unauthorized personnel.

Do not spray ether into an engine if the engine is equipped with a thermal starting aid for cold weather starting.

Lines, Tubes, and Hoses

Do not bend high-pressure lines. Do not strike high-pressure lines. Do not install any lines that are bent or damaged.

Repair any lines that are loose or damaged. Leaks can cause fires. Consult your Cat dealer for repair or for replacement parts.

Check lines, tubes, and hoses carefully. Do not use your bare hand to check for leaks. Use a board or cardboard to check for leaks. Tighten all connections to the recommended torque.

Replace the parts if any of the following conditions are present:

- End fittings are damaged or leaking.
- Outer coverings are chafed or cut.
- Wires are exposed.
- Outer coverings are ballooning.
- Flexible parts of the hoses are kinked.
- Outer covers have embedded armoring.
- End fittings are displaced.

Make sure that all clamps, guards, and heat shields are installed correctly to prevent vibration, rubbing against other parts, and excessive heat.

i01359666

Crushing Prevention and Cutting Prevention

SMCS Code: 1000; 4450; 7405

Support the component properly when work beneath the component is performed.

Unless other maintenance instructions are provided, never attempt adjustments while the engine is running.

Stay clear of all rotating parts and of all moving parts. Leave the guards in place until maintenance is performed. After the maintenance is performed, reinstall the guards.

Keep objects away from moving fan blades. The fan blades will throw objects or cut objects.

When objects are struck, wear protective glasses in order to avoid injury to the eyes.

Chips or other debris may fly off objects when objects are struck. Before objects are struck, ensure that no one will be injured by flying debris.

i01377941

Mounting and Dismounting

SMCS Code: 1000; 4450; 7405

Generator sets in permanent installations may require the use of a ladder or a work platform in order to provide access for normal maintenance. The owner and/or the user is responsible for providing safe access that conforms to SAE J185 and/or local building codes.

Inspect the steps, the handholds, and the work area before mounting the generator set. Keep these items clean and keep these items in good repair.

Mount the generator set and dismount the generator set only at locations that have steps and/or handholds. Do not climb on the generator set, and do not jump off the generator set.

Face the generator set in order to mount the generator set or dismount the generator set. Maintain a three-point contact with the steps and handholds. Use two feet and one hand or use one foot and two hands. Do not use any controls as handholds.

Do not jump from an elevated platform. Do not jump from a ladder or stairs.

Do not stand on components which cannot support your weight. Use an adequate ladder or use a work platform. Secure the climbing equipment so that the equipment will not move.

Do not carry tools or supplies when you mount the generator set or when you dismount the generator set. Use a hand line to raise and lower tools or supplies.

i03690560

Sound Information

SMCS Code: 1000

Note: Information of the sound level is for machines in European Union countries and in countries that adopt the directives of the European Union.

NOTICE
Hearing protection may be needed when working near an operating generator set.

Sound levels will vary depending on the configuration of the generator set and the final installation of the generator set.

Refer to the following for sound levels:

- The sound pressure level of a complete generator set (including the radiator) at 1 meter is 111 dB(A) for the noisiest configuration when “ISO 8528-10:1998(E) clause 14” is used at 75 percent of the rated power.
- The sound power level of a complete generator set (including the radiator) is 125 dB(A) for the noisiest configuration when “ISO 8528-10:1998(E) clause 13” is used at 75 per cent of the rated power.

Note: The preceding sound levels are emission levels. The preceding sound levels are not necessarily safe sound levels. There is a correlation between the emission levels and the level of exposure. The correlation between emission levels and the level of exposure can not be used to determine if further precautions are required.

Refer to the following for factors that influence the level of exposure:

- The characteristics of the area around the generator set
- Other sources of noise
- The number of machines and other adjacent processes
- The length of time of exposure to the noise

This information will enable the user of the machine to evaluate the hazard and the risk.

i03560601

Before Starting Engine

SMCS Code: 1000

NOTICE
For initial start-up of a new or rebuilt engine, and for start-up of an engine that has been serviced, make provision to shut the engine off should an overspeed occur. This may be accomplished by shutting off the air and/or fuel supply to the engine.

⚠ WARNING

Engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.

Inspect the engine for potential hazards.

Do not start the engine or move any of the controls if there is a “DO NOT OPERATE” warning tag or similar warning tag attached to the start switch or to the controls.

Before starting the engine, ensure that no one is on, underneath, or close to the engine. Ensure that the area is free of personnel.

If equipped, ensure that the lighting system for the engine is suitable for the conditions. Ensure that all lights work properly, if equipped.

All protective guards and all protective covers must be installed if the engine must be started in order to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Do not bypass the automatic shutoff circuits. Do not disable the automatic shutoff circuits. The circuits are provided in order to help prevent personal injury. The circuits are also provided in order to help prevent engine damage.

See the Service Manual for repairs and for adjustments.

i06273354

Engine Starting

SMCS Code: 1000

If a warning tag is attached to the engine start switch or to the controls, DO NOT start the engine or move the controls. Consult with the person that attached the warning tag before the engine is started.

All protective guards and all protective covers must be installed if the engine must be started in order to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Start the engine from the operator compartment or from the engine start switch.

Always start the engine according to the procedure that is described in this Operation and Maintenance Manual, “Engine Starting” topic (Operation Section). Knowing the correct procedure will help to prevent major damage to the engine components. Knowing the procedure will also help to prevent personal injury.

To ensure that the jacket water heater (if equipped) and/or the lube oil heater (if equipped) is working properly, check the water temperature gauge and the oil temperature gauge during the heater operation.

Engine exhaust contains products of combustion that can be harmful to your health. Always start the engine and operate the engine in a ventilated area. If the engine is started in an enclosed area, vent the engine exhaust to the outside.

i01032808

Engine Stopping

SMCS Code: 1000

To avoid overheating of the engine and accelerated wear of the engine components, stop the engine according to this Operation and Maintenance Manual, “Engine Stopping” topic (Operation Section).

Use the Emergency Stop Button (if equipped) ONLY in an emergency situation. DO NOT use the Emergency Stop Button for normal engine stopping. After an emergency stop, DO NOT start the engine until the problem that caused the emergency stop has been corrected.

On the initial start-up of a new engine or an engine that has been serviced, make provisions to stop the engine if an overspeed condition occurs. This may be accomplished by shutting off the fuel supply and/or the air supply to the engine.

i02347814

Electrical System

SMCS Code: 1000; 1400

Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operating. A spark can cause the combustible gases that are produced by some batteries to ignite.

When the engine is started from an external source, follow this procedure: first, connect the positive “+” jump start cable from the external power source to the positive “+” battery terminal of the engine that is being started. Then connect the negative “−” jump start cable from the external power source to the negative “−” terminal of the starting motor. This will help to prevent sparks from igniting combustible gases that are produced by some batteries.

Check the electrical wires daily for wires that are loose or frayed. Tighten all loose electrical wires before the engine is operated. Repair all frayed electrical wires before the engine is started.

Grounding Practices

The electrical systems for the generator, the engine and the control systems must be properly grounded. Proper grounding is necessary for optimum performance and reliability. Improper grounding will result in uncontrolled electrical circuit paths and in unreliable electrical circuit paths.

Uncontrolled electrical circuit paths can result in damage to main bearings, to the surface of crankshaft journals, and to aluminum components. Uncontrolled electrical circuit paths can also cause electrical activity that may degrade the performance of the generator set's electronics.

The charging alternator and the starting motor must be bonded to the negative “−” battery terminal.

For engines with an alternator that is grounded to an engine component, a ground strap must connect that component to the negative “−” battery terminal. Also, that component must be electrically isolated from the engine.

The ground strap for the charging alternator must be of a size that is adequate for carrying the full charging current of the alternator.

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Generator Isolating for Maintenance

SMCS Code: 4450

When you service an electric power generation set or when you repair an electric power generation set, follow the procedure below:

1. Stop the engine.

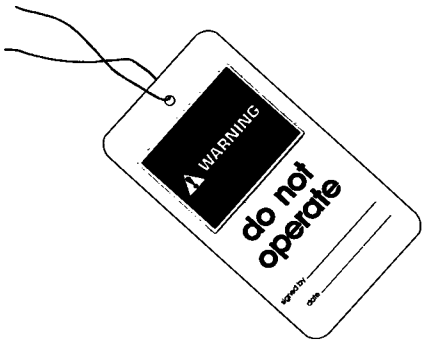

Illustration 21 g00104545

2. Attach a “DO NOT OPERATE” or similar warning tag to the engine prime mover starting circuit. Disconnect the engine starting circuit.

3. Disconnect the generator from the distribution system.

4. Lock out the circuit breaker. Attach a “DO NOT OPERATE” or similar warning tag to the circuit breaker. Refer to the electrical diagram. Verify that all points of possible reverse power flow have been locked out.

5. Remove the fuses for the transformers for the following circuitry:

- power
- sensing
- control

6. Attach a “DO NOT OPERATE” or similar warning tag to the generator excitation controls.

7. Remove the cover of the generator's terminal box.

8. Use an audio/visual proximity tester in order to verify that the generator is de-energized. This tester must be insulated for the proper voltage rating. Follow all guidelines in order to verify that the tester is operational.

9. Determine that the generator is in a de-energized condition. Add ground straps to the conductors or terminals. During the entire work period, these ground straps must remain connected to the conductors and to the terminals.

Product Information Section

General Information

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Model View Illustrations

SMCS Code: 1000

The illustrations show typical features of the 3516E Standby Generator Set Engine. The illustrations do not show all the options that are available.

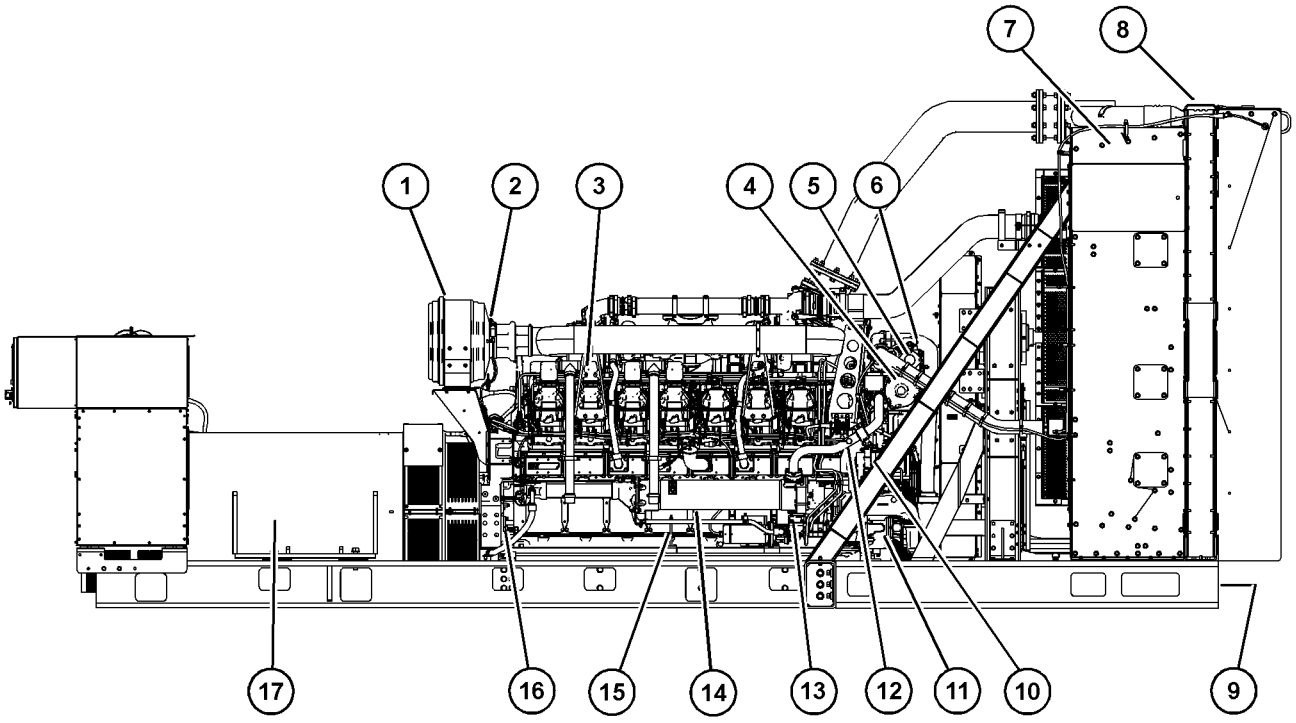

Illustration 22 g06233426

3516E Right Side View

(1) Air cleaner
(2) Air cleaner pressure differential sensor
(3) Crankcase breather
(4) Engine oil filler
(5) Fuel filter
(6) Fuel priming pump
(7) Radiator
(8) Radiator fill cap
(9) Radiator drain valve
(10) Alternator
(11) Engine oil pump
(12) Engine oil sampling port
(13) Fuel transfer pump
(14) Oil cooler
(15) Engine oil level gauge
(16) Barring device
(17) Generator

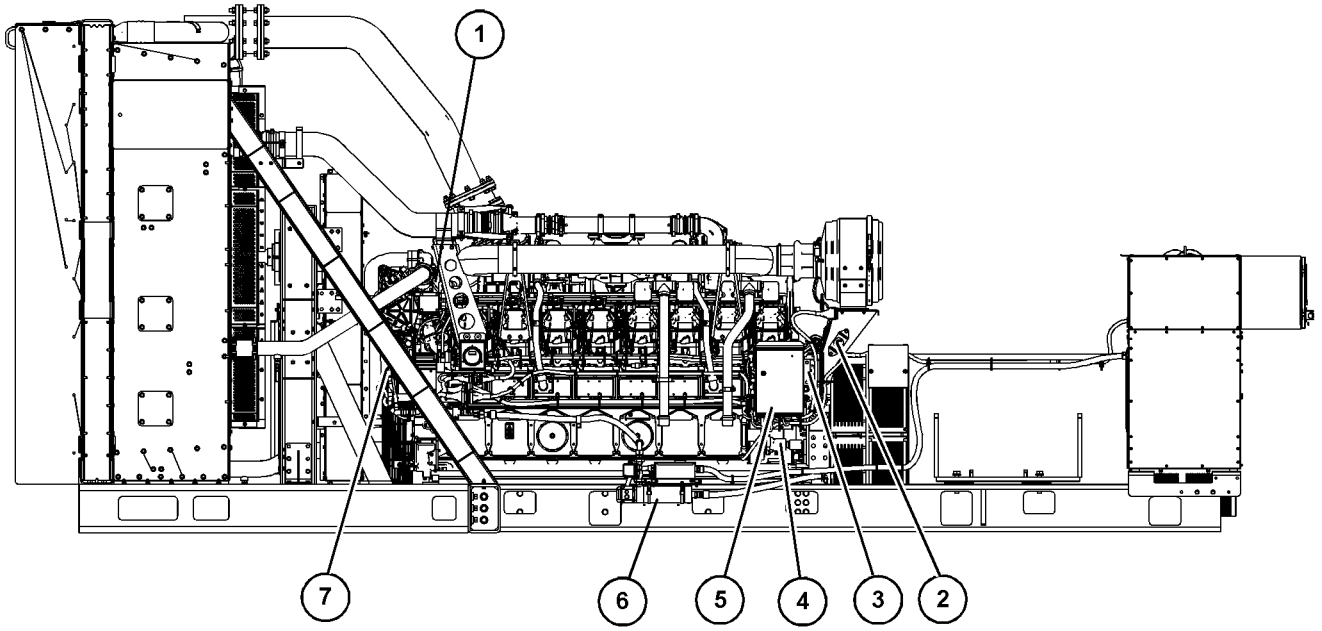

Illustration 23 g06233438

3516E Left Side View

(1) Coolant temperature regulator
(2) Battery disconnect switch
(3) Emergency stop switch
(4) Electric starting motor
(5) Circuit breaker box
(6) Jacket water heater
(7) Electronic Control Module (ECM)

i07139763

Product Description

SMCS Code: 1000; 4450; 4491

The 3516E Generator Sets consist of an engine, a generator, and control systems.

Intended Use

This Power Generator is used to generate electrical power.

Engine Description

3516E Generator Set Engine is an electronically controlled diesel engine. The engine has electronic fuel injectors. The engine can be equipped with either separate circuit aftercooling (SCAC) or air-to-air aftercooling (ATAAC).

Engine efficiency and engine performance depend on adherence to proper operation and maintenance recommendations. Use the recommended fuels, lubrication oils, and coolant. Pay special attention to the air cleaner, to the fuel system, to the lubrication system, and to the cooling system maintenance. Refer to this Operation and Maintenance Manual, “Maintenance Interval Schedule” for more information on maintenance items.

Generator Description

The brushless generator can be used with the following loads: mixed loads of motors and lights, SCR-controlled equipment, computer centers, installations of communications and petroleum drilling applications.

The generator set package is utilized for standby power generation, mission critical standby, and prime power.

The generator is utilized in three-phase full-wave excitation and regulation. The generator is a four-pole design with a six lead configuration or a twelve-lead configuration. The generator produces electrical power in either 50 Hz or 60 Hz applications.

Product Identification Information

i06683570

Plate Locations and Film Locations

SMCS Code: 1000; 4450

Engine Identification

Cat dealers need the information from the serial number plate to determine the components that were included with the engine. Cat dealers also need the information from the information plate to determine the components that were included with the engine. This information permits accurate identification of replacement part numbers.

Serial Number Plate

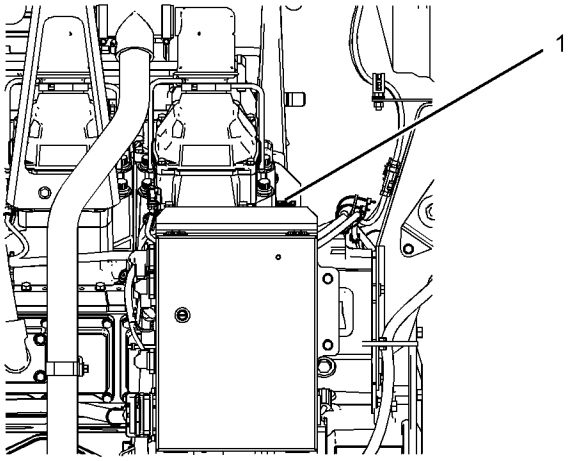

Illustration 24 g03865022

(1) Serial number plate

The serial number plate is on the left side of the cylinder block near the rear of the engine.

The following information is stamped on the serial number plate: engine serial number, model, and arrangement number.

Information Plate

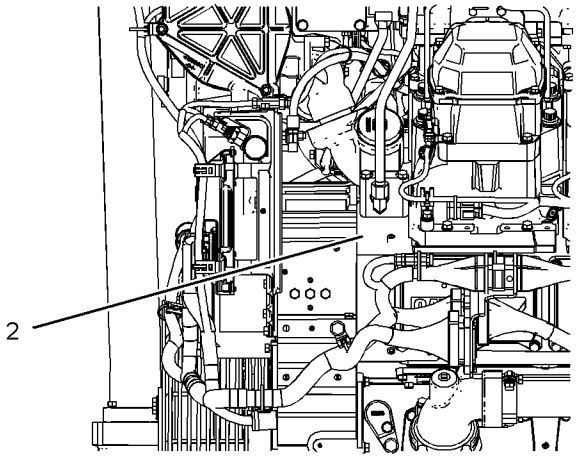

Illustration 25 g03865081

(2) Information plate

The information plate is on the left side top surface of the cylinder block in front of the front cylinder head.

The following information is stamped on the information plate: maximum altitude of the engine, horsepower, high idle, full load rpm, fuel settings, and other information.

Identification of the Generator Set

The identification plate for the generator set is on the right side of the barrel of the generator.

When service is required, the information that is given on this plate should be used. The identification plate for the generator set includes the following information: serial number, model number, and the rating of the generator set. The generator set consists of the engine and the generator. All pertinent generator data is also included on the plate to provide the information that is necessary to order parts.

Serial Number Plate for the Generator

The serial number for the generator is on the right side of the generator on the generator barrel.

Output Lead Wiring

All generator lead wiring information can be found on a decal that is on the side panel of the generator terminal box. If the generator is equipped with a circuit breaker, the decal may be found on the sheet metal of the circuit breaker panel.

For low voltage, decals labeled “T1” , “T2” , “T3” , and “T0” (Neutral) are next to the corresponding customer connection bus bars inside the terminal box. There is no external decal.

European Union

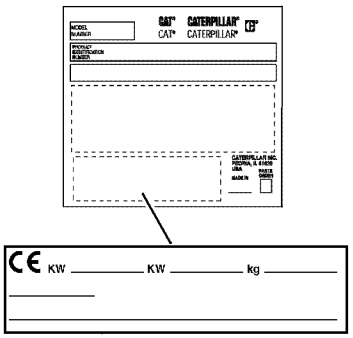

Illustration 26 g01880193

This plate is positioned on the bottom left side of the plate for the PIN.

Note: The CE plate is on machines that are certified to the European Union requirements that were effective then.

For machines that are compliant to 2006/42/EC, the following information is stamped onto the CE plate. For quick reference, record this information in the spaces that are provided below.

- Engine Power for Primary Engine (kW)_____
- Engine Power for Additional Engine (If Equipped) _____
- Typical Machine Operating Weight for European Market (kg)_____
- Year of Construction_____
- Machine Type _____

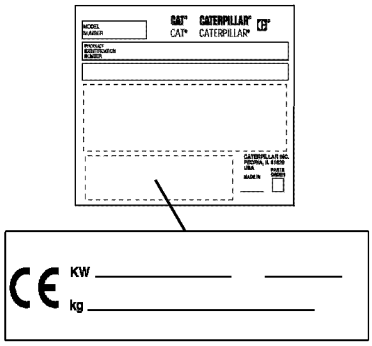

Illustration 27 g01120192

This plate is positioned on the bottom left side of the plate for the PIN.

Note: The CE plate is on machines that are certified to the European Union requirements that were effective then.

For machines that are compliant to 1998/42/EC, the following information is stamped onto the CE plate. For quick reference, record this information in the spaces that are provided below.

- Engine Power for Primary Engine (kW)_____
- Typical Machine Operating Weight for European Market (kg)_____
- Year_____

For the name and the address of the manufacturer, and the country of origin of the machine, refer to the PIN plate.

For the name, the address and the country of origin of the manufacturer, see the PIN plate.

i04605109

Emissions Certification Film

SMCS Code: 1000; 7405

Note: This information is pertinent in the United States, in Canada and in Europe.

Consult your Cat dealer for an Emission Control Warranty Statement.

This label is located on the engine.

i01400354

Reference Information

SMCS Code: 1000; 4450

Information for the following items may be needed to order parts. Locate the information for your engine. Record the information on the appropriate space. Make a copy of this list for a record. Retain the information for future reference.

Record for Reference

Engine Model _____

Engine Serial Number _____

Engine Arrangement Number _____

Packaging Arrangement Number _____

Modification Number _____

Engine Low Idle rpm _____

Engine Power Rating _____

Engine Full Load rpm _____

Performance Specification Number _____

Governor Group Number _____

Turbocharger _____

Primary Fuel Filter _____

Secondary Fuel Filter Element _____

Lubrication Oil Filter Element _____

Air Cleaner Element _____

Alternator Belt _____

Fan Drive Belt Set _____

Lubrication System Capacity _____

Total Cooling System Capacity _____

Operation Section

Lifting and Storage

i07037741

Product Lifting

SMCS Code: 7000; 7002

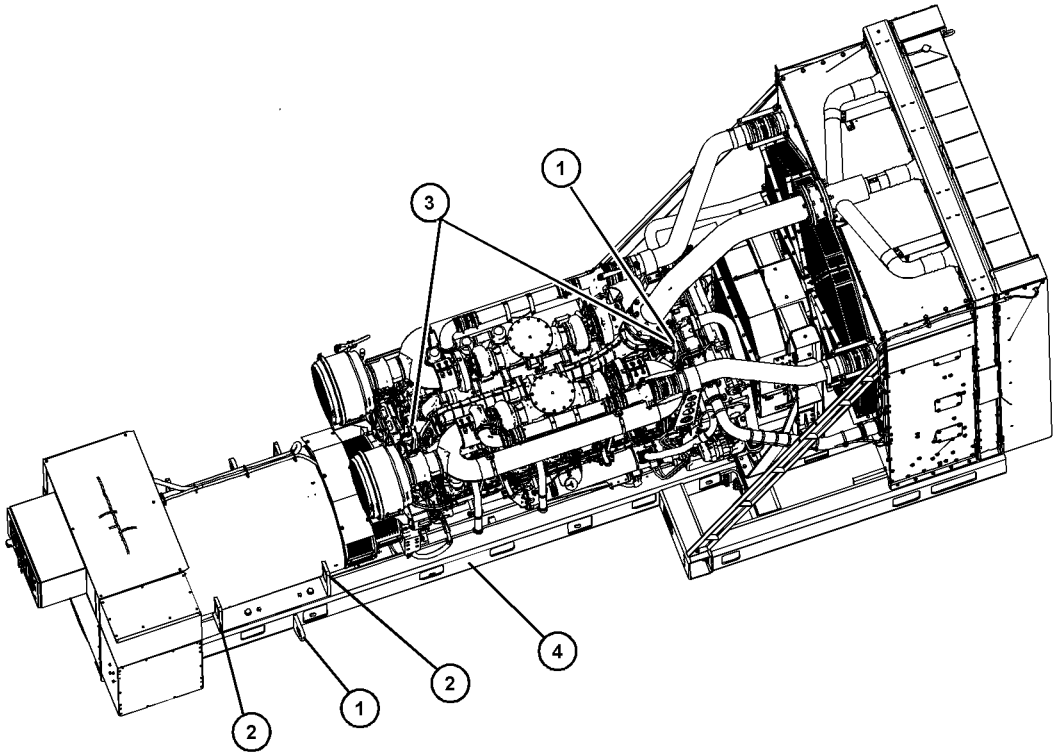

Illustration 28 g06233473

(1) Generator set package lifting eyes
(2) Generator lifting eyes
(3) Engine lifting eyes
(4) Center of gravity

The following lifting label is at each designated lifting point.

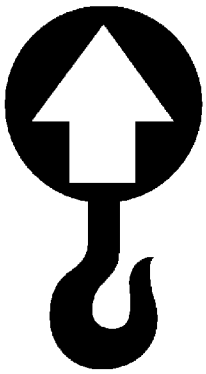

Illustration 29 g03807539

The following center of gravity film is on the right and left side of the generator set base.

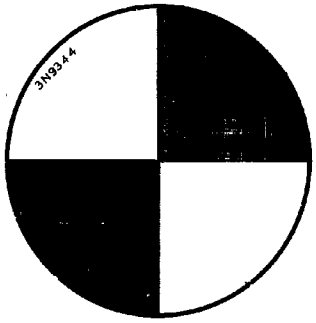

Illustration 30 g01187534

NOTICE
Never bend the eyebolts and the brackets. Only load the eyebolts and the brackets under tension. Remember that the capacity of an eyebolt is less as the angle between the supporting members and the object becomes less than 90 degrees.

When it is necessary to remove a component at an angle, only use a link bracket that is properly rated for the weight.

Use a hoist to remove heavy components. Use an adjustable lifting beam to lift the entire package. Use an adjustable lifting beam to lift the engine. All supporting members (chains and cables) should be parallel to each other. The chains and cables should be perpendicular to the top of the object that is being lifted.

Some removals require lifting fixtures to obtain proper balance. Lifting fixtures also help to provide safety.

Lifting eyes are designed and installed for each package. Alterations to the lifting eyes and/or the package make the lifting eyes and the lifting fixtures obsolete. If alterations are made, ensure that proper lifting devices are provided. Consult your Cat dealer for information regarding fixtures for proper lifting.

NOTICE
Unless otherwise noted, factory shipped loose radiators are not designed to be lifted or hoisted while installed on a generator package. Shipped loose radiators must be installed on site after the packages (engine, generator, rails) are set in place. Radiators that are factory installed but shipped without coolant cannot be lifted while installed on a generator package if they are filled with coolant. Only those packages that are shipped from the factory filled with coolant can be lifted or hoisted while filled with coolant. Refer to the shipping consist to determine if coolant was included on the order prior to lifting the generator set package.

Lifting the Entire Package (Three Point Lifting)

Do NOT use only the engine lifting eyes or only the generator lifting eyes to lift the entire package. The procedure for lifting the package utilizes a four-point lifting method. The lifting points are the lifting eyes (1) that are on both the sides of the generator set base near the rear. The lifting eye is also at the front of the engine.

Lifting the Engine Only

To remove the engine ONLY, use two lifting eyes (3) that are on the engine.

Lifting the Generator Only

Note: The control panel and the terminal box (if equipped) will need to be removed before attempting to lift the generator.

To remove the generator ONLY, use lifting eyes (2) that are on the right and left side of generator.

i07150846

Product Storage

SMCS Code: 7002

Short Time Storage

If the generator is not installed immediately, store the generator in a clean area. This area should also have the following conditions: low humidity, stable humidity, and stable temperature. Space heaters must be energized to keep condensation from the windings. All accessory equipment that is supplied with the unit should be stored with the generator. The combined unit should be covered with a durable cover to protect against the following contaminants:

- Dust
- Dirt
- Moisture
- Other airborne abrasive substances

Long Time Storage

Engine Storage

If the engine will not be started for several weeks, the lubricating oil will drain from the cylinder walls and from the piston rings. Rust can form on the cylinder liner surface, which will increase engine wear which can reduce engine service life.

To help prevent excessive engine wear, use the following guidelines:

- Complete all the lubrication recommendations that are listed in this Operation and Maintenance Manual, “Maintenance Interval Schedule” (Maintenance Section).
- If freezing temperatures are expected, check the cooling system for adequate protection against freezing. See this Operation and Maintenance Manual, “Refill Capacities and Recommendations” (Maintenance Section).

If an engine is out of operation and if use of the engine is not planned, special precautions should be made. If the engine will be stored for more than 1 month, a complete protection procedure is recommended.

Your Cat dealer will have instructions for preparing the engine for extended storage periods.

For more detailed information on engine storage, see Special Instruction, SEHS9031, “Storage Procedure for Caterpillar Products”.

Generator Storage

A storage period more than 6 months should be preceded by the following preparation:

1. Install desiccant bags inside the exciter cover. For generators that have 1800 frames, install desiccant bags inside the screen of the fan.
2. Seal the unit in a covering of plastic or other material that has been designed for that purpose.
3. Adequately tag the generator. This procedure will ensure that preservative greases and desiccant bags are removed before the generator is placed in operation.

Bearing Inspection

New bearings are greased at the manufacturer. This grease is designed for long life, but the grease may deteriorate under certain conditions in storage.

If the generator is stored for more than 1 year and the bearings are not turned during the year, new ball bearings may be required.

Cat Y5000 frame generators stored for longer than 6 months will require twice the amount of grease than the standard maintenance volume.

Every 3 months rotate the generator shaft a few turns while injecting a standard volume of grease.

Electrical Measurements

Measure the insulation resistance of each winding if the generator was exposed to the following conditions:

- Rapid changes in temperature
- Freezing
- Wet climate during storage

Note: These tests should be conducted prior to any power connections that are being made. These tests should be conducted prior to any control connections that are made.

Refer to the Generator Maintenance section of this manual to measure the following items:

- Exciter Field (Stator)
- Exciter Armature (Rotor)
- Generator Field (Rotor)

- Generator Armature (Stator)

For additional information on generator storage, consult your Cat dealer for assistance.

Installation

i06683736

Product Installation

SMCS Code: 1000; 1404; 4450; 7002

Receiving Inspection

If the generator is received during cold weather, allow the unit to reach room temperature before you remove the protective packing material. Warming the generator to room temperature will prevent the following problems:

- Water condensation on cold surfaces
- Early failures due to wet windings
- Early failures due to wet insulating materials

Unpacking

Moving the Generator

⚠ WARNING

Improper lift rigging can allow unit to tumble causing injury and damage.

NOTICE
Do not use the engine lifting eyes to remove the engine and generator together.

Unpack the equipment with care to avoid scratching painted surfaces. Move the unit to the mounting location. The unit can be moved by either of the following methods:

- Attach an overhead crane to the eyebolts that are installed on the generator frame.
- Use a lift truck to lift the generator.

The hoist and the hoist cables should have a rating that is greater than the weight of the generator. When the unit is moved, ensure that the generator is supported by the lift truck fork tines. Also ensure that the generator is balanced on the lift truck fork tines. Slide the fork tines beneath the attached skid to lift the generator.

Location

The location of the generator must comply with all local regulations. The location of the generator must also comply with all special industrial regulations. Locate the generator in an area that meets the following requirements:

- Clean
- Dry
- Ventilated
- Easily accessible for inspection and maintenance

Access to the radiator filler cap is on the roof of the enclosure. There must be safe access to the roof of the enclosure. There must be sufficient clearance above the roof of the enclosure.

Do not obstruct air inlet openings. Do not obstruct discharge openings. Air flow must reach these openings. If the generator is exposed to harsh environmental conditions, the generator can be modified in the field to add filters and space heaters. In addition, a more rigid periodic maintenance schedule should be established.

Electrical Measurements

Measure the insulation resistance of each winding if the generator was exposed to the following conditions:

- Rapid changes in temperature
- Freezing
- Wet climate during shipment
- Wet climate during storage

Note: These tests should be conducted prior to any power connections that are being made. These tests should be conducted prior to any control connections that are being made.

Refer to this Operation and Maintenance Manual, “Rotating Rectifier - Test” to measure the following items:

- Exciter field (stator)
- Exciter armature (rotor)
- Generator field (rotor)
- Generator armature (stator)

Note: For further information concerning the installation of this generator set, see the appropriate Application and Installation Guide.

Protective Devices

The output to the load of the generator should always be protected with an overload protection device such as a circuit breaker or fuses. Fuses should be sized by using the lowest possible current rating. However, this rating must be above the current rating for full load. A common recommendation is 115 percent of rated current. Determine the size of fuses or determine the size of circuit breakers in accordance with NEMA, IEC, and Local Electrical Codes.

Features and Controls

i02755536

Alarms and Shutoffs

SMCS Code: 7400

This section contains some general information about the function of typical engine protective devices.

Alarms and shutoffs are electronically controlled. The operation of all alarms and shutoffs utilize components which are actuated by a sensing unit. The alarms and shutoffs are set at critical operating temperatures, pressures, or speeds in order to protect the engine from damage.

The alarms function in order to warn the operator when an abnormal operating condition occurs. The shutoffs function in order to shut down the engine when a more critical abnormal operating condition occurs. The shutoffs help to prevent damage to the equipment.

If an engine protective device shuts off the engine, always determine the cause of the shutoff. Make the necessary repairs before attempting to start the engine.

Become familiar with the following information:

- Types of the alarm and shutoff controls
- Locations of the alarm and shutoff controls
- Conditions which cause each control to function
- Resetting procedure that is required before starting the engine

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Battery Disconnect Switch

SMCS Code: 1411

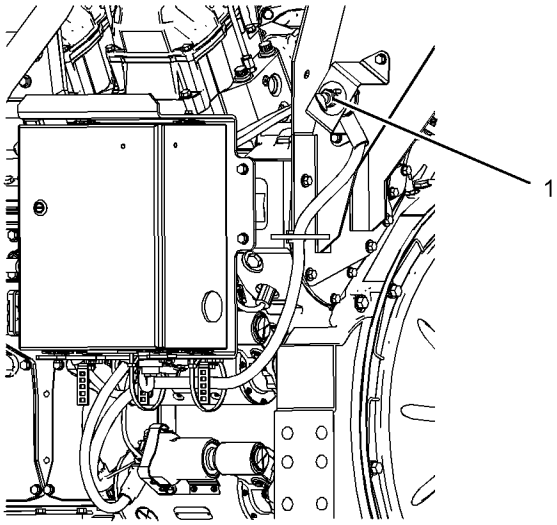

Illustration 31 g03880546

(1) Battery disconnect switch

The battery disconnect switch and the engine start switch perform different functions. Turn off the battery disconnect switch in order to disable the entire electrical system. The battery remains connected to the electrical system when you turn off the engine start switch.

Turn the battery disconnect switch to the OFF position and remove the key when you service the electrical system or any other components.

Turn the battery disconnect switch to the OFF position and remove the key when the engine will not be used for an extended time. This procedure will prevent drainage of the battery.

NOTICE
Never move the battery disconnect switch to the OFF position while the engine is operating. Serious damage to the electrical system could result.

To ensure that no damage to the engine occurs, verify that the engine is fully operational before cranking the engine. Do not crank an engine that is not fully operational.

Perform the following procedure in order to check the battery disconnect switch for proper operation:

1. With the battery disconnect switch in the ON position, verify that electrical components are functioning. Verify that the hour meter is displaying information. Verify that the engine will crank.
2. Turn the battery disconnect switch to the OFF position.
3. Verify that the following items are not functioning: electrical components, hour meter and engine cranking. If any of the items continue to function with the battery disconnect switch in the OFF position, consult your Cat dealer.

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Electronic Modular Control Panel 4 (EMCP 4)
(EMCP 4.1 / 4.2 / 4.2B)

SMCS Code: 4490

Electronic Control Module (Generator Set)

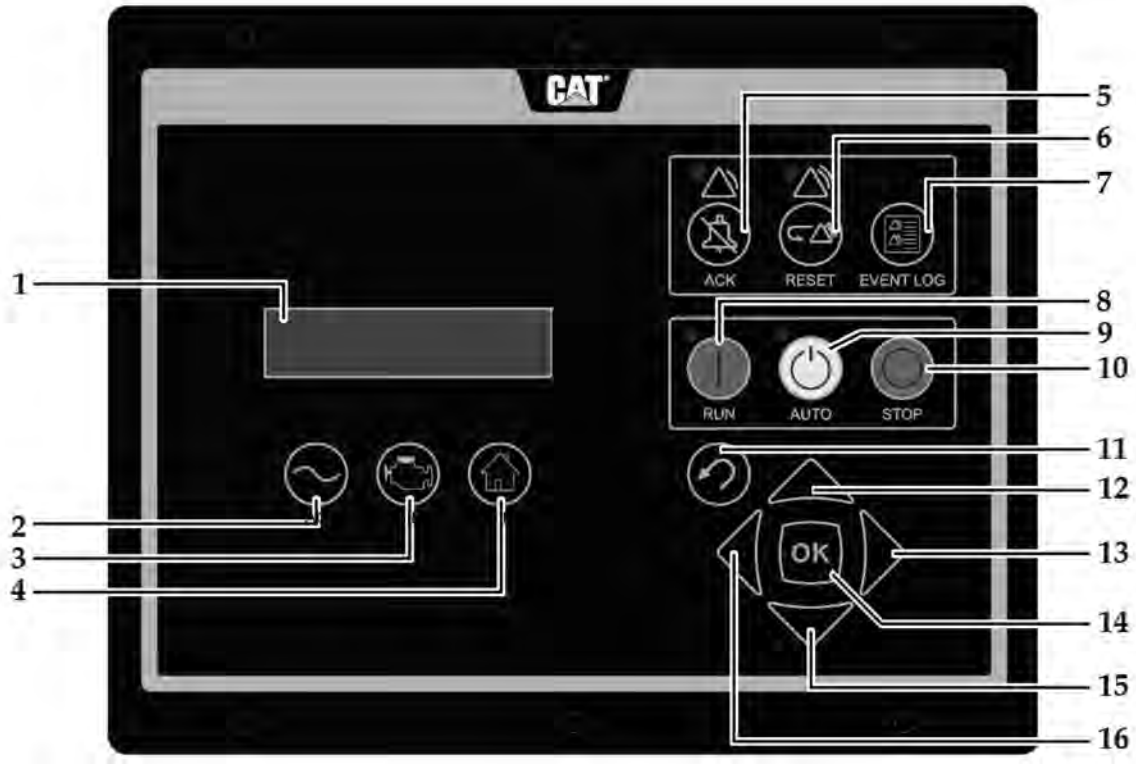

Illustration 32 g02082653

EMCP 4 Control System Panel

(1) Display screen
(2) AC overview key
(3) Engine overview key
(4) Main menu key
(5) Alarms acknowledge key
(6) Reset shut down Key
(7) Event log
(8) Run key

(9) Auto key
(10) Stop key
(11) Escape key
(12) Up key
(13) Right key
(14) OK key
(15) Down key
(16) Left key

Navigation Keys

AC Overview (2) – The “AC OVERVIEW” key will navigate the display to the first screen of AC information. The “AC OVERVIEW” information contains various AC parameters that summarize the electrical operation of the generator set.

Engine Overview (3) – The “ENGINE OVERVIEW” key will navigate the display to the first screen of engine information. The “ENGINE OVERVIEW” information contains various engine parameters that summarize the operation of the generator set.

Main Menu Key (4) – The “MAIN MENU” key will navigate the display to the main menu directly without having to navigate out of menus.

Acknowledge Key(5) – Pressing the “ACKNOWLEDGE” key will cause the horn relay to turn off. The horn relay being turned off will silence the horn. Pressing the “ACKNOWLEDGE” key will also cause any red or yellow flashing lights to either turn off or to come on continuously. The “ACKNOWLEDGE” key may also be configured to send out a global alarm silence signal on the J1939 Data Link. Sending out a global alarm silence signal on the J1939 Data Link will silence the horns on the annunciators.

Reset Key (6) – Pressing the “RESET” key will reset various events.

Event Log Key (7) – Pressing the “EVENT LOG” key will navigate the display to the event log.

RUN Key (8) – Pressing the “RUN” key will start the engine.

AUTO Key (9) – Pressing the “AUTO” key will cause the engine to enter the “AUTO” mode. The engine will start if the module receives a start command from a remote source.

STOP Key (10) – Pressing the “STOP” key will stop the engine.

Escape Key (11) – The “ESCAPE” key is used in order to navigate through the menus. When the key is pressed, the user moves backward or the user moves upward through the menus. The “ESCAPE” key is also used to exit out of entering data when the user is programming the setpoints. If the “ESCAPE” key is pressed while the user is programming the setpoints, changes made on the screen will not be saved to memory.

Up Key (12) – The “UP” key is used to navigate through the various menus and monitoring screens. The “UP” key is also used when a setpoint is entered. When entering numeric data, the “UP” key is used in order to increment the digits (0-9). If the setpoint requires selection from a list, the “UP” key is used to navigate UP through the list.

Right Key (13) – The “RIGHT” key is used during setpoint adjustment. The “RIGHT” key is used to select which digit is edited while entering numeric data. The “RIGHT” key is also used during some setpoint adjustments in order to select or to unselect a check box. If a check box has a check mark, the function has been enabled. Pressing the “RIGHT” key will disable the function. Pressing the “RIGHT” key will also cause the check mark to disappear. If the check box does not have a check mark, the function is disabled. Pressing the “RIGHT” key will enable the function. Pressing the “RIGHT” key will also cause a check mark to appear.

Enter Key (14) – The “ENTER” key is used in order to navigate through the menus. When the key is pressed, the user moves forward or the user moves downward through the menus. The “ENTER” key is also used to save any changes while the setpoints are being programmed. Pressing the “OK” key during programming the setpoints causes the changes to be saved to memory.

Down Key (15) – The “DOWN” key is used to navigate downward through the various menus or screens. The “DOWN” key is also used to program the setpoints. The “DOWN” key is used to decrease the digits when entering numeric data. If the setpoint requires selection from a list, the “DOWN” key is used to navigate DOWN through the list.

Left Key (16) – The “LEFT” key is used during setpoint adjustment. The “LEFT” key is used to select the digit that is edited during the entry of numeric data. The “LEFT” key is also used during some of the setpoint adjustments to select a check box. The key is also used to unselect a check box. If a check box has a check mark, pressing the “LEFT” key will disable the function. Pressing the key will also remove the check mark. Pressing the “LEFT” key will also cause the check mark to disappear. If the check box does not have a check mark, pressing the “LEFT” key will enable the function. Pressing the “LEFT” key will also cause a check mark to appear.

Alarm Indicators

Yellow Warning Lamp – A yellow warning lamp is located above the “ACKNOWLEDGE” key. A flashing yellow light indicates that there are active warnings that have not been acknowledged. A continuous yellow light indicates that there are acknowledged warnings that are active. If there are any active warnings, the yellow light will change from flashing yellow to continuous yellow after the “ACKNOWLEDGE” key is pressed. If there are no longer any active warnings, the yellow light will turn off after the “ACKNOWLEDGE” key is pressed.

Red Shutdown Lamp – A red shutdown lamp is located above the “RESET” key. A flashing red light indicates that there are active shutdowns that have not been acknowledged. A continuous red light indicates that there are active shutdowns that have been acknowledged. If there are any active shutdowns, the red light will change from flashing red to continuous red after the “ACKNOWLEDGE” key is pressed. Any condition that has caused a shutdown must be manually reset. If there are no longer any active shutdowns, the red light will turn off.

Digital Inputs

There are several digital inputs and outputs on “EMCP 4.1” and “EMCP 4.2” . For detailed information about the inputs on this electronic control module, see Systems Operation, Troubleshooting, Testing, and Adjusting, UENR1209, “EMCP4.1/ EMCP4.2”.

There are several digital inputs and outputs on “EMCP 4.2B” . For detailed information about the inputs on this electronic control module, see Systems Operation, Troubleshooting, Testing, and Adjusting, UENR7097, “EMCP4.2B”.

Control Panel

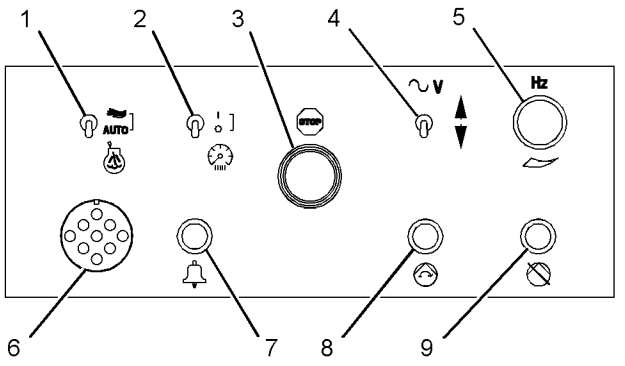

Illustration 33 g01185966

(1) Starting aid auto/manual switch (if equipped)
(2) Panel light switch
(3) Emergency stop push button
(4) Voltage adjust switch (if equipped)
(5) Speed potentiometer (if equipped)
(6) Customer connection (if equipped)
(7) Horn (if equipped)
(8) Pump run switch (if equipped)
(9) Pump stop switch (if equipped)

Starting Aid Auto/Manual Switch (1) – The starting aid switch is optional. The starting aid switch is used to inject ether into the engine when you are starting the engine in cold-weather conditions. When the starting aid switch is in the ON position, the solenoid valve is energized. The switch then meters a specific amount of ether into a holding chamber. When the starting aid switch is released, the solenoid releases the ether to the engine.

Panel Light Switch (2) – The panel lights switch turns on or the panel lights switch turns off the panel lights.

Emergency Stop Push Button (3) – The emergency stop push button (ESPB) is used to shut down the engine during an emergency situation. If equipped, the ESPB shuts off the fuel and the ESPB activates the optional air shutoff.

Voltage Adjust Switch (4) – This switch can be used to raise the voltage. The switch can also be used to lower the voltage.

Speed Potentiometer (5) – The speed potentiometer is optional. The speed potentiometer can be used with the generator set that has an electronic governor.

Customer Connection (6) – The customer connection is a 9-pin connector for connecting the Cat Electronic Technician.

Horn (7) – The horn provides an audible alarm.

Pump Run Switch (if equipped)(8) – Under normal circumstances, the fuel transfer process is automatic. In some instances, a manual operation may be required. Press the pump run switch once in order to start the pump manually.

Pump Stop Switch (if equipped)(9) – The pump stop switch is a push-button switch that locks into position. The pump stop switch will stop the pump if the switch is locked into position. Releasing the switch will place the pump back into the run mode.

Annunciator Module

Illustration 34 g02111119

(20) Alarm acknowledge button

General Information

The annunciator module is used to indicate various system events and conditions. The annunciator module uses indicator lights and an audible horn to give the operator information about the status of the system. The annunciator module can be used to announce faults and/or status signals to the operator. The annunciator module allows the operator to silence the horn. The annunciator module also allows the operator to acknowledge faults to the system.

There are 17 pairs of LED indicators on the front panel of the annunciator. The 16 pairs of LED indicators are used to announce events, diagnostics, and ready signals. The 17th pair of LED indicators is used as a combined network/module status LED. The 17th pair of LED indicators can tell the operator if there is a problem with the J1939 data link connection.

Basic Operation

Each pair of LED indicators on the annunciator consists of two of the following three colors: green, yellow and red. For example, a pair of red and yellow LED indicators may be configured for engine oil pressure. If a low engine oil pressure warning is read over the data link, the annunciator will flash the yellow LED. The audible horn will then sound. If the low engine oil pressure shutdown is read over the data link, the annunciator will flash the red LED. The audible horn will then sound.

To acknowledge the shutdown and alarm conditions or to silence the horn, press the “Alarm Acknowledge” button (20).

To test the LED indicators or the horn when the data link is either connected or disconnected, hold the “Lamp Test” button in.

Configuration

The annunciator module can be customized in order to signal many different conditions that are related to the system. Each pair of LEDs must be configured by using the appropriate service tool. Once the service tool has been connected to the annunciator, the user must enter the “Configuration” screen. Each pair of LEDs has four settings: SPN, Trigger Type, Trigger Severity Level and Failure Mode Identifier (FMI).

For detailed information about the annunciator module, see Systems Operation, Troubleshooting, Testing, and Adjusting, UENR1209, “EMCP4.1/4.2”.

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Gauges and Indicators

SMCS Code: 7450

Gauges provide indications of engine performance. Ensure that the gauges are in good working order. Determine the normal operating range by observing the gauges over.

Noticeable changes in gauge readings can indicate potential gauge or engine problems. Problems may also be indicated by gauge readings that change even if the readings are within specifications. Determine and correct the cause of any significant change in the readings. Consult your Cat dealer for assistance.

Your engine may not have the same gauges or all the gauges that are described below.

NOTICE
If no oil pressure is indicated, STOP the engine. The engine will be damaged from operating without oil pressure.

Engine Oil Pressure – This gauge indicates the pressure of the engine oil. The engine oil pressure will be highest after a cold engine is started. The engine oil pressure will decrease as the engine warms up. The engine oil pressure will increase when the engine rpm is increased. The engine oil pressure will stabilize when the engine rpm is stable. The typical range for engine oil pressure at low idle rpm is 186 kPa (27 psi) to 344 kPa (50 psi). The typical range for engine oil pressure at rated rpm is 280 kPa (41 psi) to 600 kPa (87 psi).

Oil Filter Differential Pressure – This gauge indicates the difference in pressure between the inlet side and the outlet side of the engine oil filters. As the oil filter elements become plugged, oil filter differential pressure will increase. Replace the engine oil filter elements when the oil filter differential pressure reaches a maximum of 150 kPa (22 psi).

Jacket Water Coolant Temperature – This gauge indicates the temperature of the engine coolant at the outlet for the jacket water. The jacket water coolant temperature may vary according to the load. Do not allow the jacket water coolant temperature to exceed the boiling temperature of the pressurized cooling system. The operating range for jacket water coolant temperature is 88° C (190° F) to 100° C (212° F). Higher temperatures may occur under certain conditions.

The engine should operate within the normal temperature range. The sensor for jacket water coolant temperature must be fully submerged to detect the temperature correctly. If the engine is operating above the normal temperature range, perform the following procedure:

1. Reduce the load and the engine rpm.

2. Inspect the cooling system for leaks.

3. Determine if the engine must be shut down immediately or if the engine can be cooled by reducing the load and rpm.

NOTICE
High inlet manifold air temperature increases the risk of engine damage. Maximum inlet air temperature is 115 °C (235 °F).

Inlet Manifold Air Temperature – This gauge indicates the inlet manifold air temperature to the cylinders. The sensor for inlet manifold air temperature is located after the aftercooler.

Maintain the aftercooler in good condition. Ensure that the inlet manifold air temperature at engine operating temperature does not vary by more than 4 °C (7 °F) from the maximum inlet manifold air temperature.

Inlet Manifold Air Pressure – This gauge indicates the air pressure (turbocharger boost pressure) in the air plenum (air inlet manifold) after the aftercooler. The inlet manifold air pressure depends on the engine rating, the load, and the operating conditions.

Pyrometer – The pyrometer indicates the exhaust stack temperature at the exhaust elbows. For engines with two exhaust stacks, the two exhaust stack temperatures may vary slightly. This variation may be due to the sensitivity of the two thermocouples. Maximum exhaust stack temperature can vary from 480° C (896° F) to 590° C (1094° F).

The pyrometer also indicates the temperature of the exhaust gas of each individual cylinder. These temperatures are measured at the exhaust port of each cylinder head. The exhaust temperature will vary slightly between the cylinders.

Tachometer – This gauge indicates the engine rpm.

NOTICE
To help prevent engine damage, never exceed the high idle rpm. An overspeed can result in serious damage to the engine. The engine can be operated at high idle without damage, but the engine should never be allowed to exceed the high idle rpm.

Note: The high idle rpm and the full load rpm are stamped on the engine Information Plate.

Service Hour Meter – The service hour meter indicates the total number of clock hours on the engine.

Fuel Pressure – This meter indicates fuel pressure to the fuel injection pump from the fuel filter. The normal fuel pressure range is 345 kPa (50 psi) to 520 kPa (75 psi). Minimum fuel pressure is 275 kPa (40 psi) at the rated speed.

A decrease in fuel pressure usually indicates a dirty fuel filter or a plugged fuel filter. As the fuel filter becomes plugged, there will be a noticeable reduction in the engine performance.

Fuel Filter Differential Pressure – This gauge indicates the difference in fuel pressure between the inlet side and the outlet side of the fuel filter. As the fuel filter element becomes plugged, the difference in pressure between the two sides of the fuel filter increases. Service the fuel filter when the fuel filter differential pressure reaches 105 kPa (15 psi).

Air Cleaner Differential Pressure – This gauge indicates the difference in air pressure between the inlet side and the engine side of the air filter element. The air cleaner differential pressure is measured from the air inlet to the turbocharger. As the air filter element becomes plugged, the difference in pressure between the two sides of the air cleaner element will increase. For optimum engine performance, replace the air cleaner elements when the air cleaner differential pressure reaches 3.75 kPa (15 inches of H_2O). Maximum air cleaner differential pressure is 7.5 kPa (30 inches of H_2O).

Ammeter – This gauge indicates the amount of charge or discharge in the battery charging circuit. Operation of the indicator should be to the right side of “0” (zero).

Engine Oil Temperature – This gauge indicates that the engine oil temperature after the oil has passed through the oil cooler. The maximum oil temperature at rated rpm and rated load is 114 kPa (17 psi).

Cranking Timers – There is a cranking timer which may be used on an Automatic Start/Stop mode. The timer allows the engine to crank for 30 seconds. If the engine does not start within the 30 second interval, the Status Control Module will not activate. This condition indicates a failure to start.

Coolant Pressure – This gauge can be used for jacket water pressure or auxiliary water pressure.

Engine Diagnostics

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Configuration Parameters

SMCS Code: 1000; 1900; 1901; 1902

Configuration parameters concern various engine features. Some parameters can affect the performance of the engine. Most of the parameters may be programmed with an Electronic Technician (ET) service tool. Some of the parameters require a password to be programmed.

Note: For information on programming the parameters, use the appropriate ET service tool and see the Service Manual, “Troubleshooting”, M0082969.

Ensure that the “Air Shutoff” and the “Ether Control” parameters are “Enabled/ON” (if equipped) . If the engine does not have these options, ensure that these two parameters are “DISABLED/OFF” .

No password is required for programming a new ECM during the first 100 hours of service life. This 100 hour “free configuration” feature enables the customer to tailor the programmable setpoints to the requirements of the installation. Exceptions are the following parameters: “Fuel Limit” , “Personality Module Mismatch” , “ECM Hours” , and “ECM Total Fuel Consumption” .

Cat Monitoring System

The engine is equipped with a programmable Cat Monitoring System. The ECM monitors the operating parameters of the engine. The ECM can initiate responses if a specific engine parameter exceeds an acceptable range. Three possible responses may be available for each parameter: “WARNING” , “DERATE” , and “SHUTDOWN” . Some of the responses are not available for some of the parameters. An ET service tool is used to perform the following activities:

- Select the available responses.
- Program the level for monitoring.
- Program delay times for each response.

The settings for the parameters are programmed at the factory. If the application requires the settings for the parameters to be reprogrammed, then the parameter must be programmed with an ET service tool.

The screens of the ET service tool provide guidance for the programming. The following options can be programmed: “ON/OFF” , “WARNING” , “DERATE” , and “SHUTDOWN” .

The screens of the ET service tool also provide guidance for changing setpoints. For information on programming the Cat Monitoring System, use the appropriate ET service tool and see the Service Manual, “Troubleshooting” module.

Data Link Features

CAT Data Link Flash

Flash – A method of downloading or programming electronic information.

The CAT Data Link Flash provides the capability to flash the software that controls the engine by using the CAT Data Link.

CAT Secondary Data Link

The CAT Secondary Data Link provides the ability for each ECM to have a CAT Data Link that is local to that engine. This feature also enables a global CAT Data Link to connect to other engine controls through a common data link. This procedure enables the operator to communicate through a single Customer Communication Module (CCM) or through a telephone line with all the engines that are in an engine room.

The Cat Secondary Data Link provides the capability for as many as eight generator set engines to communicate via a remote display or a control panel. The Cat Secondary Data Link is for use with the following systems: switchgear, remote monitoring, and control systems.

Switching between data links requires the use of the Cat ET software. Refer to Systems Operation, Troubleshooting, Testing and Adjusting, RENR7902, “Electronic Modular Control Panel 3 (EMCP 3)” for more information.

Cold Mode Operation

During Cold Mode operation, timing is controlled by the Electronic Control Module (ECM) and adjusted depending on the temperature of the engines coolant, the engine load, and engine speed. Cold Mode helps reduce the possibility of engine damage and to minimize white smoke.

Cold Mode is activated whenever the engine coolant temperature is below 70° C (158° F) and engine load is below 0.35 mL (0.012 oz). Cold mode remains active until the engine coolant temperature is warmer than 72° C (162° F) or delivered fuel volume is above 0.35 mL (0.012 oz).

Idle Cylinder Cutout

Idle Cylinder Cutout operation increases exhaust temperature which prevents wet-stacking accumulation. During Idle Cylinder Cutout, eight injectors are disabled. The set of eight injectors that are disabled are rotated on a set time interval.

The following parameters are the enablement conditions to activate Idle Cylinder Cutout:

- Engine speed must be within 10 RPM of desired speed.
- Load factor must be less than 9 percent.
- Exhaust temperature must be less than 500° C (932° F).
- The Idle Cylinder Cutout parameter is programmed to ENABLED.

If any of these parameters are not within this range, Idle Cylinder Cutout will immediately deactivate.

Cold Cylinder Cutout

The Cold Cylinder Cutout strategy is used so that the ECM may perform the following functions:

- Reduce the white smoke for cold starting.
- Minimize the duration of advanced timing (cold mode).

The ECM monitors the change of the fuel rack to determine if a cylinder is firing. If the cylinder is firing, the ECM activates the electronic unit injector. If the cylinder is not firing, the electronic unit injector remains deactivated. This process reduces white smoke.

The following conditions must be met to activate the Cold Cylinder Cutout strategy:

- The Cold Cylinder Cutout parameter is programmed to ENABLED.
- The delivered fuel volume is less than 0.3 mL (0.01 oz).
- One of the following:
- Atmospheric temperature needs to be less than 10° C (50° F).
- The jacket water coolant temperature is less than 63° C (145° F).

The Cold Cylinder Cutout strategy is activated under the following condition:

- Ten seconds after the engine reaches the low idle RPM.

The following conditions will deactivate the Cold Cylinder Cutout strategy:

- The Cold Cylinder Cutout parameter is programmed to DISABLED.
- Atmospheric temperature is more than 10° C (50° F).
- The jacket water coolant temperature is more than 70° C (158° F).
- The ET service tool is used for the Cold Cylinder Cutout test.
- The coolant temperature sensor has failed.
- If the engine speed varies more than 50 RPM from the start of the Cold Cylinder Cutout.
- If the delivered fuel volume is greater than 0.3 mL (0.01 oz).

Display of Engine Performance

Histogramming

The ET service tool can display the trends of the engine performance. The information can be used to improve the overall performance of the engine. The historical information is stored in a format that can be used to construct histograms. Data is available for the following parameters:

- Engine rpm
- Engine load
- Left side exhaust temperatures
- Right side exhaust temperatures

Incrementing the Hours of the ECM

A new ECM that is installed on an engine can be programmed to display the correct total number of operating hours for that engine. The hour meter can only be increased. An ET service tool and a factory level security password are required.

Adjusting the Calculation of Fuel Consumption

When the engine is shipped from the factory, an estimate of the engine fuel consumption is programmed into the ECM. The estimate is based on the engine performance specifications. The actual fuel consumption can be determined with a meter that measures the flow of the fuel. Customers are likely to find a slight difference between the estimate of fuel consumption that was programmed and the actual fuel consumption. The customer can use an ET service tool to program the ECM for the actual fuel consumption. No password is required to change this parameter.

To program the ECM for the actual fuel consumption, change the Fuel Correction Factor that is already programmed into the ECM. The Fuel Correction Factor can be programmed in increments of 0.5 percent between ± 25 percent.

The new Fuel Correction Factor must be calculated. The following variables must be known to perform the calculation:

- The actual fuel consumption
- The fuel consumption that has been calculated by the ECM
- The original Fuel Correction Factor that was programmed into the ECM

A factor for error must be calculated first. Use the formula in Table 1 .

Table 1

Error Calculation For the Fuel Correction Factor
e = [(a − s) ÷a] × 100
“e” is the factor for error.
“a” is the actual fuel consumption.
“s” is the fuel consumption that is calculated by the ECM.(1)

(1) The fuel consumption that is calculated by the ECM is based on the original Fuel Correction Factor.

To determine the new Fuel Correction Factor, use the formula in Table 2 .

Table 2

Calculation For The Fuel Correction Factor
N = O + [(100 + O) × e] ÷ 100
“N” is the new Fuel Correction Factor.
“O” is the original Fuel Correction Factor.
“e” is the error that was calculated with the equation in Table 1 .

Adjusting the Total Fuel Consumption for the ECM

A new ECM that is installed on an engine can be programmed to display the correct total fuel consumption for that engine. The total fuel consumption can only be increased. An ET service tool and a factory level security password are required.

Engine Starting

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Before Starting Engine

SMCS Code: 1000; 1400; 1450

⚠ WARNING

Engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.

Perform the required daily maintenance and other periodic maintenance before starting the engine. Inspect the engine room. This inspection can help prevent major repairs at a later date. See this Operation and Maintenance Manual (Maintenance Section), “Maintenance Interval Schedule”.

Walk-Around Inspection

NOTICE
For any type of leak (coolant, lube, or fuel) clean up the fluid. If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more often than recommended until the leak is found or fixed, or until the suspicion of a leak is proved to be unwarranted.

To obtain maximum service life for your engine, make a thorough inspection before starting the engine. Make a walk-around inspection of the installation. Look for items such as oil or coolant leaks, loose bolts and trash buildup. Remove any trash. Arrange for repairs, as needed.

- The guards must be in the proper place. Repair damaged guards or replace missing guards.
- Ensure that the areas around the rotating parts are clear.

Air Inlet System

- Ensure that the air inlet piping and the air filters are in place.
- Ensure that all clamps and connections are secure.
- Observe the air cleaner service indicator. Service the air cleaner when the yellow diaphragm enters the red zone, or when the red piston locks in the visible position.

Cooling System

- Inspect the cooling system for leaks or loose connections.
- Inspect the cooling system hoses for cracks and for loose clamps.
- Inspect the water pumps for evidence of leaks.
- Inspect the fan drive belts for cracks and for deterioration.
- Check the coolant level. Add coolant, if necessary. For information on the proper coolant to use, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations”.

Driven Equipment

- Perform any maintenance that is required for the driven equipment. Refer to the Operation and Maintenance Manual for the generator.
- Ensure that the main circuit breaker is open.

Electrical System

Inspect the wiring for the following conditions:

- Loose connections
- Wiring that is worn or frayed

Inspect the alternator belt for cracks and for deterioration.

Ensure that the grounds are secure.

Fuel System

NOTICE
All valves in the fuel return line must be open before and during engine operation to help prevent high fuel pressure. High fuel pressure may cause filter housing failure or other damage.

- Inspect the fuel lines for loose fittings and leaks. Ensure that the fuel lines are properly clamped.
- Ensure that the fuel is supplied to the engine.

If the engine has not been started for several weeks, fuel may have drained from the fuel system. Air may have entered the filter housing. Also, when fuel filters have been changed, some air space will be left in the housing. In these instances, prime the fuel system. See this Operation and Maintenance Manual (Maintenance Section), “Fuel System-Prime” for information on priming the fuel system.

Lubrication System

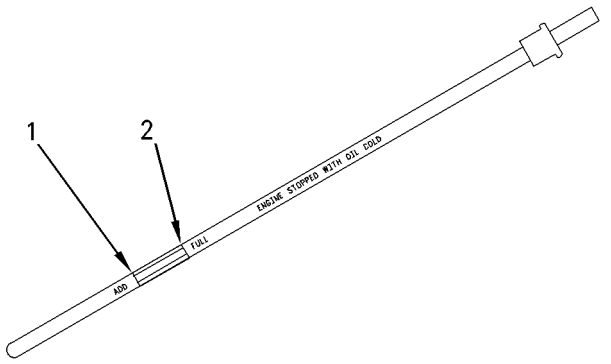

Illustration 35 g00736087

Oil level gauge

(1) “ADD” mark
(2) “FULL” mark

- Check the engine crankcase oil level. Maintain the oil level between the “ADD” and “FULL ” marks on the “ENGINE STOPPED” side of the oil level gauge. For information on the proper oil to use, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations”.
- Check for leaks at the following components: crankshaft seals, crankcase, oil filters, oil gallery plugs, sensors and valve covers.
- Inspect the tubes, tee pieces, and clamps on the crankcase breathers.
- Inspect the Closed Crankcase Ventilation (CCV) filter, if equipped. If the restriction indicator is visible, service the CCV.

Starting System

- Disconnect any battery chargers that are not protected against the high current drain that is created when the electric starting motor is engaged.
- Inspect the battery cables for good connections and for corrosion.
- Inspect the gauges and the control panel for good condition.
- Reset the shutoff and alarm components.

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Cold Weather Starting

SMCS Code: 1000; 1250; 1450; 1453; 1456; 1900

Note: Oil pan immersion heaters are not recommended for heating the lube oil. To ensure the compatibility of the components, only use equipment that is recommended by Caterpillar.

Startability will be improved at temperatures below 16 °C (60 °F) with a starting aid. A jacket water heater may be needed and/or the crankcase oil may require warming.

A jacket water heater is available as an option for starting in temperatures as low as 0 °C (32 °F). The jacket water heater can maintain the water temperature at approximately 32 °C (90 °F). The heated water will help to keep the oil in the engine block warm enough to flow when the engine is started.

Maintain the proper level of electrolyte in the batteries. Keep the batteries fully charged.

To maximize the battery power, heat the battery compartment or store the batteries in a warm location. Typically, batteries only have 50 percent of the capability at −10 °C (14 °F) versus 27 °C (80 °F).

Extra battery capacity may be necessary for cold temperatures.

When No. 2 diesel fuel is used, a fuel heater will maintain the temperature of the fuel above the cloud point. Fuel line insulation will help to maintain the fuel temperature.

Consult your Cat dealer for more information on the starting aids that are available for cold weather starting.

i06275688

Starting the Engine

SMCS Code: 1000; 1450

⚠ WARNING

Engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.

Automatic Starting

⚠ WARNING

When the engine is in the AUTOMATIC mode, the engine can start at any moment. To avoid personal injury, always remain clear of the the engine when the engine is in the AUTOMATIC mode.

To enable automatic starting, the control panel must be in “AUTO” mode. To place the control panel into auto mode, press the “AUTO” key. The engine will automatically start when the remote start/stop initiate contact closes.

Manual Starting

NOTICE
For initial start-up of a new or rebuilt engine, and for start-up of an engine that has been serviced, make provision to shut the engine off should an overspeed occur. This may be accomplished by shutting off the air and/or fuel supply to the engine.

Do not start the engine if there is a “DO NOT OPERATE” warning tag or a similar warning tag attached to the start switch. Do not move any of the controls if there is a “DO NOT OPERATE” warning tag or a similar warning tag attached to the controls.

Ensure that no one will be endangered before the engine is started and when the engine is started.

1. Perform all of the procedures that are described in this Operation and Maintenance Manual, “Before Starting Engine”.

NOTICE
Do not engage the starting motor when flywheel is turning. Do not start the engine under load.

If the engine fails to start within 30 seconds, release the starter switch or button and wait two minutes to allow the starting motor to cool before attempting to start the engine again.

2. To start an engine with a control panel, press the “RUN” key.

i03204322

Starting with Jump Start Cables

SMCS Code: 1000; 1401; 1402; 1900

⚠ WARNING

Improper jump start cable connections can cause an explosion resulting in personal injury.

Prevent sparks near the batteries. Sparks could cause vapors to explode. Do not allow jump start cable ends to contact each other or the engine.

If the installation is not equipped with a backup battery system, then it may be necessary to start the engine from an external electrical source.

Many batteries which are considered unusable are still rechargeable. After jump starting, the alternator may not be able to fully recharge batteries that are severely discharged. The batteries must be charged to the proper voltage with a battery charger. For information on testing and charging, refer to the Special Instruction, SEHS7633, “Battery Test Procedure”.

NOTICE
Using a battery source with the same voltage as the electric starting motor. Use ONLY equal voltage for jump starting. The use of higher voltage will damage the electrical system.

Do not reverse the battery cables. The alternator can be damaged. Attach ground cable last and remove first.

When using an external electrical source to start the engine, turn the generator set control switch to the “OFF” position. Turn all electrical accessories OFF before attaching the jump start cables.

Ensure that the main power switch is in the OFF position before attaching the jump start cables to the engine being started.

Turn off all auxiliary power and accessories of the engine. Otherwise, these components will operate when the power source is connected.

Before attaching the jump start cables, ensure that the control switch for the generator set is in the “OFF” position.

1. Perform all of the procedures in this Operation and Maintenance Manual (Operation Section), “Before Starting Engine”.

2. Connect the end of one jump start cable to the positive “+” terminal of the battery for the engine that is being started. Connect the other end to the positive “+” terminal of the power source.

3. Connect one end of the second jump start cable to the negative “−” terminal of the power source. Connect the other end to the negative “−” ground of the starting motor.

4. Press the “RUN button” .

5. After the engine starts, disconnect the cable from the negative “−” ground of the starting motor. Disconnect the other end of the cable from the negative “−” terminal of the power source.

6. Disconnect the cable from the positive “+” terminal of the battery for the engine that was started. Disconnect the other end of the cable from the positive “+” terminal of the power source.

i00736680

After Starting Engine

SMCS Code: 1000

Note: After the engine has been installed or rebuilt, carefully monitor the engine in order to detect any unusual engine performance.

Warm-up

1. Operate the engine at low idle for two to three minutes. Allow the jacket water temperature to begin to rise before increasing the engine rpm to rated rpm.

Note: More warm-up time may be necessary when the ambient temperature is below −18 °C (0 °F).

2. Check all of the gauges during the warm-up period.

3. Make another walk-around inspection. Inspect the engine for fluid leaks and air leaks.

The time that is needed for the engine to reach the normal mode of operation is usually less than the time that is needed for a walk-around inspection.

The engine will reach normal operating temperature faster when the engine is operated at rated rpm and low power demand. This procedure is more effective than idling the engine with no load. The engine should reach normal operating temperature in a few minutes.

Engaging the Driven Equipment

1. Ensure that the gauges are in the normal ranges for the engine rpm.

2. Increase the engine rpm to rated rpm. Always increase the engine speed to rated rpm before applying the load.

3. Adjust the voltage and the frequency, if necessary.

4. Close the main circuit breaker in order to apply the load.

5. Continue to check the gauges and the driven equipment.

Engine Operation

i05843093

Engine Operation

SMCS Code: 1000

Proper operation and maintenance are key factors in attaining the maximum service life and economy for the engine. Follow the instructions in this Operation and Maintenance Manual in order to minimize operating costs and maximize the service life of the engine.

Observe the gauges frequently while the engine is operating. Record the data from the gauges in a log regularly. Compare the data to the specifications for normal engine operation. Comparing the data over time will help to detect changes in engine performance.

Investigate any significant change in the gauge readings. Monitor the engine operation and act when discrepancies are found.

Operating the Engine and the Driven Equipment

Check the gauges and the driven equipment frequently while the engine is operating under a load. The engine can be operated for extended periods of time at full load.

Partial Load Operation

Extended operation at reduced load (less than 30%) may cause increased oil consumption and carbon buildup in the cylinders. Extended operation at reduced load may also cause fuel to slobber through the exhaust system. A loss of power and/or poor performance may result.

To maintain engine efficiency and performance, apply a full load to the engine on an hourly basis. Operating the engine at a load level that is greater than 30% will also maintain engine efficiency and performance. This action will burn excess carbon from the cylinders.

i00165110

Fuel Conservation Practices

SMCS Code: 1000; 1250

The efficiency of the engine can affect the fuel economy. Caterpillar's design and technology in manufacturing provides maximum fuel efficiency in all applications. Follow the recommended procedures in order to attain optimum performance for the life of the engine.

- Avoid spilling fuel.

Fuel expands when the fuel is warmed up. The fuel may overflow from the fuel tank. Inspect fuel lines for leaks. Repair the fuel lines, as needed.

- Be aware of the properties of the different fuels. Use only the recommended fuels.
- Avoid unnecessary idling.

Shut off the engine rather than idle for long periods of time.

- Observe the service indicator frequently. Keep the air cleaner elements clean.
- Ensure that the turbochargers are operating correctly so that the proper air/fuel ratio is maintained. Clean exhaust indicates proper functioning.
- Maintain a good electrical system.

One defective battery cell will overwork the alternator. This will consume excess power and excess fuel.

- Ensure that the belts are properly adjusted. The belts should be in good condition.
- Ensure that all of the connections of the hoses are tight. The connections should not leak.
- Ensure that the driven equipment is in good working order.
- Cold engines consume excess fuel. Utilize heat from the jacket water system and the exhaust system, when possible. Keep cooling system components clean and keep cooling system components in good repair. Never operate the engine without water temperature regulators. All of these items will help maintain operating temperatures.
- Settings for the fuel system and the limits for the operating altitude are stamped on the Engine Information Plate. If an engine is moved to a higher altitude, the settings must be changed by a Caterpillar dealer. Changing the settings will help prevent damage to the turbocharger. Changing the settings will help to provide the maximum efficiency for the engine. Engines can be operated safely at higher altitudes, but the engines will deliver less horsepower. The fuel settings should be changed by a Caterpillar dealer in order to obtain the rated horsepower.

Generator Operation

i06683747

Generator Operation

SMCS Code: 4450

Loading of the Generator

When a generator is installed or reconnected, be sure that the total current in one phase does not exceed the nameplate rating. Each phase should carry the same load which allows the engine to work at the rated capacity. If one-phase current exceeds the nameplate amperage, an electrical unbalance can result in an electrical overload and overheating.

Allowable combinations of unbalanced loads are shown in Illustration 36 . When you operate with significant single-phase loads, the combinations of single-phase load and three-phase load may be used. Such combinations should be located below the line on the graph.

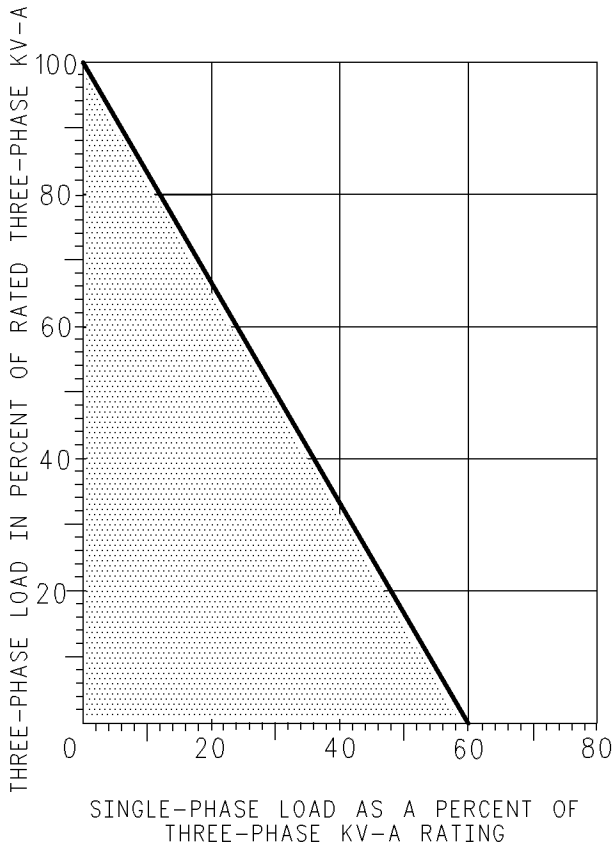

Illustration 36 g00627416

Allowable Combinations of Unbalanced Loads

Block Loading

Block loading is the instantaneous application of an electrical load to a generator set. This load may be anywhere from a moderate percentage of the rated load up to the rated load.

The block loading capability of a generator set depends on the following factors.

- Engine transient response
- Voltage regulator response
- Type of the voltage regulator
- Altitude of operation of the generator set
- Type of load (power factor for the load)
- The percentage of load before the application of the block load

If derating for the block load is required, refer to ISO 3046 Standards or SAE J1349 Standards. Also, reference Engine Data Sheet, LEKX4066, “Loading Transient Response” and Engine Data Sheet, LEKX4067, “Block and Transient Response”.

Note: ISO stands for International Standards Organization.

Power Factor

The power factor represents the efficiency of the load. Power factor is the ratio of apparent power to total power. The power factor is expressed as a decimal. The power factor represents that portion of the current which is doing useful work. The portion of current which is not doing useful work is absorbed in maintaining the magnetic field in motors or other devices.

In most applications, electric motors and transformers determine the power factor of the system. Induction motors usually have a 0.8 or smaller power factor. Incandescent lighting is a resistive load of about 1.0 power factor, or unity.

The power factor of a system may be determined by a power factor meter or by calculations. Determine the power requirement in kW by multiplying the power factor by the kVA that is supplied to the system. As the power factor increases, the total current that is supplied to a constant power demand will decrease. For example, a 100 kW load at a 0.8 power factor will draw more current than a 100 kW load at 0.9 power factor. High-power factor will result in full engine load at less than the rated amperage of the generator. A lower power factor increases the possibility of overloading the generator.

Note: If no other power factor is specified, Cat generators are designed for a 0.8 lagging power factor.

Excitation Systems

Low Idle Adjustment

Generator sets normally have a higher low idle setting than industrial engines. Low idle will be approximately 66% of the full load speed of 60 Hz units. Low idle will be approximately 80% of the full load speed of 50 Hz units.

There is no low idle stop on generator sets with electronic governors. On generator sets with mechanical governors and natural gas generator sets, the low idle is set at the factory. The low idle should only be adjusted by your Cat dealer if adjustment is required.

Note: Operating the generator set at low idle speed for an extended time will cause some voltage regulators to shut off. The generator set must be shut down. Then, the generator set must be restarted which will allow the voltage regulator to produce an output.

Standby Generator Sets

Most standby units are installed with controls that will start the unit automatically. Standby units perform the following tasks without an operator in attendance: start, pick up the load, run, and stop.

Standby units cannot change the governor control automatically. Standby units cannot change the voltage settings automatically. The governor speed and voltage level must be preset for the proper operation of the standby unit. Whenever the set is operated manually, be sure that the governor speed and voltage levels are correct for automatic operation. Check all switches for the proper setting. The start select switch should be in the AUTOMATIC position. Emergency Stop Switches should be in RUN position.

Generator Options

Space Heaters

These space heaters are installed for operation in high humidity conditions. For more information on space heaters, refer to Maintenance Section, “Space Heater - Check”.

Moisture can damage generators and other electrical equipment. Make every effort to keep the generator set as dry as possible.

Generators can operate without problems in humid environments. However, problems can occur when the generator is inactive. Moisture can condense on the windings. This condition can result in poor performance. Also, damage to the windings can occur.

Use space heaters to help keep the windings dry. When the generator is not active, ensure that the space heaters are operating. When the generator is operating, turn OFF the space heaters.

Embedded Temperature Detectors

The generators are available with embedded temperature detectors. The detectors are installed in the slots of the main armature. The main armature is also called a stator. The detectors are used with the equipment that is provided by the customer. Thus, the temperature of the main armature winding can be measured or monitored. Three types of temperature detectors are available. Contact your Cat dealer for more information.

Bearing Temperature Detectors

Bearing temperature detectors are available as an option on the generators. Bearing temperature detectors measure main bearing temperature. Bearing temperature detectors are used with the equipment that is provided by the customer. Thus, the temperature of the bearing can be measured or monitored. Bearing temperature measurements may help to prevent premature bearing failure.

Stator Winding Temperature

Some generators are provided with optional 100 Ohm Resistance Temperature Detectors (RTD). When the temperature of the stator winding is suspected to be high, measure the temperature. If the generator is furnished with Resistance Temperature Detectors, the detectors are installed in the slots of the main armature (stator). The detectors are used with equipment that is available from the factory. This equipment is used to measure the main armature winding temperature.

i01490164

Single Unit Operation

SMCS Code: 4450

Initial Start-Up

Before the initial start-up, perform the megohmmeter test on the main stator winding. Refer to the Special Instruction, SEHS9124, “Cleaning and Drying of Electric Set Generators” for the procedure.

Starting

1. Make all preliminary engine starting checks.

2. Be sure that the main circuit breaker or the line circuit breaker is open.

3. Start the engine. Allow the engine to warm up.

4. Adjust to the full load engine speed.

5. Close the main circuit breaker.

6. Apply the load. Do not try to apply the full load. Apply the load in increments in order to maintain system frequency at a constant level.

7. Readjust the governor for rated frequency.

Stopping

1. Remove the load in increments.

2. Open the circuit breaker.

3. Allow the engine to run for five minutes in order to cool.

4. Stop the engine.

i06683796

Parallel Operation

SMCS Code: 4450

Initial Start-Up

Preparing a generator for parallel operation requires special attention. Before you attempt to parallel units for the first time, check all the units for the following three conditions.

- same phase rotation
- same alternating current frequency
- same voltage adjustment

Several methods may be used to parallel generators. The preferred method is the utilization of a switch gear that uses automatic paralleling.

A method of manually paralleling generators which requires thorough understanding of the process is outlined below.

1. Check the phase rotation.

Units that operate in parallel must have the same phase rotation. There are two methods that may be used to determine if the incoming unit and the unit that is on-line have the same phase rotation. These methods are listed below:

- using a phase rotation meter
- using a set of three light bulbs

Use the procedure below to determine the proper phase rotation by using three light bulbs.

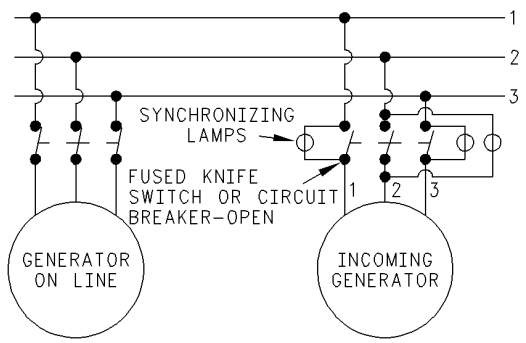

Illustration 37 g00695380

⚠ WARNING

When servicing or repairing electric power generation equipment:

Make sure the unit is off-line (disconnected from utility and/or other generators power service), and either locked out or tagged DO NOT OPERATE. Remove all fuses.

a. Connect the light bulbs with rated voltage between the generator leads and the corresponding line phase. For example, connect terminal 1 to line 1 across the open circuit breaker.

b. Start the units that will be in operating in parallel. Bring the units up to speed. As the units approach the same speed, the lights will start to blink.

- If the lights blink in sequence, one of the units is connected backward. To correct the problem, stop the units. Remove generator leads 1 and 3 at the circuit breaker. Exchange the generator leads which reverse the direction of phase rotation. Terminal 2 should always be connected to line 2. Go to 5.
- Both generators have the same phase rotation when the lights blink in unison. The first condition of “Initial Start-Up” had been met.

2. Adjust the frequency.

The units that will be operating in parallel must operate at the same speed. Speed is proportional to the alternating current frequency.

a. Allow each electric set to run under load for about 30 minutes.

b. Adjust the control to give the rated frequency at full load.

c. Remove the load and check the high idle speed. The high idle speed should be approximately 2 to 5 percent above full load speed for generators that are equipped with droop. If these speeds cannot be obtained, contact your Cat dealer.

d. For the most consistent results, repeat 2.b and 2.c until the second condition “Initial Start-Up” had been met.

3. Adjust the voltage. The generator voltage regulator should be programmed to the nominal values. Refer to Operation and Maintenance Manual, “Voltage Regulators”.

Note: Make sure that the speed droop is identical for all the engines before adjustments are made to the generator.

a. Program the reactive droop for the voltage regulator to approximately 2%. Initially program the same value on all generators which will be paralleled.

b. The no-load voltages should be identical for all the generators that are operating in parallel. Connect the generators in parallel. Try to obtain a 0 kW power exchange by adjusting the speed of the generator. Try to minimize the circulating currents between generators by altering the voltage setting on one of the generators.

Note: Do not change the voltage settings after this step.

c. Apply the available load. The setting is correct only if a reactive load is available. Equalize the Kilowatts or divide the rated power of the units proportionally by altering the speed. Alter the voltage droop to equalize the currents or divide the currents.

Starting Multiple Units

Use the procedure for starting single units to start multiple units. Refer to Operation Section, “Single Unit Operation”.

Paralleling Multiple Units

Units may be paralleled at no load. Units may also be paralleled with units under load. After the initial conditions for start-up are satisfied, verify for the following requirements:

- Generators must have voltage droop compensation or cross current compensation.

1. Start the unit which will be paralleled.

2. Turn on the synchronizer lights.

3. After the engine has run a few minutes, bring the engine up to synchronous speed. This procedure means that the frequency of the incoming unit will be the same frequency as the unit that is on-line. The synchronizing lights will begin to blink.

Note: The frequency of the incoming unit should be slightly greater than the line frequency. This condition will allow the incoming unit to assume some of the load instead of adding to the system load.

4. By using the control, adjust the engine speed until the lights blink slowly.

5. The lights are off when the voltages of the two units are in-phase. Quickly close the breaker when the lights are out.

6. Use the controls to share kW load between engines.

7. Generator temperature will be stabilized in approximately 1 hour. After the generator temperature has been stabilized, adjust the voltage droop rheostat of each generator. This procedure will share the reactive load and will limit the circulating currents. Less droop increases the reactive current that is carried by the generator.

Stopping

To remove a generator from the line, perform the following procedure.

1. Check the load. The load must be less than the rated capacity of the remaining units.

2. Be sure that the neutral of one of the remaining units is grounded.

3. Remove the load from the outgoing unit. See the Parallel Operation, “Load Division - Speed Droop”. The amperage may never go to zero due to circulating currents.

4. Open the circuit breaker.

5. Allow the engine to cool for 5 minutes.

6. Stop the engine.

Circulating Currents

Understanding the circulating currents becomes important when you parallel the units. These circulating currents are flowing between generators in parallel operation. The circulating currents are caused by voltage differences between the generators. The circulating currents are not doing useful work. The amount of the circulating current can be determined by subtracting the amperage which is going to the load from the total generator amperage.

The circulating current may be as high as 25 percent of rated amperes with cold generator sets.

As the generators warm, the circulating currents will decrease. The ammeter readings should decrease slightly, but the voltage meter readings should remain constant.

i06684188

Voltage Regulators

SMCS Code: 4467

Cat Digital Voltage Regulator (Cat DVR)

⚠ DANGER

The Cat Digital Voltage Regulator presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

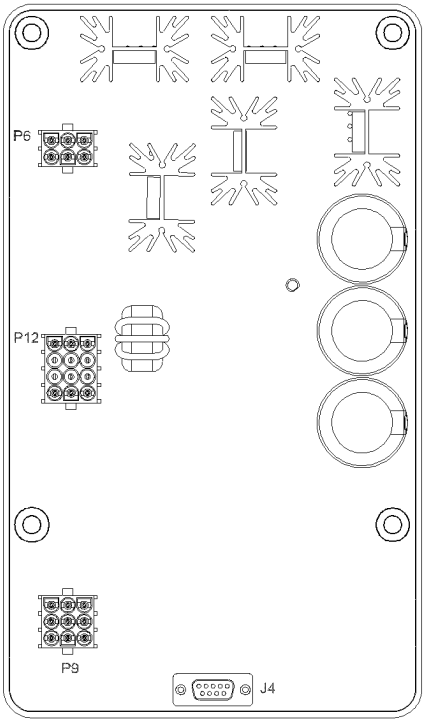

Illustration 38 g03844029

The Cat DVR is a microprocessor-based voltage regulator. Control power for the Cat DVR is supplied from an external source of 24 VDC. The power stage of the Cat DVR is supplied from a multiple pole high frequency permanent magnet generator. The multiple pole high frequency permanent magnet generator is mounted on the end of the generator shaft. Connections to the Cat DVR are made through three connectors. The communication between the Cat DVR and the service tool is accomplished by using a CANBUS protocol.

The Cat DVR has the following features:

- Three control modes:

1. Automatic voltage regulation (AVR)

2. Power factor (PF) regulation

3. Reactive power (VAR) regulation

- Programmable stability settings
- Soft start control with an adjustable time setting in AVR mode
- Dual slope voltage versus frequency (V/Hz) characteristic
- Three-phase or single-phase voltage sensing
- Single-phase current sensing
- Field current sensing and field voltage sensing
- Ten protection functions

Adjusting the Cat DVR

To view and configure the parameters of the Cat DVR, a PC with the Cat DVR software is required.

Refer to Specifications, Systems Operation, Testing and Adjusting, RENR7941, “Cat Digital Voltage Regulator” for complete information.

Integrated Voltage Regulator (IVR)

The Integrated Voltage Regulator (IVR) provides excitation current to the generator. The IVR is controlled by the IVR function in the EMCP4. The IVR function allows the EMCP4 to control the generator voltage, optimize transient performance, and provide feature specification.

The excitation module may interface with any of the following excitation systems: Self-Excitation (SE), Internal Excitation (IE), and Permanent Magnet (PMG) excitation systems.

For additional information about the IVR, see Application and Installation, LEBE0006, and Special Instruction, REHS9106.

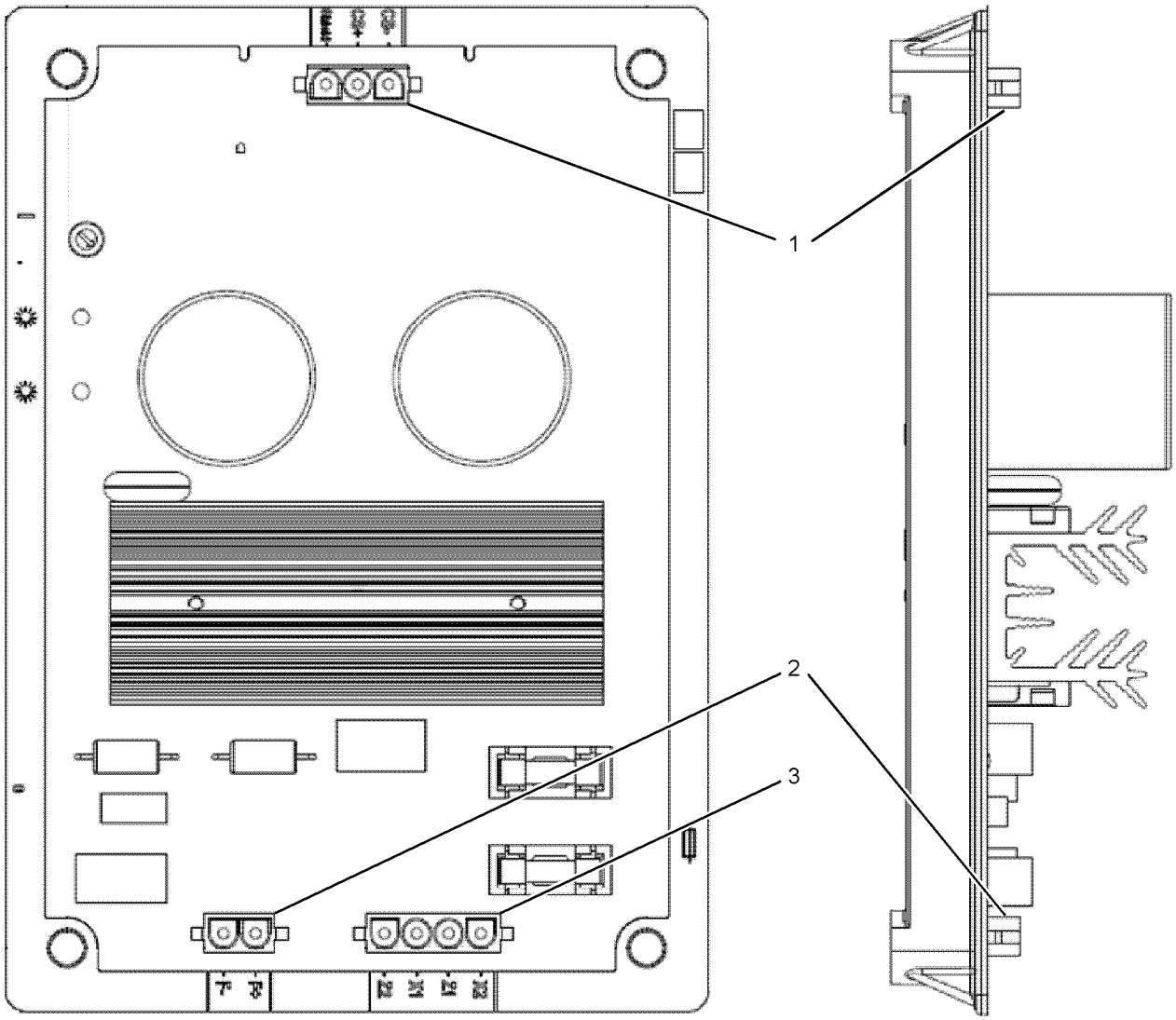

Illustration 39 g03727475

Excitation Module 15 (EM15)

(1) Connector P3 (2) Connector P2 (3) Connector P4

EMCP IVR Connection

To regulate the generator terminal voltage, the EMCP communicates the desired excitation command to the excitation module through a pulse width modulation (PWM) signal. A twisted pair of shielded cable must be used for the communication link. Table 3 details the connections to be made between the EMCP and Excitation Module.

Table 3

EMCP 4.1 and EMCP 4.2 Connections to Excitation Module (70-pin connector)			
EMCP 4.1 and EMCP 4.2 70-Pin Connector		Excitation Module 3-Pin Connector	
Digital Output #2 / IVR CS+	68	CS+	P3-2

(continued)

(Table 3, contd)

Battery negative splice	60 or 65	CS-	P3-3
Battery negative splice	60 or 65	Shield	P3-1
EMCP 4.3 and EMCP 4.4 Connections to Excitation Module (120-pin connector)			
EMCP 4.3 and EMCP 4.4 120-Pin Connector		Excitation Module 3-Pin Connector	
PWM Output #2 Positive	28	CS+	P3-2
PWM Output #2 Negative	8	CS-	P3-3
Shield	19	Shield	P3-1

Table 4 provides information on the technical specification of the EM15 module. Selection of the appropriate module must be determined by the following:

- Nominal and maximum generator excitation current at full load (standby 0.8 PF).
- The maximum AC voltage input.

Table 4

EM15 Technical Specifications	
	EM15
Compatible Generator Excitation Types	Permanent Magnet (PM) Self-Excitation (SE) Internal Excitation (IE/AREP)(1)
Nominal Field Current Output	7A
Maximum (forcing) Field Current Output	15A
Maximum AC Voltage Input	240Vms

(1) Internal Excitation (IE is also referred to as “Auxiliary Regulation Excitation Principle”(AREP)

IVR Excitation Module Connections

The EM15 excitation module has three plug type multiple-pin connectors. The connectors are labeled P2, P3, and P4. Table 5 describes the signal and function of each connector pin.

Table 5

Excitation Module Connections		
Terminal	**Label**	**Signal/Function**
P2-1	F+	Exciter Field Positive
P2-2	F-	Exciter Field Negative

(continued)

(Table 5, contd)

Excitation Module Connections		
Terminal	**Label**	**Signal/Function**
P3-1	Shield	Excitation Command Control Signal Shield
P3-2	CS+	Excitation Command Control Signal Positive
P3-3	CS-	Excitation Command Control Signal Negative
P4-1	X2	Excitation Power Supply Input X2
P4-2	Z1	Excitation Power Supply Input Z1
P4-3	X1	Excitation Power Supply Input X1
P4-4	Z2	Excitation Power Supply Input Z2

Note: The X2 and Z1 connections are internally linked within the excitation module. The link provides a point of common connection for the auxiliary windings where an AREP or IE excitation supply is available. Also, the X2 and Z1 connections may be linked externally to the excitation module. Only three connections (X1, X2, and Z2) are needed for the EM. Refer to Systems Operation/Test and Adjust/Troubleshooting, UENR1209, “Integrated Voltage Regulator Connections” for excitation module wiring connections. The wiring diagrams are for self-excitation (shunt), auxiliary windings (AREP/IE), and permanent magnet (PM) configurations.

The voltage regulator knee frequency must be configured for your specific package requirements. The knee frequency for 50 Hz operation will usually be between 48.0 and 49.8 Hz. For 60 Hz operation, the parameter must be set between 58.0 to 59.8 Hz.

Refer to Illustration 38 for an example under-frequency roll-off (loading) profile.

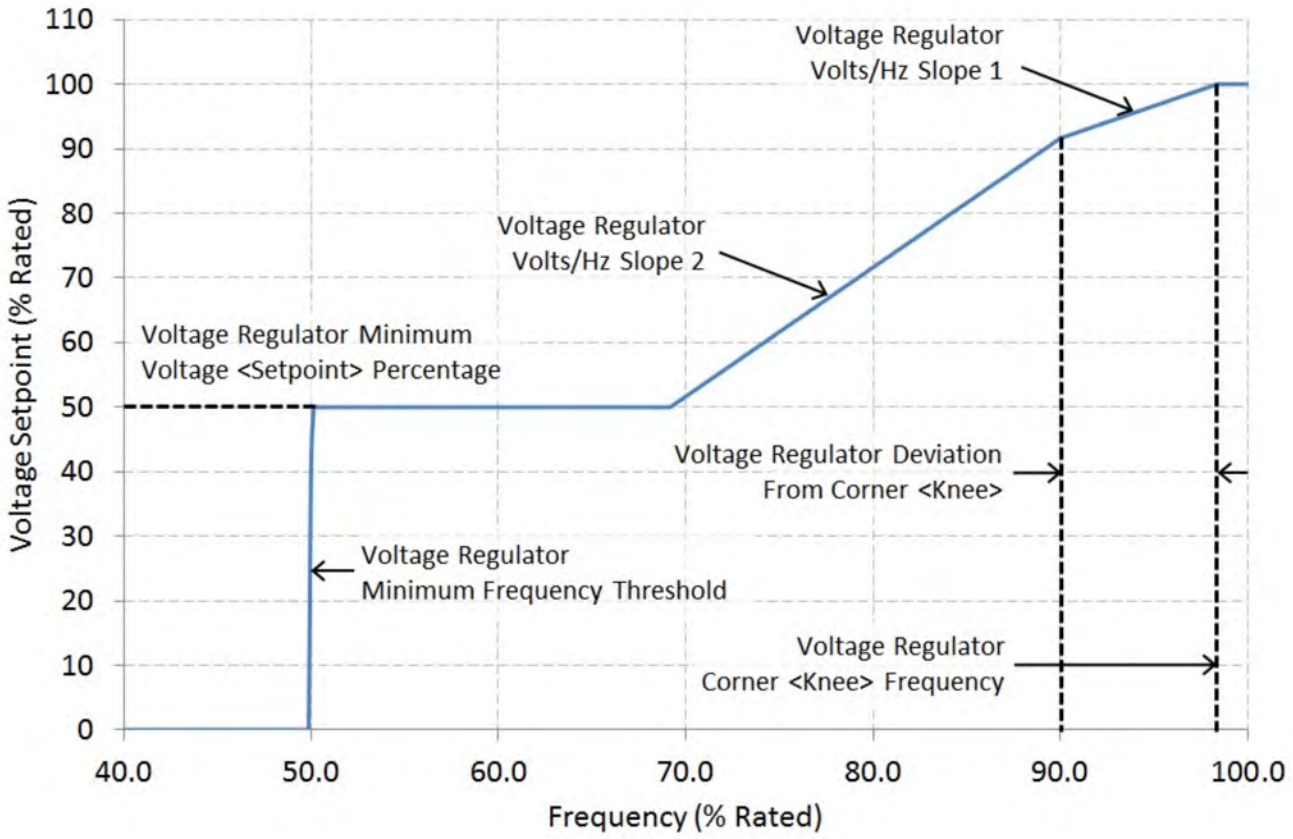

Illustration 40 g03487998

Under-frequency (loading) profile slope1 = 1.0 V/Hz, slope2 = 2.0 V/Hz

Cold Weather Operation

i05264084

Fuel and the Effect from Cold Weather

SMCS Code: 1000; 1250; 1280

The following fuels are the grades that are available for Cat engines:

- No. 1
- No. 2
- Blend of No. 1 and No. 2

No. 2 diesel fuel is the most commonly used fuel. Either No. 1 diesel fuel or a blend of No. 1 and No. 2 is best suited for cold-weather operation.

Quantities of No. 1 diesel fuel are limited. No. 1 diesel fuels are usually available during the months of the winter in the colder climates. During cold-weather operation, if No. 1 diesel fuel is not available, use No. 2 diesel fuel, if necessary.

There are three major differences between No. 1 and No. 2 diesel fuel. No. 1 diesel fuel has the following properties:

- Lower cloud point
- Lower pour point
- Lower rating of kJ (BTU) per unit volume of fuel

When No. 1 diesel fuel is used, a decrease in power and in fuel efficiency may be noticed. Other operating effects should not be experienced.

The cloud point is the temperature when a cloud of wax crystals begins to form in the fuel. These crystals can cause the fuel filters to plug. The pour point is the temperature when diesel fuel will thicken. The diesel fuel becomes more resistant to flow through fuel pumps and through fuel lines.

Be aware of these values when diesel fuel is purchased. Anticipate the average ambient temperature of the area. Engines that are fueled in one climate may not operate well if the engines are moved to another climate. Problems can result due to changes in temperature.

Before troubleshooting for low power or for poor performance in the winter, check the type of fuel that is being used.

When No. 2 diesel fuel is used the following components provide a means of minimizing problems in cold weather:

- Starting aids
- Engine oil pan heaters
- Engine coolant heaters
- Fuel heaters
- Fuel line insulation

For more information on cold-weather operation, see Special Publication, SEBU5898, “Cold Weather Recommendations”.

i01250450

Fuel Related Components in Cold Weather

SMCS Code: 1000; 1250; 1280

Fuel Tanks

Condensation can form in partially filled fuel tanks. Top off the fuel tanks after you operate the engine.

Fuel tanks should contain some provision for draining water and sediment from the bottom of the tanks. Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe.

Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

Drain the water and sediment from any fuel storage tank at the following intervals: weekly, oil changes and refueling of the fuel tank. This will help prevent water and/or sediment from being pumped from the fuel storage tank and into the engine fuel tank.

Fuel Filters

It is possible that a primary fuel filter is installed between the fuel tank and the engine fuel inlet. After you change the fuel filter, always prime the fuel system in order to remove air bubbles from the fuel system. Refer to the Operation and Maintenance Manual in the Maintenance Section for more information on priming the fuel system.

The micron rating and the location of a primary fuel filter is important in cold weather operation. The primary fuel filter and the fuel supply line are the most common components that are affected by cold fuel.

NOTICE
In order to maximize fuel system life and prevent premature wear out from abrasive particles in the fuel, a two micron absolute high efficiency fuel filter is required for all Caterpillar Electronic Unit Injectors. Caterpillar High Efficiency Fuel Filters meet these requirements. Consult your Caterpillar dealer for the proper part numbers.

Fuel Heaters

Fuel heaters help to prevent fuel filters from plugging in cold weather due to waxing. A fuel heater should be installed in the fuel system before the primary fuel filter.

The following fuel heaters are recommended for Caterpillar engines:

- 7C-3557 Fuel Heater Group
- 7C-3558 Heater Kit

For further information on fuel heaters, consult your Caterpillar dealer.

Disconnect the fuel heater in warm weather.

Note: Fuel heaters that are controlled by the water temperature regulator or self-regulating fuel heaters should be used with this engine. Fuel heaters that are not controlled by the water temperature regulator can heat the fuel in excess of 65°C (149°F). A loss of engine power can occur if the fuel supply temperature exceeds 37°C (100°F).

Note: Heat exchanger type fuel heaters should have a bypass provision in order to prevent overheating of the fuel in warm weather operation.

Engine Stopping

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Emergency Stopping

SMCS Code: 1000; 7418

NOTICE
Emergency shutoff controls are for EMERGENCY use ONLY. DO NOT use emergency shutoff devices or controls for normal stopping procedure.

Ensure that any components for the external system that aid the engine operation are secured after the engine is stopped.

Emergency Stop Button

Use of the emergency stop will shut off the fuel. If the engine is equipped with air shutoffs, the air shutoffs will also be activated.

NOTICE
Do not start the engine until the problem necessitating the emergency stop has been located and corrected.

Resetting the emergency stop button before the engine can be restarted may be necessary.

If the emergency stop button is used, both of the air shutoffs must be reset before the engine can be restarted.

The power for the ECM must be cycled before the engine can be restarted.

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Manual Stop Procedure

SMCS Code: 1000; 7418

NOTICE
Stopping the engine immediately after it has been working under load can result in overheating and accelerated wear of engine components.

Excessive temperatures in the turbocharger centerhousing will cause oil coking problems. Excessive temperatures in the turbocharger centerhousing may damage the turbocharger bearing/shaft system and significantly shorten the life of the turbocharger.

Allow the engine to gradually cool before stopping the engine

1. Open the main circuit breaker in order to disengage the driven equipment.
2. Turn the engine control switch to the “OFF/ RESET” position. The engine will immediately shut off.
3. Press the red “STOP” button on the EMCP3 controller. If the setpoint for the duration of the cooldown period is set to a value that is greater than zero, the engine will operate for a programmed period of time before the engine stops. Otherwise, the engine will immediately shut off.

Automatic Stopping

Automatic stopping will occur when the engine is operating in the automatic mode and the remote start/stop initiate contact opens. If the cooldown feature is utilized, the engine will operate for a programmed period of time before the engine stops. Otherwise, the engine will immediately shut off.

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After Stopping Engine

SMCS Code: 1000

- Check the engine crankcase oil level. Maintain the oil level between the “ADD” and “FULL” marks on the “ENGINE STOPPED” side of the oil level gauge. Complete all of the lubrication recommendations that are listed in Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations”.
- If necessary, perform minor adjustments. Repair any leaks and tighten loose bolts.
- Note the service hour meter reading. Perform the maintenance that is in the Operation and Maintenance Manual, “Maintenance Interval Schedule”.
- Fill the fuel tank in order to help prevent accumulation of moisture in the fuel. Do not overfill the fuel tank.

Note: Only use the antifreeze coolant solutions that are recommended in Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations”. Failure to follow the recommendations in Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations” can cause engine damage.

- Allow the engine to cool. Check the coolant level. Maintain the cooling system at 13 mm (0.5 inch) from the bottom of the pipe for filling.

- If freezing temperatures are expected, check the coolant for proper antifreeze protection. The cooling system must be protected against freezing to the lowest expected outside temperature. See Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations”. Add the proper coolant/water mixture, if necessary.
- Perform all required periodic maintenance on the generator. The generator maintenance is outlined in the Operation and Maintenance Manual that is supplied with the generator.

Maintenance Section

Refill Capacities

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Refill Capacities

SMCS Code: 1000; 1348; 1395; 7560

Lubricant Capacities

The capacity of the engine lubrication system includes the capacity of the oil filters that are installed at the factory. Auxiliary oil filter systems (if equipped) will require more oil. Refer to the specifications that are provided by the OEM of the auxiliary oil filter system.

Table 6

Approximate Refill Capacity for the 3516E Engine Lubrication System	
Compartment or System	**3516E**
Engine crankcase	466 L (123 US gal)

Coolant Capacities

To maintain the cooling system, the total cooling system capacity must be determined. The total cooling system capacity will vary between individual installations. The total cooling system capacity can include the following components: engine, expansion tank, heat exchanger, radiator, and piping.

Refer to the specifications that are provided by Caterpillar or the OEM of the installation. Record the total cooling system capacity in the appropriate Table.

Table 7

Approximate Refill Capacities for 3516E Generator Set Cooling System		
Ambient	**Engine Cooling System**	**Radiator**
Standard (1)	233 L (62 US gal)	202 L (53 US gal)
High (2)	233 L (62 US gal)	255 L (67 US gal)

(1) Rated for 43° C (109.4° F) ambient temperature.

(continued)

(Table 7, contd)

(2) Rated for 50° C (122° F) ambient temperature.

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Fluid Recommendations

SMCS Code: 1280; 1348; 1395; 7560

Refer to this Operation and Maintenance Manual, “Severe Service Application” for information about operating an engine in a severe service application.

Note: The interval for changing the coolant varies depending on the type of coolant being replaced. Refer to this article “Coolant Recommendations”, for the intervals for changing the coolant.

Diesel Engine Oil

For more information, refer to Special Publication, SEBU6251, “Cat Commercial Engine Fluids Recommendations”.

Cat Diesel Engine Oil (Cat DEO)

Cat oils have been developed and tested to provide the full performance and service life that has been designed and built into Cat engines. Cat oils are currently used to fill Cat Diesel Engines at the factory. These oils are offered by Cat dealers for continued use when the engine oil is changed. Consult your Cat dealer for more information on these oils.

Due to significant variations in the quality and in the performance of commercially available oils, Caterpillar makes the following recommendations:

Table 8

Cat Lubricants		Viscosity Grade
Diesel Engine Oil-Ultra Low Sulfur	Cat DEO-ULS	SAE 15W-40
		SAE 10W-30
	Cat DEO-ULS SYN	SAE 5W-40
	Cat Cold-Weather DEO-ULS	SAE 0W-40
Diesel Engine Oil	Cat DEO	SAE 15W-40
		SAE 10W-30
	Cat DEO SYN	SAE 5W-40

Note: Cat DEO and Cat DEO-ULS multigrade oils are the preferred oils for use in this Cat Diesel Engine.

Commercial Oil

Note: Commercial oils that are not Cat oils are second choice oils for your engine.

NOTICE
Caterpillar does not warrant the quality or performance of fluids that are not Cat fluids.

The three current Cat ECF specifications are: Cat ECF-1-a, Cat ECF-2, and Cat ECF-3. Each higher Cat ECF specification provides increased performance over lower Cat ECF specifications.

A commercial oil must meet the following standards to be considered an equivalent of a Cat Diesel Engine Oil:

Table 9

Cat Engine Crankcase Fluids (ECF) Definitions	
Cat Performance Requirement	Cat ECF Specifications Requirements
Cat ECF-3	API CJ-4 Oil Category performance requirements
Cat ECF-2	API CI-4 / CI-4 PLUS Oil Category performance requirements
	Passing standard Cat C13 engine test per API requirements
	Oils of sulfated ash > 1.50 percent are not allowed
Cat ECF-1-a	API CH-4 Oil Category performance requirements
	For oils that are between 1.30 percent and 1.50 percent sulfated ash, passing one extra Cat 1P SCOTE test (“ASTM D6681”) is required
	Oils of sulfated ash > 1.50 percent are not allowed

In selecting oil for any engine application, both of the following must be satisfied: the oil viscosity and the category of oil performance or the specification for oil performance . Using only one of these parameters will not sufficiently define oil for an engine application.

The proper SAE viscosity grade of oil is determined by the following temperatures: minimum ambient temperature during cold engine start-up and maximum ambient temperature during engine operation.

Refer to Table 10 (minimum temperature) to determine the required oil viscosity for starting a cold engine.

Refer to Table 10 (maximum temperature) to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

Note: Generally, use the highest oil viscosity that is available to meet the requirement for the temperature at start-up.

Table 10

Lubricant Viscosities for Ambient Temperatures for Cat Diesel Engines					
Oil Type and Performance Requirements	**Viscosity Grade**	**°C**		**°F**	
		Min	**Max**	**Min**	**Max**
Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 0W-30	−40	30	−40	86
Cat Cold-Weather DEO-ULS Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 0W-40	−40	40	−40	104
Cat DEO-ULS Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 5W-30	−30	30	−22	86
Cat DEO-ULS SYN Cat DEO Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 5W-40	−30	50	−22	122
Cat ECF-1-a Cat ECF-2 Cat ECF-3	SAE 10W-30	−18	40	0	104
Cat DEO-ULS Cat DEO	SAE 10W-40	−18	50	0	122
	SAE 15W-40	−9.5	50	15	122

Note: A cold soaked start occurs when the engine has not been operated recently, allowing the oil to become more viscous due to cooler ambient temperatures. Supplemental heat is recommended for cold soaked starts below the minimum ambient temperature. Supplemental heat may be necessary for cold soaked starts that are above the minimum temperature depending on factors such as parasitic load.

Total Base Number (TBN) and Fuel Sulfur Levels

The use of Cat S·O·S Services oil analysis is recommended strongly for determining oil life.

The minimum required Total Base Number (TBN) for oil depends on the fuel sulfur level. The TBN for new oil is typically determined by the “ASTM D2896” procedure. For direct injection engines that use distillate fuel, the following guidelines apply:

Table 11

TBN recommendations for applications in Cat engines (1)		
Fuel Sulfur Level percent (ppm)	Cat Engine Oils	TBN of Commercial Engine Oils
≤0.05 percent (≤500 ppm)	Cat DEO-ULS Cat DEO	Min 7
0. 1- 0.05 percent (1000-500 ppm)	Cat DEO-ULS Cat DEO	Min 7
Above 0.1 percent (above 1000 ppm)(2)	Cat DEO(3)	Min 10

(1) When using fuel with 0.10% sulfur (1000 ppm) or higher, refer to this Operation and Maintenance Manual, “Severe Service Application” for more information.
(2) For fuels of sulfur levels that exceed 1.0 percent (10,000 ppm), refer to TBN and engine oil guidelines given in this section.
(3) Cat DEO-ULS may be used if an oil analysis program is followed. Base the oil change interval on the analysis.

S·O·S Services Oil Analysis

Caterpillar has developed a maintenance tool that evaluates oil degradation. the maintenance management also detects the early signs of wear on internal components. The Cat tool for oil analysis is called S·O·S oil analysis and the tool is part of the S·O·S Services program. S·O·S oil analysis divides oil analysis into four categories:

- Component wear rate
- Oil condition
- Oil contamination
- Identification of oil

These four types of analysis are used to monitor the condition of your equipment. The four types of analysis will also help you identify potential problems. A properly administered S·O·S oil analysis program will reduce repair costs and the program will lessen the impact of downtime.

The S·O·S Oil Analysis program uses a wide range of tests to determine the condition of the oil and the crankcase. Guidelines that are based on experience and a correlation to failures have been established for these tests. Exceeding one or more of these guidelines could indicate serious fluid degradation or a pending component failure. A trained person at your Cat dealership should make the final analysis.

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

Refer to Special Publication, SEBU6251, “Cat Commercial Engine Fluids Recommendations” to obtain additional information about S·O·S Services oil analysis. You can also contact your local Cat dealer.

Fuel

Note: Caterpillar strongly recommends the filtration of fuel through a fuel filter with a rating of four microns(c) absolute or less. This filtration should be on the device that dispenses the fuel to the fuel tank for the engine. This filtration should also be on the device that dispenses fuel from the bulk storage tank. Series filtration is recommended.

NOTICE
In order to meet expected fuel system component life, 4 micron(c) absolute or less secondary fuel filtration is required for all Cat Diesel Engines that are equipped with unit injected fuel systems. All current Cat Diesel Engines are factory equipped with Cat Advanced Efficiency 4 micron(c) absolute fuel filters.

Caterpillar does not warrant the quality or performance of non-Cat fluids and filters.

Diesel engines can burn a wide variety of fuels. These fuels are divided into two general groups. The two groups are called the preferred fuels and the permissible fuels.

Note: The permissible fuels are some crude oils, some blends of crude oil with distillate fuel, some biodiesel, and some marine diesel fuel. These fuels are not suitable for use in all engine applications. The acceptability of these fuels for use is determined on an individual basis. A complete fuel analysis is required.

For more information, refer to Special Publication, SEBU6251, “Cat Commercial Engine Fluids Recommendations” or consult your Cat dealer for further information.

Diesel Distillate Fuel

Diesel engines may burn a wide variety of fuels. These fuels are divided into two general groups. The two groups are called the preferred fuels and the permissible fuels.

The preferred fuels provide maximum engine service life and performance. The preferred fuels are distillate fuels. These fuels are commonly called diesel fuel, furnace oil, gas oil, or kerosene. These fuels must meet the “Cat Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines” found in this Special Publication, “Distillate Diesel Fuel” article.

Note: The permissible fuels are some crude oils, some blends of crude oil with distillate fuel, some biodiesel, and some marine diesel fuel. **These fuels are not suitable for use in all engine applications.** The acceptability of these fuels for use is determined on a case by case basis. A complete fuel analysis is required. Consult your Cat dealer for further information.

NOTICE
The footnotes are a key part of the “Cat Specification for Distillate Diesel Fuel for Off-Highway Diesel Engines” Table. Read ALL of the footnotes.

Table 12

Cat Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	**Requirements**	**ASTM Test**	**ISO Test**
Aromatics	35% maximum	“D1319”	“ISO 3837”
Ash	0.01% maximum (weight)	“D482”	“ISO 6245”
Carbon Residue on 10% Bottoms	0.35% maximum (weight)	“D524”	“ISO 4262”
Cetane Number (1)	40 minimum (DI engines)	“D613” or “D6890”	“ISO 5165”
	35 minimum (PC engines)		
Cloud Point	The cloud point must not exceed the lowest expected ambient temperature.	“D2500”	“ISO 3015”
Copper Strip Corrosion	No. 3 maximum	“D130”	“ISO 2160”
Distillation	10% at 282 °C (540 °F) maximum	“D86”	“ISO 3405”
	90% at 360 °C (680 °F) maximum		
Flash Point	legal limit	“D93”	“ISO 2719”

(continued)

(Table 12, contd)

Cat Specification for Distillate Fuel for Nonroad Diesel Engines			
Specifications	**Requirements**	**ASTM Test**	**ISO Test**
Thermal Stability	Minimum of 80% reflectance after aging for 180 minutes at 150 °C (302 °F)	“D6468”	No equivalent test
API Gravity (2)	30 minimum	“D287”	No equivalent test
	45 maximum		
Pour Point	6 °C (10 °F) minimum below ambient temperature	“D97”	“ISO 3016”
Sulfur	(3)(4)(5)	“D5453” or “D2622”	ISO 20846 or ISO 20884
Kinematic Viscosity	1.4 cSt minimum and 20.0 cSt maximum as delivered to the fuel injection pumps	-	-
	1.4 cSt minimum and 4.5 cSt maximum as delivered to the rotary fuel injection pumps		
Water and Sediment	0.05% maximum	“D1796” or “D2709”	“ISO 3734”
Water	0.05% maximum	“D6304”	No equivalent test
Sediment	0.05% maximum (weight)	“D473”	“ISO 3735”
Gums and Resins (6)	10 mg per 100 mL maximum	“D381”	“ISO 6246”
Lubricity	0.52 mm (0.0205 inch) maximum at 60 °C (140 °F)	“D6079”	No equivalent test

(1) Alternatively, to ensure a minimum cetane number of 35 (PC engines), and 40 (DI engines), distillate diesel fuel should have a minimum cetane index of 37.5 (PC engines), and 44.2 (DI engines) when the “ASTM D4737-96a” test method is used. A fuel with a higher cetane number may be required for operation at a higher altitude or in cold weather.

(2) Via standards tables, the equivalent kg/m^3 (kilograms per cubic meter) using the “ASTM D287” test method temperature of 15.56° C (60° F) for the minimum API gravity of 30 is 875.7 kg/m^3, and for the maximum API gravity of 45 is 801.3 kg/m^3.

(3) ULSD 0.0015% (<15 ppm S) is required by law for Tier 4 engines and engines with aftertreatment devices.

(continued)

(Table 12, contd)

(4) Certain Cat fuel systems and engine components can operate on fuel with a maximum sulfur content of 3%. Contact your Cat dealer for guidance about appropriate maintenance intervals and fluids for engines operating on fuel with sulfur levels between 0.1% and 3%.

(5) An engine which operates on fuel with 0.1% (1000 ppm) of sulfur or more is operating in a severe service application. Refer to this Operation and Maintenance Manual, “Severe Service Application” for information about operating an engine in a severe service application.

(6) Follow the test conditions and procedures for gasoline (motor).

Biodiesel

A biodiesel blend of up to 20 percent may be used in the engine when the fuel blend meets the recommendations in table 13 and meets the recommendations in Special Publication, SEBU6251, “Biodiesel”.

Note: A complete Cat S·O·S Services oil analysis program is recommended when using biodiesel blends above 5 percent.

Table 13

Biodiesel Blends for Cat Commercial Engines		
Biodiesel blend stock	Final blend	Distillate diesel fuel used for blend
Cat biodiesel specification, “ASTM D6751”or “EN14214”	B20: “ASTM D7467” and “API” gravity 30-45	Cat distillate diesel fuel specification, “ASTM D975”or “EN590”

Fuel Additives

Cat Diesel Fuel Conditioner

Cat Diesel Fuel Conditioner is a proprietary formulation that has been extensively tested for use with distillate diesel fuels for use in Cat Diesel Engines. Cat Diesel Fuel Conditioner is a high performance diesel fuel conditioner for use with lower quality fuels that do not meet the minimum requirements of any of the following:

- “Cat Specification for Distillate Diesel Fuel”
- National Conference on Weights and Measures (NCWM) Premium Diesel definition (refer to the2004or newer National Institute of Standards & Technology (NIST) Handbook).
- EN590 (non-arctic)
- ASTM D975

Cat Diesel Fuel Conditioner is the only fuel conditioner/additive available to the end user that is tested and approved by Caterpillar for use in Cat Diesel Engines.

Refer to Special Publication, SEBU6251, “Cat Commercial Diesel Engine Fluids Recommendations” for information about the use of Cat Diesel Fuel Conditioner.

Cat Diesel Fuel System Cleaner

Note: Cat Diesel Fuel System Cleaner is the only fuel system cleaner available to the end user that is tested and approved by Caterpillar for use in Cat Diesel Engines.

Cat Diesel Fuel System Cleaner is a proven high performance detergent product designed specifically for cleaning deposits that form in the fuel system. Deposits in the fuel system reduce system performance and can increase fuel consumption. Cat Diesel Fuel System Cleaner addresses the deposits formed due to the use of degraded diesel fuel, poor quality diesel fuel, and diesel fuel containing high quantities of high molecular weight compounds. Cat Diesel Fuel System Cleaner addresses deposits formed due to the use of biodiesel, biodiesel blends, and biodiesel that does not meet the appropriate quality specifications. Continued use of Cat Diesel Fuel System Cleaner is proven to inhibit the growth of new deposits.

Caterpillar strongly recommends that Cat Diesel Fuel System Cleaner be used with biodiesel and biodiesel blends. Cat Diesel Fuel System Cleaner is suitable for use with biodiesel/biodiesel blends that meet Cat biodiesel recommendations and requirements. Not all fuel cleaners are suitable for use with biodiesel/biodiesel blends. Read and follow all applicable label usage instructions. Also, refer to Special Publication, SEBU6251, “Cat Commercial Diesel Engine Fluids Recommendations” “Distillate Diesel Fuel”, article and also refer to the “Biodiesel” article, which includes Caterpillar biodiesel recommendations and requirements.

Aftermarket Fuel Additives

There are many different types of fuel additives that are available to use. Caterpillar does not generally recommend the use of fuel additives.

In special circumstances, Caterpillar recognizes the need for fuel additives. Use fuel additives with caution. The additive may not be compatible with the fuel. Some additives may precipitate. This action causes deposits in the fuel system. The deposits may cause seizure. Some additives may plug fuel filters. Some additives may be corrosive, and some additives may be harmful to the elastomers in the fuel system. Some additives may damage emission control systems. Some additives may raise fuel sulfur levels above the maximum levels that are allowed by the following agencies: EPA and other regulatory agencies. Contact your fuel supplier for those circumstances when fuel additives are required. Your fuel supplier can make recommendations for additives to use and for the proper level of treatment.

Note: For best results, your fuel supplier should treat the fuel when additives are needed.

Cooling System

Note: Refer to Special Publication, SEBU6251, “Cat Commercial Diesel Engine Fluids Recommendations” for complete information about the proper fluids for use in the cooling system.

⚠ WARNING

The cooling system operates under pressure which is controlled by the radiator pressure cap. Removing the cap while the system is hot may allow the escape of hot coolant and steam, causing serious burns.

Before you remove the radiator cap, allow the system to cool. Use a thick cloth and turn the radiator cap slowly to the first stop to allow pressure to escape before fully removing the cap.

Avoid contact with coolant.

NOTICE
Never add coolant to an overheated engine. Engine damage could result. Allow the engine to cool first.

NOTICE
If the engine is to be stored in, or shipped to an area with below freezing temperatures, the cooling system must be either protected to the lowest outside temperature or drained completely in order to prevent damage caused by freezing coolant.

NOTICE
Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the proper operating temperature. Cooling system problems can develop without water temperature regulators. Removing the regulators allows some coolant to bypass the radiator, potentially causing overheating.

Coolant Recommendations

Note: A Cat Diesel Engine equipped with air-to-air aftercooling (ATAAC) requires a minimum of 30 percent glycol to help prevent water pump cavitation.

Table 14

Coolant Recommendations for Cat Diesel Engines			
Recommendations	**Product**	**Service Hours(1)(2)(3)**	**Required Maintenance**
Preferred	Cat ELC and Cat ELI	12000 hours or 6 years	Add Cat ELC Extender at 6000 service hours or one half of service life
Min requirements	Cat EC-1 specification and “ASTM D6210” and Organic Additive Technology (OAT) based on a combination of a monocarboxylic acid and a dicarboxylic acid Phosphate, borate, and silicate free Tolyltriazole: minimum typical concentration of 900 ppm Nitrite: minimum typical concentration of 500 ppm in new coolants	6000 hours or 6 years	Add Extender at 3000 service hours or one half of service life
Acceptable	Cat DEAC	3000 hours or 3 years	SCA at maintenance intervals
	Cat SCA in water	3000 hours or 2 years	SCA at maintenance intervals
Min requirements for fully formulated Heavy-Duty Commercial coolants	“ASTM D6210” and Nitrite (as NO2) concentration: Minimum of 1200 ppm (70 grains/US gal) and maximum of 2400 ppm (140 grains/US gal) Silicon concentration: minimum of 100 ppm and maximum of 275 ppm	3000 hours or 2 years	SCA at maintenance intervals
Min requirements for Commercial coolants requiring SCA precharge	“ASTM D4985” and(1) Nitrite (as NO2) concentration: Minimum of 1200 ppm (70 grains/US gal) and maximum of 2400 ppm (140 grains/US gal) Silicon concentration: minimum of 100 ppm and maximum of 275 ppm	3000 hours or 1 year	SCA at initial fill and SCA at maintenance intervals
Min requirements for SCA and water	Commercial supplemental coolant additive and water	3000 hours or 1 year	Per manufacturer recommendations

(1) New Coolants at 50 volume percent diluted. Coolants that are prediluted at the coolant manufacturer must be diluted with water that meets Reagent 4 “ASTM D1193” requirements.
(2) Maintain the in-service coolant at the given limits.
(3) When referring to the service hours, use the interval that occurs first. These coolant change intervals are only achievable with annual S·O·S Services Level 2 coolant sampling analysis.

Table 15

Special Requirements	
Cat C7-C32 Marine Engines with heat exchangers	Minimum of 30% glycol is required. 50% Glycol is recommended. Water alone or water with SCA or with ELI is **NOT** allowed.

Table 16

Phosphate Dosing Applicability(1)				
	Aluminum Radiator	**Copper Radiator**	**Comments**	**Comments**
Cat ELC	YES	NO	Extended Life Coolants	
Cat DEAC/NGEC	NO	NO	Conventional Coolants (Diesel Engine Antifreeze Coolant), (Natural Gas Engine Coolant)	Silicate Based

(continued)

(Table 16, contd)

Non Cat Long Life Coolant - with Nitrites	YES	NO		
Non Cat Long Life Coolant - with Nitrites and Silicates	NO	NO		Silicate Based
Non Cat Long Life Coolant - without Nitrites	NO	NO		
Non Cat Long Life Coolant - without Nitrites	NO	NO		
Non Cat Conventional Coolants	NO	NO		Silicate Based
Treated Water Systems - using SCA	NO	NO	Supplemental Coolant Additive	Silicate Based
Treated Water Systems - using Cat ELI	YES	NO	Extended Life Inhibitors PELF1212	Additives similar to ELC

(1) Required to maintain nitrites and coolant color.

NOTICE
Use Only Approved SCAs and Extenders

Conventional coolants require the maintenance addition of SCA throughout the expected life of the coolants. Do NOT use an SCA with a coolant unless approved specifically by the coolant supplier. The coolant manufacturer is responsible for ensuring compatibility and acceptable performance.

To help ensure expected performance, EC-1 coolants require the one time maintenance addition of an extender at coolant service mid-life. Do not use an extender with a coolant unless the extender has been approved specifically for use by the coolant manufacturer. The coolant manufacturer is responsible for ensuring compatibility and acceptable performance.

Failure to follow these recommendations can result in shortened cooling system component life.

Cat ELC can be recycled into conventional coolants.

For more information, refer to Special Publication, SEBU6251, “Cat Commercial Engine Fluids Recommendations”.

S·O·S Services Coolant Analysis

Testing the engine coolant is important to ensure that the engine is protected from internal cavitation and corrosion. The analysis also tests the ability of the coolant to protect the engine from boiling and freezing. S·O·S coolant analysis can be done at your Cat dealer. Cat S·O·S coolant analysis is the best way to monitor the condition of your coolant and your cooling system. S·O·S coolant analysis is a program that is based on periodic samples.

Table 17

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**
Cat DEAC Cat SCA Conventional Heavy-Duty Coolants	Every 250 hours	Yearly(1)
Cat ELC Cat ELI Commercial EC-1 Coolants	Optional(1)	Yearly(1)

(1) The Level 2 Coolant Analysis should be performed sooner if a problem is suspected or identified.

Note: Check the SCA (Supplemental Coolant Additive) of the conventional coolant at every oil change or at every 250 hours. Perform this check at the interval that occurs first.

S·O·S Services Coolant Analysis (Level 1)

A coolant analysis (Level 1) is a test of the properties of the coolant.

The following properties of the coolant are tested:

- Glycol concentration for freeze protection and boil protection
- Ability to protect from erosion and corrosion
- pH

- Conductivity
- Visual analysis
- Odor analysis

The results are reported, and appropriate recommendations are made.

S·O·S Services Coolant Analysis (Level 2)

A coolant analysis (Level 2) is a comprehensive chemical evaluation of the coolant. This analysis is also a check of the overall condition of the cooling system.

The S·O·S coolant analysis (Level 2) has the following features:

- Full coolant analysis (Level 1)
- Identification of metal corrosion and of contaminants
- Identification of buildup of the impurities that cause corrosion
- Identification of buildup of the impurities that cause scaling
- Determination of the possibility of electrolysis within the cooling system of the engine

The results are reported, and appropriate recommendations are made.

For more information on S·O·S coolant analysis, consult your Cat dealer.

Greases

If choosing a single grease is necessary, choose a grease that meets or exceeds the requirements of the most demanding application. Remember that the products which meet the minimum performance requirements can be expected to produce the minimum lives of your parts. False economy is being used if a grease is purchased with the lowest cost as the only consideration. Instead, use the grease that yields the lowest total operating cost. The cost should be based on an analysis that includes the costs of parts, labor, downtime, and the cost of the amount of grease that is required.

For more information, refer to Special Publication, SEBU6251, “Cat Commercial Engine Fluids Recommendations”.

Maintenance Recommendations

i05264090

General Maintenance Information

SMCS Code: 4450; 7000

Note: Read the warnings and read the instructions that are contained in the Safety Section of this manual. These warnings and instructions must be understood before you perform any operation or any maintenance procedures.

Rotating electric machines are complex structures that are exposed to the following forms of stress:

- mechanical
- electrical
- thermal
- environmental

These stresses may be of varying magnitudes. The electrical insulation systems are susceptible to damage that is caused by the stresses that are listed above. Exposure to these stresses may shorten the effective life of the electrical insulation system. Therefore, the service life of an electric machine will largely depend on the serviceability of the electrical insulation systems. An inspection program and a testing procedure are recommended. An inspection program and a testing procedure will ensure that the equipment is maintained in satisfactory condition. This will increase field reliability.

A regular maintenance and inspection program can provide an evaluation of the present condition of the equipment. A regular maintenance program and a regular inspection program can also reveal future problems. The frequency of this maintenance program will depend on the following factors:

- application
- environmental conditions
- experience level of the operator
- philosophy of the operator

A regular maintenance program is strongly recommended. This program would involve the following steps:

- periodic disassembly
- knowledgeable visual examination of the equipment
- the application of electrical tests

Never perform a test over the rated potential. These tests can damage insulation that is contaminated or insulation that is in marginal condition. For more information, refer to “I.E.E.E. Standard 432-1992” or consult a Cat dealer.

i02909163

System Pressure Release

SMCS Code: 1250; 1300; 1350; 5050

Coolant System

⚠ WARNING

Pressurized system: Hot coolant can cause serious burn. To open cap, stop engine, wait until radiator is cool. Then loosen cap slowly to relieve the pressure.

To relieve the pressure from the coolant system, turn off the engine. Allow the cooling system pressure cap to cool. Remove the cooling system pressure cap slowly in order to relieve pressure.

Fuel System

To relieve the pressure from the fuel system, turn off the engine.

High Pressure Fuel Lines (If Equipped)

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

The high pressure fuel lines are the fuel lines that are between the high pressure fuel pump and the high pressure fuel manifold and the fuel lines that are between the fuel manifold and cylinder head. These fuel lines are different from fuel lines on other fuel systems.

This is because of the following differences:

- The high pressure fuel lines are constantly charged with high pressure.
- The internal pressures of the high pressure fuel lines are higher than other types of fuel system.

Before any service or repair is performed on the engine fuel lines, perform the following tasks:

1. Stop the engine.

2. Wait for ten minutes.

Do not loosen the high pressure fuel lines in order to remove air pressure from the fuel system.

Engine Oil

To relieve pressure from the lubricating system, turn off the engine.

i05909227

Welding on Engines with Electronic Controls

SMCS Code: 1000

NOTICE
Because the strength of the frame may decrease, some manufacturers do not recommend welding onto a chassis frame or rail. Consult the OEM of the equipment or your Cat dealer regarding welding on a chassis frame or rail.

Proper welding procedures are necessary in order to avoid damage to the engine ECM, sensors, and associated components. When possible, remove the component from the unit and then weld the component. If removal of the component is not possible, the correct procedure must be followed. When welding on a unit that is equipped with a Cat Electronic Engine, the following is considered to be the safest procedure:

NOTICE
Do not ground the welder to electrical components such as the ECM or sensors. Improper grounding can cause damage to the drive train, the bearings, hydraulic components, electrical components, and other components.

Do not ground the welder across the centerline of the package. Improper grounding could cause damage to the bearings, the crankshaft, the rotor shaft, and other components.

Clamp the ground cable from the welder to the component that will be welded. Place the clamp as close as possible to the weld. This will help reduce the possibility of damage.

Note: Perform the welding in areas that are free from explosive hazards.

1. Stop the engine. Turn the switched power to the OFF position.

2. Disconnect the negative battery cable from the battery. If a battery disconnect switch is provided, open the switch.

3. Disconnect the J1/P1 and J2/P2 connectors from the ECM. Move the harness to a position that will not allow the harness to move back accidentally, and contact any of the ECM pins.

4. Disconnect any component with a microprocessor from the engine harness, such as:

- Engine ECM
- Product Link
- Cell/Sat Radio
- DOC Identity Modules

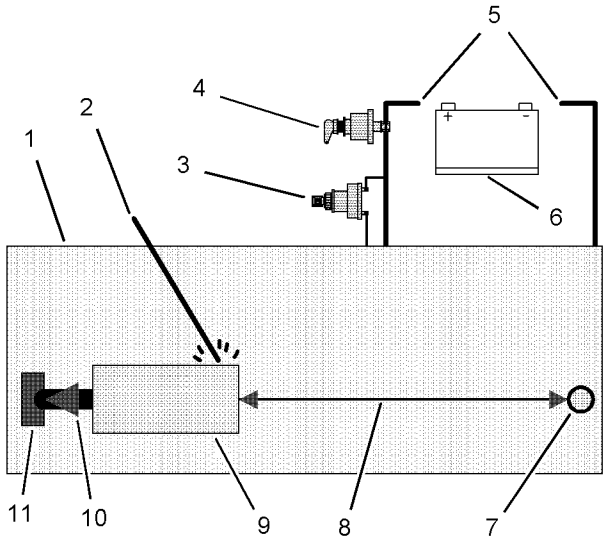

Illustration 41 g01075639

Use the example above. The current flow from the welder to the ground clamp of the welder will not damage any associated components.

(1) Engine
(2) Welding electrode
(3) Keyswitch in the OFF position
(4) Battery disconnect switch in the open position
(5) Disconnected battery cables
(6) Battery
(7) Electrical/Electronic component
(8) Minimum distance between the component that is being welded and any electrical/electronic component
(9) The component that is being welded
(10) Current path of the welder
(11) Ground clamp for the welder

5. Connect the welding ground cable directly to the part that will be welded. Place the ground cable as close as possible to the weld. This location will reduce the possibility of welding current damage to bearings, hydraulic components, electrical components, and ground straps.

Note: If electrical/electronic components are used as a ground for the welder, current flow from the welder could severely damage the component. Current flow from the welder could also severely damage electrical/electronic components that are located between the welder ground and the weld.

6. Protect the wiring harness from welding debris and spatter.

7. Use standard welding practices to weld the materials.

i03211424

Generator Start-up Checklist

SMCS Code: 4450

Table 18

GENERATOR START-UP CHECKLIST							
RATING INFORMATION							
Engine Serial Number:				Arrangement Number:			
Serial Number for the Generator:				Arrangement Number:			
GENERATOR NAME PLATE INFORMATION							
Voltage:			Package (prime, continuous, standby):				
Amperage:			Kilowatts:				
Storage Location:							
Megohmmeter Reading for the Main Stator:		Before Storage:		After Storage :			
The generator was dried for 24 hours prior to start-up.			(Y/N)	Drying method:			
SPACE HEATERS		**Yes**	**No**	**Comments**			
The space heaters are operating properly.							
The space heater was operated 48 hours before start-up.							
MEGOHMMETER TEST (1)		30 second reading	60 second reading	30 second corrected	60 second corrected	Ambient temperature	Comments
Beginning of Storage	Main Stator						
	Main Rotor						
	Exciter Stator						
	Exciter Rotor						
	PMG(2) Stator						

(continued)

(Table 18, contd)

GENERATOR START-UP CHECKLIST							
Start-up	Main Stator						
	Main Rotor						
	Exciter Stator						
	Exciter Rotor						
	Stator for the PMG						
Regulator		**Voltage**	**Amperage**	**Comments**			
No Load	“T1” to “T2”	AC					
	“T1” to “T3”	AC					
	“T2” to “T3”	AC					
	“PMG1” to “PMG2”	AC					
	“PMG2” to “PMG3”	AC					
	“PMG1” to “PMG3”	AC					
Full Load	“T1” to “T2”	AC					
	“T1” to “T3”	AC					
	“T2” to “T3”	AC					
	“PMG1” to “PMG2”	AC					
	“PMG2” to “PMG3”	AC					
	“PMG1” to “PMG3”	AC					

(1) Special Publication, SEHS9124, “Cleaning and Drying of Electric Set Generators”
(2) Permanent Magnet Exciter

Table 19

GENERATOR START-UP CHECKLIST (CONTINUED)				
ELECTRICAL		**Yes**	**No**	**Comments**
	The unit is properly grounded.			
	Check diodes and check the varistor.			
	Overcurrent protection			
	Overvoltage protection			
	Check for loose wiring.			
	Adjust voltage.			
	Adjust frequency.			
MECHANICAL		**Data**		**Comments**
	Bearing temperature readings at full load	Front _____ Rear _____		
	Temperature reading of the stator at full load	A0 _____ B0 _____ C0 _____		
	Air gap on main stator	Top _____ Bottom _____		
	Air gap on exciter stator	Top _____ Bottom _____		
	Air gap of PMG	Top _____ Bottom _____		
	Ambient air to generator at full load	Temperature _____		

(continued)

(Table 19, contd)

	Supplier air opening to generator set				Size of Opening _____			
SWITCH GEAR/PARALLEL OPERATION								
	Manufacturer:							
				Setting 1	**Setting 2**	**Setting 3**	**Comments**	
	Circuit breaker type							
	Overload setting							
	Reverse power relay							
	VAR/PF Controller							
	Load share							
INSTALLATION & LOAD INFORMATION								
	Neutral grounding system				UPS			
	Enclosure type				- Size			
	Motor:				Other loads:			
	- Total SKVA				- Lighting			
	- Total HP				- Computers			
					- Welding			
					- Non-linear			
					- Other			
FULL LOAD DATA								
Voltage	Amps		KW	KVARS	P.F.			

i07037736

Maintenance Interval Schedule (Standby)

SMCS Code: 1000; 4450; 7500

Ensure that all safety information, warnings, and instructions are read and understood before any operation or any maintenance procedures are performed. The user is responsible for the performance of maintenance, including all adjustments, the use of proper lubricants, fluids, and filters. The user is also responsible for the replacement of components due to normal wear and aging. Failure to adhere to proper maintenance intervals and procedures may result in diminished performance of the product and/or accelerated wear of components. Use fuel consumption, service hours, or calendar time, WHICH EVER OCCURS FIRST, to determine the maintenance intervals. Products that operate in severe operating conditions may require more frequent maintenance. Before each consecutive interval is performed, all maintenance from the previous interval must be performed.

When Required

Every Week

Every 6 Months

Every Year

Every 500 Service Hours or 1 Year

Every 3 Years

Every 6 Years

Every 10 Years

Commissioning

i04850565

Air Inlet Filter - Inspect/Clean/Test

SMCS Code: 1051-081; 1051-040; 1051-070

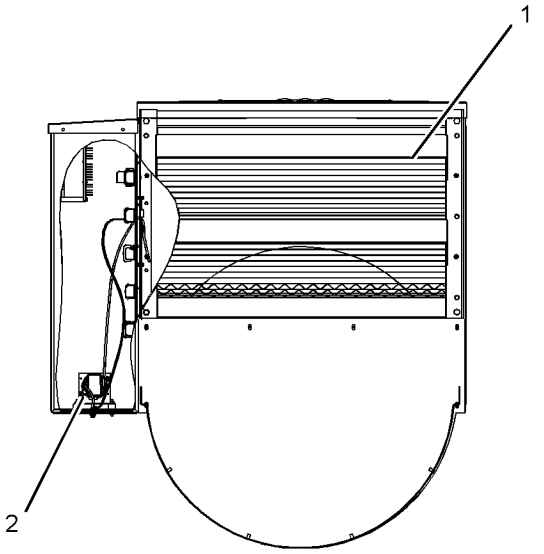

Illustration 42 g02980078

Typical Generator air inlet filter.

(1) Filter element
(2) Differential pressure switch

Monitor the connector contacts of the differential pressure switch for the air inlet filter. If the differential pressure rises above 15.2 mm (0.6 inch) of water, clean the filter with a solution of soap and water. Be sure that the filter is thoroughly dry before the start-up. Replace the filter, if necessary.

i02676048

Alternator - Inspect

SMCS Code: 1405-040

Caterpillar recommends a scheduled inspection of the alternator. Inspect the alternator for loose connections and proper battery charging. Inspect the ammeter (if equipped) during engine operation in order to ensure proper battery performance and/or proper performance of the electrical system. Make repairs, as required.

Check the alternator and the battery charger for proper operation. If the batteries are properly charged, the ammeter reading should be very near zero. All batteries should be kept charged. The batteries should be kept warm because temperature affects the cranking power. If the battery is too cold, the battery will not crank the engine. The battery will not crank the engine, even if the engine is warm. When the engine is not run for long periods of time or if the engine is run for short periods, the batteries may not fully charge. A battery with a low charge will freeze more easily than a battery with a full charge.

i06543763

Battery - Recycle

SMCS Code: 1401; 1401-005; 1401-535; 1401-510; 1401-561

Always recycle a battery. Never discard a battery.

Always return used batteries to one of the following locations:

- A battery supplier
- An authorized battery collection facility
- Recycling facility

i03967451

Battery - Replace

SMCS Code: 1401-510

⚠ WARNING

Batteries give off combustible gases which can explode. A spark can cause the combustible gases to ignite. This can result in severe personal injury or death.

Ensure proper ventilation for batteries that are in an enclosure. Follow the proper procedures in order to help prevent electrical arcs and/or sparks near batteries. Do not smoke when batteries are serviced.

1. Turn the key start switch to the OFF position. Remove the key and all electrical loads.
2. Turn OFF the battery charger. Disconnect the charger.
3. The NEGATIVE “-” cable connects the NEGATIVE “-” battery terminal to the ground plane. Disconnect the cable from the NEGATIVE “-” battery terminal.

4. The POSITIVE “+” cable connects the POSITIVE “+” battery terminal to the starting motor. Disconnect the cable from the POSITIVE “+” battery terminal.

Note: Always recycle a battery. Never discard a battery. Return used batteries to an appropriate recycling facility.

5. Remove the used battery.

6. Install the new battery.

Note: Before connecting the cables, ensure that the key start switch is OFF.

7. Connect the cable from the starting motor to the POSITIVE “+” battery terminal.

8. Connect the cable from the ground plane to the NEGATIVE “-” battery terminal.

i05264116

Battery Charger - Check

SMCS Code: 1401-535

Checking Before Start-Up

Check the battery charger for proper operation. If the batteries are properly charged, the needle of the ammeter will register near “0” (zero).

The battery charger must not produce excessive current during start-up. Alternatively, the charger must be automatically disconnected for start-up. If the engine has an alternator, the charger must be automatically disconnected during start-up and during engine operation.

Charging the Battery

⚠ WARNING

Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operated. A spark can cause an explosion from the flammable vapor mixture of hydrogen and oxygen that is released from the electrolyte through the battery outlets. Injury to personnel can be the result.

Perform the following procedure to charge the battery:

1. Ensure that the charger is turned OFF.

2. Adjust the voltage of the charger in order to match the voltage of the battery.

3. Connect the POSITIVE “+” lead of the charger to the POSITIVE “+” battery terminal. Connect the NEGATIVE “-” lead of the charger to the NEGATIVE “-” battery terminal.

4. Turn ON the battery charger.

Overcharging of Batteries

Overcharging reduces the service life of batteries. Use a battery charger that will not overcharge the battery. DO NOT charge the battery if the meter of the battery charger is in the RED zone.

Overcharging is indicated by the following symptoms:

- The battery is warm to the touch.
- A strong odor of acid is present.
- The battery emits smoke or a dense vapor (gas).

Perform one of the following procedures if the battery shows symptoms of overcharging:

- Reduce the rate of charging by a significant amount. Complete the charging at the reduced rate.
- Turn OFF the charger.

Table 20 describes the effects of overcharging on different types of batteries.

Table 20

Effects of Overcharging Batteries	
Type of Battery	**Effect**
Cat General Service Batteries Cat Premium High Output Batteries	All of the battery cells have a low level of electrolyte.
	When the plates of the battery are inspected through the filler holes, the plates may appear to be warped. This is caused by an excessive temperature.
	The battery may not pass a load test.
Cat Maintenance Free Batteries	The battery may not accept a charging current.

(continued)

(Table 20, contd)

	The battery may not pass a load test.

Checking After Stopping

Ensure that the battery charger is connected properly. Observe the meter of the charger. Record the amperage.

i07185134

Battery Electrolyte Level - Check

SMCS Code: 1401-535-FLV

When the engine has not run for long or short periods of time, the batteries may not fully recharge. Ensure a full charge to help prevent the battery from freezing.

In warmer climates, check the electrolyte level more frequently.

Ensure that the electrolyte level is 13 mm (0.5 inch) above the top of the separators.

⚠ WARNING

All lead-acid batteries contain sulfuric acid which can burn the skin and clothing. Always wear a face shield and protective clothing when working on or near batteries.

1. Remove the filler caps. Maintain the electrolyte level to the “FULL” mark on the battery.

   If the addition of water is necessary, use distilled water. If distilled water is not available, use clean water that is low in minerals. Do not use artificially softened water.

2. Check the condition of the electrolyte with the 245-5829 Coolant Battery Tester Refractometer.

3. Keep the batteries clean.

   Clean the battery case with one of the following cleaning solutions:

   - A mixture of 0.1 kg (0.2 lb) of baking soda and 1 L (1 qt) of clean water
   - A mixture of 0.1 L (0.11 qt) of ammonia and 1 L (1 qt) of clean water

   Thoroughly rinse the battery case with clean water.

   Use the 1U-9921 Battery Service Tool to clean the battery terminals. Use a wire brush to clean the cable clamps. Clean the items until the surfaces are bright or shiny. DO NOT remove material excessively. Excessive removal of material can cause the clamps to fit improperly. Coat the clamps and the terminals with 5N-5561 Silicone Lubricant, petroleum jelly or MPGM.

i06738663

Battery or Battery Cable - Disconnect

SMCS Code: 1401; 1402-029

⚠ WARNING

The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Turn the start switch to the OFF position. Turn the ignition switch (if equipped) to the OFF position and remove the key and all electrical loads.
2. Disconnect the negative battery terminal at the battery that goes to the start switch. Ensure that the cable cannot contact the terminal. When four 12 volt batteries are involved, the negative side of two batteries must be disconnected.
3. Tape the leads in order to help prevent accidental starting.
4. Proceed with necessary system repairs. Reverse the steps in order to reconnect all of the cables.

i06684335

Belts - Inspect/Adjust/Replace

SMCS Code: 1357-025; 1357-510; 1357-040

Inspection

Inspect the alternator belt and the fan drive belts for wear and for cracking. Replace the belts if the belts are not in good condition.

Check the belt tension according to the information in the Service Manual, “Specifications”.

Slippage of loose belts can reduce the efficiency of the driven components. Vibration of loose belts can cause unnecessary wear on the following components:

- Belts
- Pulleys
- Bearings

If the belts are too tight, unnecessary stress is placed on the components. Unnecessary stress reduces the service life of the components.

Adjusting the Alternator Belt

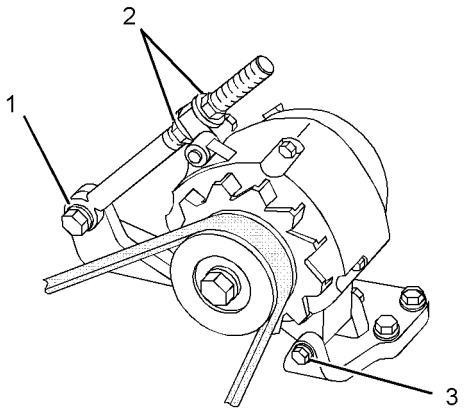

Illustration 43 g01092641

Typical alternator

(1) Mounting bolt
(2) Adjusting nuts
(3) Mounting bolt

1. Loosen mounting bolt (1), adjusting nuts (2) and mounting bolt (3).

2. Turn adjusting nuts (2) to increase or decrease the drive belt tension.

3. Tighten adjusting nuts (2). Tighten mounting bolt (3). Tighten mounting bolt (1). For the proper torque, see the Service Manual, “Specifications” module.

4. Reinstall the drive belt guard.

If new drive belts are installed, check the drive belt tension again after 30 minutes of engine operation at the rated rpm.

Fan Drive Belt

The fan drive utilizes an automatic tensioning idler pulley system.

Replacement

For applications that require multiple drive belts, replace the drive belts in matched sets. Replacing one drive belt of a matched set will cause the new drive belt to carry more load because the older drive belts are stretched. The additional load on the new drive belt could cause the new drive belt to fail.

i02456186

Circuit Breakers - Reset

SMCS Code: 1417-529; 1420-529

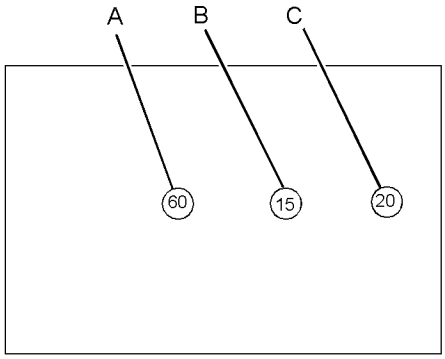

Illustration 44 g01225779

Push in on the circuit breaker in order to reset the circuit breaker.

(A) 60 Amp Circuit Breaker – This circuit breaker is for the battery charger and the circuit for the alternator.

(B) 15 Amp Circuit Breaker – This circuit breaker is for the Electronic Control Module (ECM).

(C) 20 Amp Circuit Breaker – This circuit breaker is for the control panel.

i04506312

Control Panel - Inspect/Test

SMCS Code: 4490-081; 4490-040; 7451-040; 7451-081

Inspect the condition of the panel. If a component is damaged, ensure that the component is repaired or that the component is replaced. If equipped, ensure that the electronic displays are operating properly. Inspect the wiring for good condition. Ensure that the wiring connections are secure.

Electronic Modular Control Panel 4.2 (EMCP 4.2)

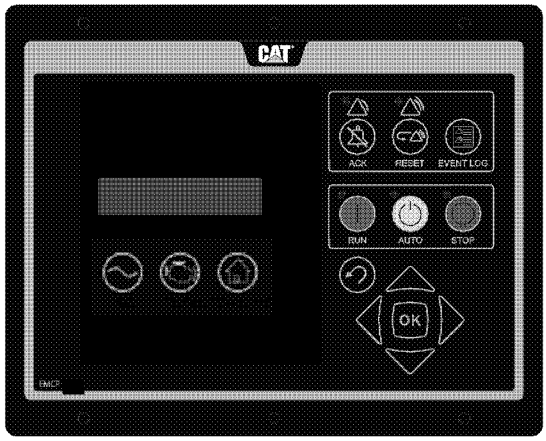

Illustration 45 g02685122

For detailed information on this electronic control panel, see Systems Operation, Troubleshooting, Testing and Adjusting, UENR1209, “EMCP4.1/4.2”.

Switch Panel

The Panel Lights switch should turn on the panel lights. Toggle the switch in order to ensure that the panel lights are working.

Annunciator Panel

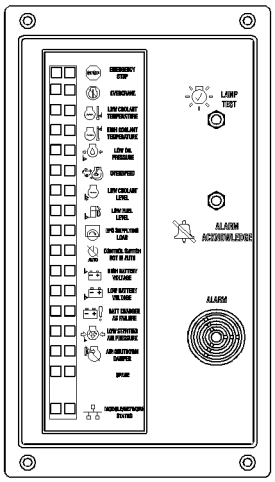

Illustration 46 g01101388

Test the LED indicators and the horn when the data link is connected and when the data link is not connected. The Lamp Test button is located near the top of the annunciator panel. Test both the horn and the indicators by pressing and holding the Lamp Test button. Replace any faulty components before starting the engine.

i07139849

Coolant (DEAC) - Change

SMCS Code: 1350-070; 1395-044

Clean the cooling system before the recommended maintenance interval if the following conditions exist:

- The engine overheats frequently.
- The coolant is foaming.
- Oil or fuel has entered the cooling system and the coolant is contaminated.

Drain the Cooling System

1. Stop the engine and allow the engine to cool. Ensure that the engine will not start when the cooling system is drained.

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

2. Loosen the radiator filler cap slowly to relieve any pressure. Remove the radiator filler cap.

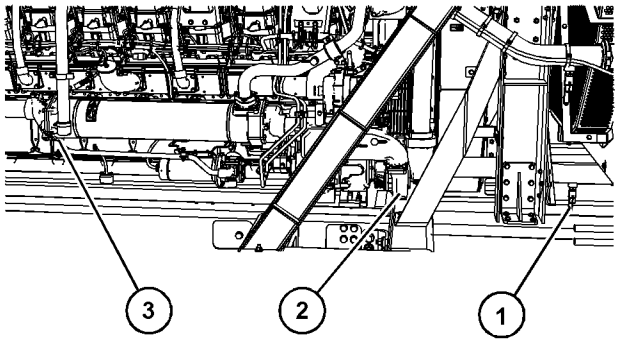

Illustration 47 g06233539

(1) Radiator drain valves
(2) Water pump drain
(3) Engine oil cooler drain

Note: If the engine has a jacket water heater, drain the coolant from the heater.

3. Open coolant drains. Allow the coolant to drain.

NOTICE
Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

For information regarding the disposal and the recycling of used coolant, consult your Cat dealer or consult Cat Dealer Service Tools:

Inside U.S.A. 1-800-542-TOOL
Inside Illinois 1-800-541-TOOL
Canada 1-800-523-TOOL
EAME phone ++41-22-849 40 56
EAME fax ++41-22-849 49 29

Clean the Cooling System

NOTICE
Use of commercially available cooling system cleaners may cause damage to cooling system components. Use only cooling system cleaners that are approved for Caterpillar engines.

1. After the cooling system has been drained, flush the cooling system with clean water to remove any debris.
2. Close the cooling system drain. Clean the cooling system drain plugs and install the cooling system drain plugs.

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

3. Fill the cooling system with a mixture of clean water and Cat Fast Acting Cooling System Cleaner. Add .5 L (1 pt) of cleaner per 15 L (4 US gal) of the cooling system capacity. Install the radiator filler cap.
4. Open the water inlet for the separate circuit aftercooler (if equipped). Start the engine. Operate the engine for a minimum of 30 minutes with a coolant temperature of at least 82 °C (180 °F).
5. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Loosen the radiator filler cap slowly to relieve any pressure. Remove the radiator filler cap. Open the coolant drain. Remove the cooling system drain plugs. Allow the water to drain.

NOTICE
Improper or incomplete rinsing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

6. Flush the cooling system with clean water until the water that drains is clean. Close the coolant drain. Clean the cooling system drain plugs and install the cooling system drain plugs. Open the water inlet for the separate circuit aftercooler (if equipped).

Cleaning a Cooling System that has Heavy Deposits or Plugging

Note: For the following procedure to be effective, there must be an active flow through the cooling system components.

1. After the cooling system has been drained, flush the cooling system with clean water to remove any debris.
2. Close the coolant drain. Clean the cooling system drain plugs and install the cooling system drain plugs.
3. Fill the cooling system with a mixture of clean water and Cat Fast Acting Cooling System Cleaner. Add .5 L (1 pt) of cleaner per 3.8 L to 7.6 L (1 to 2 US gal) of the cooling system capacity. Install the radiator filler cap.
4. Open the water inlet for the separate circuit aftercooler (if equipped). Start the engine. Operate the engine for a minimum of 90 minutes with a coolant temperature of at least 82 °C (180 °F).
5. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Loosen the radiator filler cap slowly to relieve any pressure. Remove the radiator filler cap. Open the coolant drain. Remove the cooling system drain plugs. Allow the water to drain.

NOTICE
Improper or incomplete rinsing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

6. Flush the cooling system with clean water until the water that drains is clean. Close the cooling system drain. Clean the cooling system drain plugs and install the cooling system drain plugs.

Fill the Cooling System

Note: For information about the capacity of the cooling system, see this Operation and Maintenance Manual, “Refill Capacities”. For information about the proper coolant to use, see this Operation and Maintenance Manual, “Fluid Recommendations”.

.

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

1. Fill the cooling system with coolant/antifreeze. After filling the cooling system, do not install the radiator filler cap.

2. Open the water inlet for the separate circuit aftercooler (if equipped). Start the engine. Operate the engine to purge the air from the cavities of the engine block. Allow the coolant to warm and allow the coolant level to stabilize. Stop the engine.

3. Check the coolant level. Maintain the coolant to the proper level on the sight gauge (if equipped). If a sight gauge is not equipped, maintain the coolant within 13 mm (.5 inch) below the bottom of the filler pipe.

4. Clean the radiator filler cap. Inspect the gaskets of the radiator filler cap. If the gaskets of the radiator filler cap are damaged, discard the old radiator filler cap and install a new radiator filler cap. If the gaskets of the radiator filler cap are not damaged, use a 9S-8140 Pressurizing Pump to pressure test the radiator filler cap. The correct pressure is stamped on the face of the radiator filler cap. If the radiator filler cap does not maintain the correct pressure, install a new radiator filler cap.

5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

i07140077

Coolant (ELC) - Change

SMCS Code: 1350-070; 1395-044

Use only clean water to flush the cooling system when Extended Life Coolant (ELC) is drained and replaced.

Drain the Cooling System

1. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Ensure that the engine will not start when the cooling system is drained.

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

2. Loosen the radiator filler cap slowly to relieve any pressure. Remove the radiator filler cap.

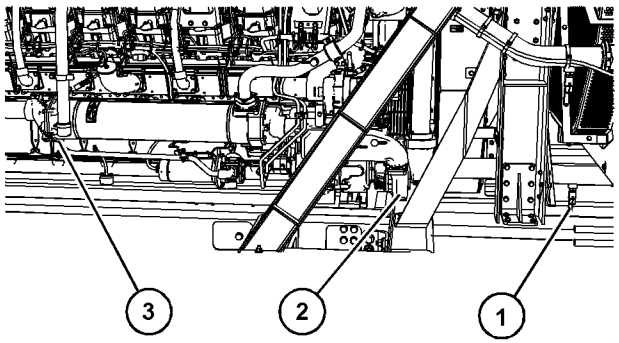

Illustration 48 g06233539

(1) Radiator drain valves
(2) Water pump drain
(3) Engine oil cooler drain

3. Open coolant drains. Allow the coolant to drain.

NOTICE
Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

For information regarding the disposal and the recycling of used coolant, consult your Cat dealer or consult Caterpillar Dealer Service Tools:

Outside Illinois 1-800-542-TOOL
Inside Illinois 1-800-541-TOOL
Canada 1-800-523-TOOL
EAME phone ++41-22-849 40 56
EAME fax ++41-22-849 49 29

Clean the Cooling System

1. After the cooling system has been drained, flush the cooling system with clean water to remove any debris.

2. Close the coolant drain.

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

3. Open the water inlet for the separate circuit aftercooler (if equipped). Fill the cooling system with clean water. Install the radiator filler cap. Operate the engine until the temperature reaches 49 °C (120 °F) to 66 °C (150 °F).

4. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Ensure that the engine will not start when the cooling system is drained. Loosen the radiator filler cap slowly to relieve any pressure. Remove the radiator filler cap.
5. Open the coolant drain. Allow the coolant to drain. Flush the cooling system with clean water. Close the coolant drain.
6. Repeat Steps 34 and 5.

Fill the Cooling System

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

Note: If equipped with a Cat radiator, the radiator must be filled with the proper amount of Phosphate additive (ELC-P). For specific information on phosphate dosing, refer to the **Phosphate Dosing Applicability** table in this Operation and Maintenance Manual, Fluid Recommendations section.

1. Fill the cooling system with Extended Life Coolant (ELC). For the correct capacity of the cooling system, see this Operation and Maintenance Manual, “Refill Capacities”. Do not install the radiator filler cap.
2. Open the water inlet for the separate circuit aftercooler (if equipped). Start the engine. Operate the engine to purge the air from the cavities of the engine block. Allow the ELC to warm and allow the coolant level to stabilize. Stop the engine.
3. Check the coolant level. Maintain the coolant to the proper level on the sight gauge (if equipped). If a sight gauge is not equipped, maintain the coolant within 13 mm (.5 inch) below the bottom of the filler pipe.
4. Clean the radiator filler cap. Inspect the gaskets of the radiator cap. If the gaskets of the radiator filler cap are damaged, discard the old radiator filler cap and install a new radiator filler cap. If the gaskets of the radiator filler cap are not damaged, use a 9S-8140 Pressurizing Pump to pressure test the radiator filler cap. The correct pressure is stamped on the face of the radiator filler cap. If the radiator filler cap does not maintain the correct pressure, install a new radiator filler cap.
5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

i03966297

Coolant Extender (ELC) - Add

SMCS Code: 1352-544-NL

Cat ELC (Extended Life Coolant) does not require the frequent additions of any supplemental cooling additives which are associated with the present conventional coolants. The Cat ELC Extender is only added once.

NOTICE
Use only Cat Extended Life Coolant (ELC) Extender with Cat ELC.

Do NOT use conventional supplemental coolant additive (SCA) with Cat ELC. Mixing Cat ELC with conventional coolants and/or conventional SCA reduces the Cat ELC service life.

Check the cooling system only when the engine is stopped and cool.

⚠ WARNING

Personal injury can result from hot coolant, steam and alkali.

At operating temperature, engine coolant is hot and under pressure. The radiator and all lines to heaters or the engine contain hot coolant or steam. Any contact can cause severe burns.

Remove cooling system pressure cap slowly to relieve pressure only when engine is stopped and cooling system pressure cap is cool enough to touch with your bare hand.

Do not attempt to tighten hose connections when the coolant is hot, the hose can come off causing burns.

Cooling System Coolant Additive contains alkali. Avoid contact with skin and eyes.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Dealer Service Tool Catalog” for tools and supplies suitable to collect and contain fluids on Cat ® products.

Dispose of all fluids according to local regulations and mandates.

1. Loosen the cooling system filler cap slowly in order to relieve pressure. Remove the cooling system filler cap.
2. Drain enough coolant from the cooling system in order to add the Cat ELC Extender.
3. Add Cat ELC Extender according to the requirements for your engine cooling system capacity. Refer to the Operation and Maintenance Manual, “Refill Capacities and Recommendations” article for more information.
4. Clean the cooling system filler cap. Inspect the gaskets on the cooling system filler cap. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.

i07140081

Coolant Level - Check

SMCS Code: 1395-082

Check the coolant level when the engine is stopped and cool.

Engines That Are Equipped with Expansion Tanks and Sight Gauges

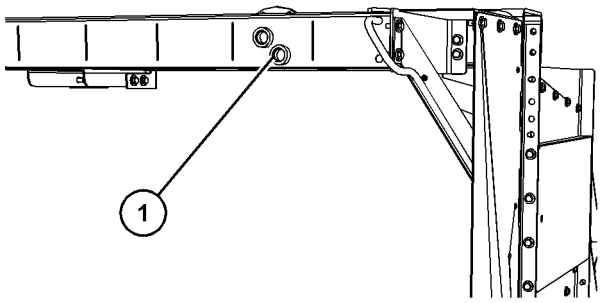

Illustration 49 g06233701

(1) Coolant level sight gauge

Check the position of the coolant in the sight gauge (1). At normal operating temperature, the proper coolant level is in the upper half of the sight gauge. If the coolant level is low, add the correct amount of coolant.

1. Loosen filler cap (1) slowly to relieve any pressure. Remove the filler cap.
2. Pour the proper coolant mixture into the tank. Refer to this Operation and Maintenance Manual, “Fluid Recommendations” for information about coolants.
3. Clean filler cap (1) and the receptacle. Reinstall the filler cap and inspect the cooling system for leaks.

Note: The coolant will expand as the coolant heats up during normal engine operation. The additional volume will be forced into the coolant recovery tank during engine operation. When the engine is stopped and cool, the coolant will return to the engine.

Engines That Are Not Equipped with a Coolant Sight Gauge

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Remove the cooling system filler cap slowly to relieve pressure.
2. Maintain the coolant level within 13 mm (0.5 inch) of the bottom of the filler pipe. If the engine is equipped with a sight glass, maintain the coolant level to the proper level in the sight glass.

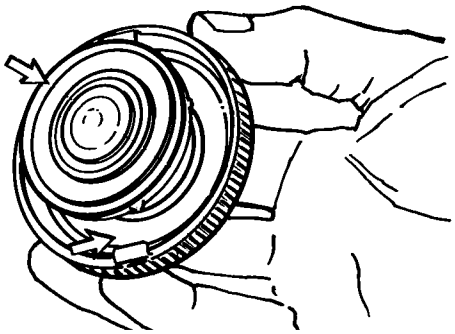

Illustration 50 g00103639

Typical filler cap gaskets

3. Clean the cooling system filler cap and check the condition of the filler cap gaskets. Replace the cooling system filler cap if the filler cap gaskets are damaged. Reinstall the cooling system filler cap.

4. Inspect the cooling system for leaks.

i04333559

Coolant Sample (Level 1) - Obtain

SMCS Code: 1350-008; 1395-008; 1395-554; 7542

Testing the engine coolant is important to ensure that the engine is protected from internal cavitation and corrosion. The analysis also tests the ability of the coolant to protect the engine from boiling and freezing. S·O·S Systems Coolant Analysis can be done at your Cat dealer. Cat S·O·S coolant analysis is the best way to monitor the condition of your coolant and your cooling system. S·O·S coolant analysis is a program that is based on periodic samples.

Note: Obtaining a Coolant Sample (Level 1) is optional if the cooling system is filled with one of the following coolants: Cat ELC (Extended Life Coolant)., Cat ELI (Extended Life Inhibitor) and Conventional Heavy-Duty Coolant.

Note: Obtain a Coolant Sample (Level 1) if the cooling system is filled with any of the following coolants: Cat DEAC, Cat SCA and Conventional Heavy-Duty Coolants.

For additional information about coolant analysis and about other coolants, see this Operation and Maintenance Manual, “Fluid Recommendations” or consult your Cat dealer.

Sampling Conditions

If the engine is equipped with a sampling port, the engine should be running at operating temperature when the sample is obtained.

If the engine is not equipped with a sampling port, the coolant should be warm.

Use the following guidelines for proper sampling of the coolant:

- Complete the information on the label for the sampling bottle before you begin to take the samples.
- Keep the unused sampling bottles stored in plastic bags.
- Obtain coolant samples directly from the coolant sample port. You should not obtain the samples from any other location.
- Keep the lids on empty sampling bottles until you are ready to collect the sample.
- Place the sample in the mailing tube immediately after obtaining the sample in order to avoid contamination.
- Never collect samples from expansion bottles.
- Never collect samples from the drain for a system.

Timing of the Sampling

Table 21

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**
Cat DEAC Cat SCA Conventional Heavy-Duty Coolants	Every 250 hours	Yearly(1)
Cat ELC Cat ELI Commercial EC-1 Coolants	Optional(1)	Yearly(1)

(1) The Level 2 Coolant Analysis should be performed sooner if a problem is suspected or identified.

Note: Check the SCA (Supplemental Coolant Additive) of the conventional coolant at every oil change or at every 250 hours. Perform this check at the interval that occurs first.

Obtain the sample of the coolant as close as possible to the recommended sampling interval. In order to receive the full effect of S·O·S analysis, establish a consistent trend of data. In order to establish a pertinent history of data, perform consistent samplings that are evenly spaced. Supplies for collecting samples can be obtained from your Cat dealer.

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

Submit the sample for Level 1 analysis.

Note: Level 1 results may indicate a need for Level 2 Analysis.

i04535891

Coolant Sample (Level 2) - Obtain

SMCS Code: 1350-008; 1395-554; 1395-008; 7542

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Refer to Operation and Maintenance Manual, “Cooling System Coolant Sample (Level 1) - Obtain” for the guidelines for proper sampling of the coolant.

Submit the sample for Level 2 analysis.

For additional information about coolant analysis, see Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engines Fluids Recommendations” or consult your Cat dealer.

i04535903

Coolant Temperature Regulator - Replace

SMCS Code: 1355-510

Replace the water temperature regulator before the water temperature regulator fails. This procedure is a recommended preventive maintenance practice. Replacing the water temperature regulator reduces the chances for unscheduled downtime. Refer to this Operation and Maintenance Manual, “Maintenance Interval Schedule” for the proper maintenance interval.

A water temperature regulator that fails in a partially opened position can cause overheating or overcooling of the engine.

A water temperature regulator that fails in the closed position can cause excessive overheating. Excessive overheating could result in cracking of the cylinder head or piston seizure problems.

A water temperature regulator that fails in the open position will cause the engine operating temperature to be too low during partial load operation. Low engine operating temperatures during partial loads could cause an excessive carbon buildup inside the cylinders. This excessive carbon buildup could result in an accelerated wear of the piston rings and wear of the cylinder liner.

NOTICE
Failure to replace your water temperature regulator on a regularly scheduled basis could cause severe engine damage.

Caterpillar engines incorporate a shunt design cooling system and require operating the engine with a water temperature regulator installed.

If the water temperature regulator is installed incorrectly, the engine may overheat, causing cylinder head damage. Ensure that the new water temperature regulator is installed in the original position. Ensure that the water temperature regulator vent hole is open.

Do not use liquid gasket material on the gasket or cylinder head surface.

Refer to two articles in the Disassembly and Assembly Manual, “Water Temperature Regulators - Remove and Water Temperature Regulators - Install” for the replacement procedure of the water temperature regulator. For additional information refer to this Operation and Maintenance Manual, “Fluid Recommendations” or consult your Cat dealer.

Note: If only the water temperature regulators are replaced, drain the coolant from the cooling system to a level that is below the water temperature regulator housing.

i07232094

Cooling System Supplemental Coolant Additive (SCA) - Test/Add

SMCS Code: 1352-045; 1395-081

⚠ WARNING

Cooling system coolant additive contains alkali. To help prevent personal injury, avoid contact with the skin and eyes. Do not drink cooling system coolant additive.

NOTICE
Excessive supplemental coolant additive concentration can form deposits on the higher temperature surfaces of the cooling system, reducing the engine's heat transfer characteristics. Reduced heat transfer could cause cracking of the cylinder head and other high temperature components.

Excessive supplemental coolant additive concentration could also result in blockage of the heat exchanger, overheating, and/or accelerated wear of the water pump seal.

Do not exceed the recommended amount of supplemental coolant additive concentration.

This maintenance procedure is required for conventional coolants such as DEAC.**Do not perform this maintenance for cooling systems that are filled with Cat Extended Life Coolant (Cat ELC) or Cat Extended Life Inhibitor (Cat ELI).**

Note: Caterpillar recommends an S·O·S coolant analysis (Level 1).

NOTICE
Do NOT mix brands or types of SCA. Do NOT mix SCAs and extenders.

Failure to follow the recommendations can result in shortened cooling system component life.

NOTICE
Use Only Approved SCAs. Conventional coolants require the maintenance addition of SCA throughout their expected life. Do NOT use an SCA with a coolant unless specifically approved by the coolant supplier for use with their coolant. It is the responsibility of the coolant manufacturer to ensure compatibility and acceptable performance.

Failure to follow the recommendations can result in shortened cooling system component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Cat Dealer Service Tool Catalog” and to Special Publication, GECJ0003, “Cat Shop Supplies and Tools” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to applicable regulations and mandates.

Note: Caterpillar recommends that an S·O·S Coolant Analysis (Level 1) is performed to check the concentration of SCA.

Maintain the Proper Concentration of SCA in the Coolant

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Remove the cooling system filler cap slowly.
2. Test the concentration of the SCA with a 286-2578 Nitrite Test Strip or review the results of the S·O·S Coolant Analysis (Level 1).
3. If necessary, drain some coolant to allow space for the addition of the SCA.
4. Add the amount of SCA required to maintain a concentration of 3 percent to 6 percent SCA in the coolant.
5. Clean the cooling system filler cap. Install the cooling system filler cap.

For further information, refer to Special Publication, SEBU6251, “Cat Commercial Diesel Engine Fluids Recommendations”.

For information on Cat coolant conditioner for aluminum components, refer to Special Instruction, REHS7296, “Instructions for Use of Cat Coolant Conditioner for Aluminum Components”.

i06194219

Crankshaft Vibration Damper - Inspect

SMCS Code: 1205-040

The crankshaft vibration damper limits the torsional vibration of the crankshaft. The visconic damper has a weight that is located inside a fluid filled case.

Damage to the crankshaft vibration damper or failure of the damper can increase torsional vibrations. This vibration can result in damage to the crankshaft and to other engine components. A deteriorating damper can cause excessive torsional vibrations.

A damper that is hot may be the result of excessive torsional vibration, worn bearings, or damage to the damper. Use an infrared thermometer to monitor the temperature of the damper during operation. Follow the instructions that are included with the infrared thermometer. If the temperature reaches 100°C (212 °F), consult your Cat dealer.

Inspect the damper for evidence of dents, cracks, and leaks of the fluid.

If a fluid leak is found, determine the type of fluid. The fluid in the damper is silicone. Silicone has the following characteristics: transparent, viscous and smooth.

If the fluid leak is oil, inspect the crankshaft seals for leaks. If a leak is observed, replace all of the seals.

Inspect the damper and repair or replace the damper for any of the following reasons.

- The damper is dented, cracked, or leaking.
- The paint on the damper is discolored from heat.
- The engine has had a failure because of a broken crankshaft.
- The crankshaft bearings are showing excessive wear.
- There is a large amount of gear train wear that is not caused by a lack of oil.

Dampers With Sampling Ports

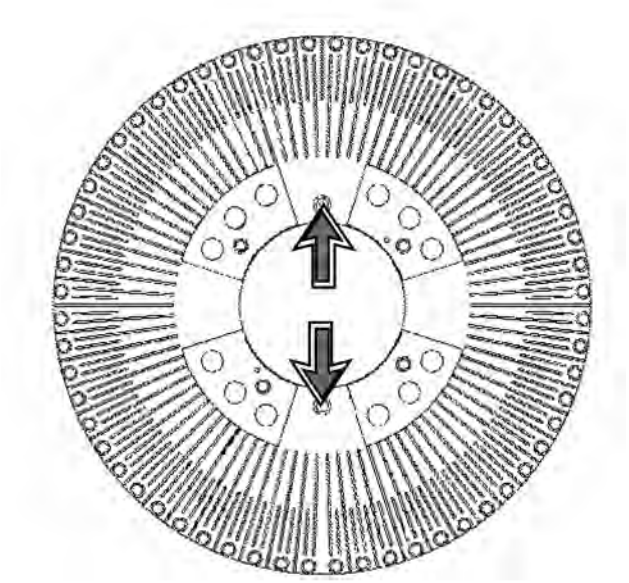

Illustration 51 g03845581

Some dampers have ports for fluid samples. If the damper has no external damage, collect a sample of the damper fluid. The fluid should be analyzed in order to check for a loss of viscosity. Use the results of the analysis to determine if the damper should be rebuilt or replaced. Kits for fluid samples are available from the address that follows. Return the kits to the same address for analysis.

Hasse & Wrede GmbH
Georg-Knorr-Straße 4
12681 Berlin
Germany
Phone +49 30 9392-3135
Fax +49 30 9392-7-3135
Alternate phone +49 30 9392-3156
Alternate fax +49 30 9392-7-3156

The typical limit for the degradation of the damper fluid viscosity that is used by Hasse & Wrede GmbH is 20 percent for most applications. The reports from Hasse & Wrede should indicate that the fluid samples meet this viscosity limit.

Dampers Without Sampling Ports

Some dampers do not have a port for a fluid sample. These dampers must be rebuilt or the dampers must be replaced when one of the following criteria has been met:

- The damper has been operated for 20000 hours.
- The engine is undergoing a major overhaul.

Removal and Installation

Refer to the Disassembly and Assembly Manual, “Vibration Damper - Remove and Install” article or consult your Cat dealer for information about damper replacement.

i06684431

Electrical Connections - Check

SMCS Code: 4459-535

Check all exposed electrical connections for tightness.

Check the following devices for loose mounting or physical damage:

- transformers
- fuses
- capacitors
- lightning arrestors
- ground cables and surface connections

Check all lead wires and electrical connections for proper clearance.

i02062908

Engine - Clean

SMCS Code: 1000-070

⚠ WARNING

Personal injury or death can result from high voltage.

Moisture could create paths of electrical conductivity.

Make sure the unit is off line (disconnected from utility and/or other generators), locked out and tagged "Do Not Operate".

NOTICE
Water or condensation can cause damage to generator components. Protect all electrical components from exposure to water.

NOTICE
Accumulated grease and oil on an engine is a fire hazard. Keep the engine clean. Remove debris and fluid spills whenever a significant quantity accumulates on the engine.

Steam cleaning the engine will remove accumulated oil and grease. A clean engine provides the following benefits:

- Easy detection of fluid leaks
- Maximum heat transfer characteristics
- Ease of maintenance

NOTICE
Water and/or condensation can cause damage to electrical components. Protect all electrical components from exposure to water.

Note: For more information on cleaning and drying electric generators, refer to Special Instruction, SEHS9124, “Cleaning and Drying of Electric Set Generators”.

i04564842

Engine Air Cleaner Element (Dual Element) - Inspect/Clean/Replace

SMCS Code: 1051; 1054-040; 1054-070; 1054-510

NOTICE
Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent airborne debris from entering the air inlet.

NOTICE
Never service the air cleaner element with the engine running since this will allow dirt to enter the engine.

Servicing the Air Cleaner Elements

If the air cleaner element becomes plugged, the air can split the material of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear. Your Cat dealer has the proper air cleaner elements for your application. Consult your Cat dealer for the correct air cleaner element.

- Check the precleaner (if equipped) daily for accumulation of dirt and debris. Remove any dirt and debris, as needed.
- Operating conditions (dust, dirt, and debris) may require more frequent service of the air cleaner element.
- The air cleaner element may be cleaned up to six times if the element is properly cleaned and inspected.
- The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Replace the dirty paper air cleaner elements with clean air cleaner elements. Before installation, thoroughly check the air cleaner elements for tears and/or holes in the filter material. Inspect the gasket or the seal of the air cleaner element for damage. Maintain a supply of suitable air cleaner elements for replacement purposes.

Dual Element Air Cleaners

The dual element air cleaner contains a primary air cleaner element and a secondary air cleaner element. The primary air cleaner element can be used up to six times if the element is properly cleaned and inspected. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

The secondary air cleaner element is not serviceable or washable. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element. When the engine is operating in environments that are dusty or dirty, air cleaner elements may require more frequent replacement.

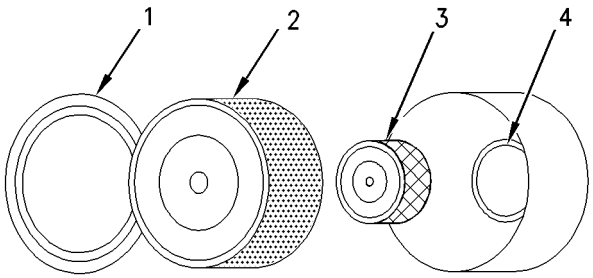

Illustration 52 g00736431

(1) Cover
(2) Primary air cleaner element
(3) Secondary air cleaner element
(4) Turbocharger air inlet

1. Remove the cover. Remove the primary air cleaner element.
2. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element.

Note: Refer to “Cleaning the Primary Air Cleaner Elements”.

3. Cover the turbocharger air inlet with tape in order to keep out dirt.
4. Clean the inside of the air cleaner cover and body with a clean, dry cloth.
5. Remove the tape for the turbocharger air inlet. Install the secondary air cleaner element. Install a primary air cleaner element that is new or cleaned.
6. Install the air cleaner cover.
7. Reset the air cleaner service indicator.

Cleaning the Primary Air Cleaner Elements

NOTICE
Caterpillar recommends certified air filter cleaning services that are available at Cat dealers. The Cat cleaning process uses proven procedures to assure consistent quality and sufficient filter life.

Observe the following guidelines if you attempt to clean the filter element:

Do not tap or strike the filter element in order to remove dust.

Do not wash the filter element.

Use low pressure compressed air in order to remove the dust from the filter element. Air pressure must not exceed 207 kPa (30 psi). Direct the air flow up the pleats and down the pleats from the inside of the filter element. Take extreme care in order to avoid damage to the pleats.

Do not use air filters with damaged pleats, gaskets, or seals. Dirt entering the engine will cause damage to engine components.

The primary air cleaner element can be used up to six times if the element is properly cleaned and inspected. When the primary air cleaner element is cleaned, check for rips or tears in the filter material. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Use clean primary air cleaner elements while dirty elements are being cleaned.

NOTICE
Do not clean the air cleaner elements by bumping or tapping. This could damage the seals. Do not use elements with damaged pleats, gaskets or seals. Damaged elements will allow dirt to pass through. Engine damage could result.

Visually inspect the primary air cleaner elements before cleaning. Inspect the air cleaner elements for damage to the seal, the gaskets, and the outer cover. Discard any damaged air cleaner elements.

There are two common methods that are used to clean primary air cleaner elements:

- Pressurized air
- Vacuum cleaning

Pressurized Air

Pressurized air can be used to clean primary air cleaner elements that have not been cleaned more than two times. Pressurized air will not remove deposits of carbon and oil. Use filtered, dry air with a maximum pressure of 207 kPa (30 psi).

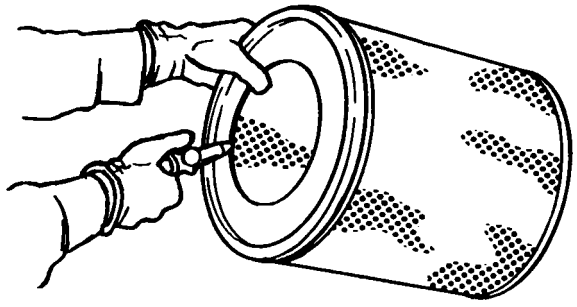

Illustration 53 g00281692

Note: When the primary air cleaner elements are cleaned, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

Aim the hose so that the air flows inside the element along the length of the filter. This procedure will prevent damage to the paper pleats. Do not aim the stream of air directly at the primary air cleaner element. Dirt could be forced further into the pleats.

Note: Refer to “Inspecting the Primary Air Cleaner Elements”.

Vacuum Cleaning

Vacuum cleaning is a good method for cleaning primary air cleaner elements which require daily cleaning because of a dry, dusty environment. Cleaning with pressurized air is recommended prior to vacuum cleaning. Vacuum cleaning will not remove deposits of carbon and oil.

Note: Refer to “Inspecting the Primary Air Cleaner Elements”.

Inspecting the Primary Air Cleaner Elements

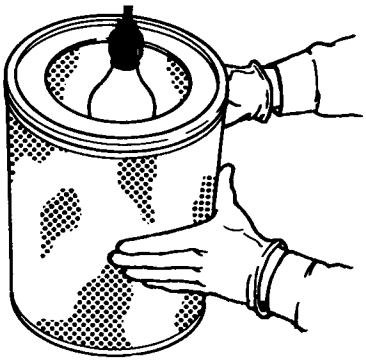

Illustration 54 g00281693

Inspect the clean, dry primary air cleaner element. Use a 60 W clear light in a dark room or in a similar facility. Place the light in the primary air cleaner element. Rotate the primary air cleaner element. Inspect the primary air cleaner element for tears and/or holes. Inspect the primary air cleaner element for light that may show through the filter material. If necessary, to confirm the result, compare the primary air cleaner element to a new air cleaner element that has the same part number.

Do not use a primary air cleaner element that has any tears and/or holes in the filter material. Do not use a primary air cleaner element with damaged pleats, gaskets, or seals. Discard damaged primary air cleaner elements.

Storing Primary Air Cleaner Elements

If a primary air cleaner element that passes inspection will not be used, the primary air cleaner element can be stored for future use.

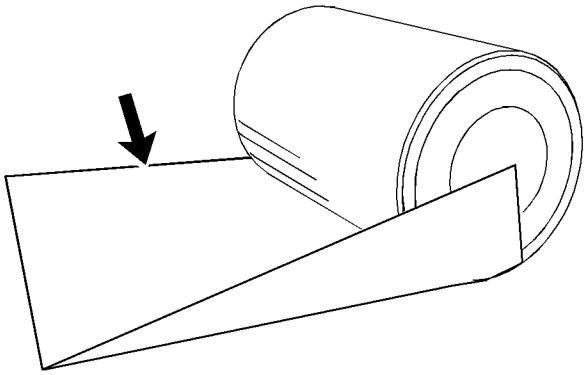

Illustration 55 g02595738
Typical example

Do not use paint, a waterproof cover, or plastic as a protective covering for storage. An airflow restriction may result. To protect against dirt and damage, wrap the primary air cleaner elements in Volatile Corrosion Inhibited (VCI) paper.

Place the primary air cleaner element into a box for storage. For identification, mark the outside of the box and mark the primary air cleaner element. Include the following information:

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

i04564858

Engine Air Cleaner Element (Single Element) - Inspect/ Clean/Replace

SMCS Code: 1051; 1054-040; 1054-070; 1054-510

NOTICE
Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent airborne debris from entering the air inlet.

NOTICE
Never service the air cleaner element with the engine running since this will allow dirt to enter the engine.

Servicing the Air Cleaner Elements

If the air cleaner element becomes plugged, the air can split the material of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear. Your Cat dealer has the proper air cleaner elements for your application. Consult your Cat dealer for the correct air cleaner element.

- Check the precleaner (if equipped) daily for accumulation of dirt and debris. Remove any dirt and debris, as needed.
- Operating conditions (dust, dirt, and debris) may require more frequent service of the air cleaner element.
- The air cleaner element may be cleaned up to six times if the element is properly cleaned and inspected.
- The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Replace the dirty paper air cleaner elements with clean air cleaner elements. Before installation, thoroughly check the air cleaner elements for tears and/or holes in the filter material. Inspect the gasket or the seal of the air cleaner element for damage. Maintain a supply of suitable air cleaner elements for replacement purposes.

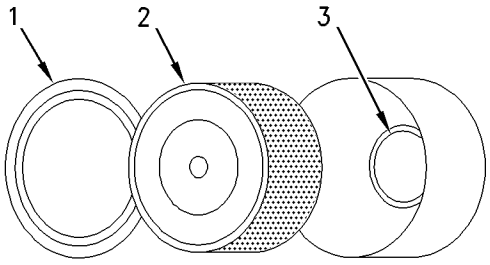

Illustration 56 g00735127
(1) Cover
(2) Air cleaner element
(3) Turbocharger air inlet

1. Remove the air cleaner cover. Remove the air cleaner element.

Note: Refer to “Cleaning the Air Cleaner Elements”.

2. Cover the air inlet with tape in order to keep out dirt.

3. Clean the inside of the air cleaner cover and body with a clean, dry cloth.

4. Remove the tape for the air inlet. Install an air cleaner element that is new or cleaned.

5. Install the air cleaner cover.

6. Reset the air cleaner service indicator.

Cleaning the Air Cleaner Elements

NOTICE
Caterpillar recommends certified air filter cleaning services that are available at Cat dealers. The Cat cleaning process uses proven procedures to assure consistent quality and sufficient filter life.

Observe the following guidelines if you attempt to clean the filter element:

Do not tap or strike the filter element in order to remove dust.

Do not wash the filter element.

Use low pressure compressed air in order to remove the dust from the filter element. Air pressure must not exceed 207 kPa (30 psi). Direct the air flow up the pleats and down the pleats from the inside of the filter element. Take extreme care in order to avoid damage to the pleats.

Do not use air filters with damaged pleats, gaskets, or seals. Dirt entering the engine will cause damage to engine components.

The air cleaner element can be used up to six times if the element is properly cleaned and inspected. When the air cleaner element is cleaned, check for rips or tears in the filter material. The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Use clean air cleaner elements while dirty elements are being cleaned.

NOTICE
Do not clean the air cleaner elements by bumping or tapping. This could damage the seals. Do not use elements with damaged pleats, gaskets or seals. Damaged elements will allow dirt to pass through. Engine damage could result.

Visually inspect the air cleaner elements before cleaning. Inspect the air cleaner elements for damage to the seal, the gaskets, and the outer cover. Discard any damaged air cleaner elements.

There are two common methods that are used to clean air cleaner elements:

- Pressurized air
- Vacuum cleaning

Pressurized Air

Pressurized air can be used to clean air cleaner elements that have not been cleaned more than two times. Pressurized air will not remove deposits of carbon and oil. Use filtered, dry air with a maximum pressure of 207 kPa (30 psi).

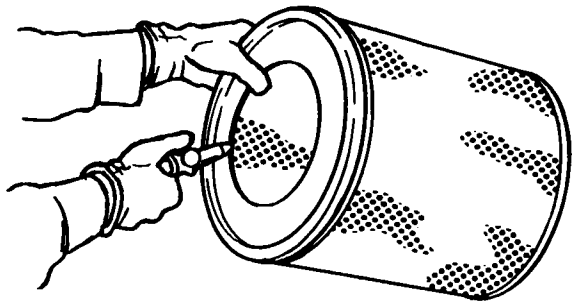

Illustration 57 g00281692

Note: When the air cleaner elements are cleaned, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

Aim the hose so that the air flows inside the element along the length of the filter. This procedure will prevent damage to the paper pleats. Do not aim the stream of air directly at the air cleaner element. Dirt could be forced further into the pleats.

Note: Refer to “Inspecting the Air Cleaner Elements”.

Vacuum Cleaning

Vacuum cleaning is a good method for cleaning air cleaner elements which require daily cleaning because of a dry, dusty environment. Cleaning with pressurized air is recommended prior to vacuum cleaning. Vacuum cleaning will not remove deposits of carbon and oil.

Note: Refer to “Inspecting the Air Cleaner Elements”.

Inspecting the Air Cleaner Elements

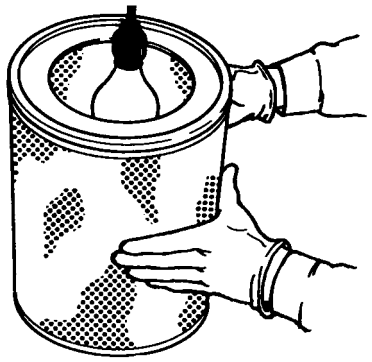

Illustration 58 g00281693

Inspect the clean, dry air cleaner element. Use a 60 W clear light in a dark room or in a similar facility. Place the light in the air cleaner element. Rotate the air cleaner element. Inspect the air cleaner element for tears and/or holes. Inspect the air cleaner element for light that may show through the filter material. If necessary, to confirm the result, compare the air cleaner element to a new air cleaner element that has the same part number.

Do not use an air cleaner element that has any tears and/or holes in the filter material. Do not use an air cleaner element with damaged pleats, gaskets, or seals. Discard damaged air cleaner elements.

Storing Air Cleaner Elements

If an air cleaner element that passes inspection will not be used, the air cleaner element can be stored for future use.

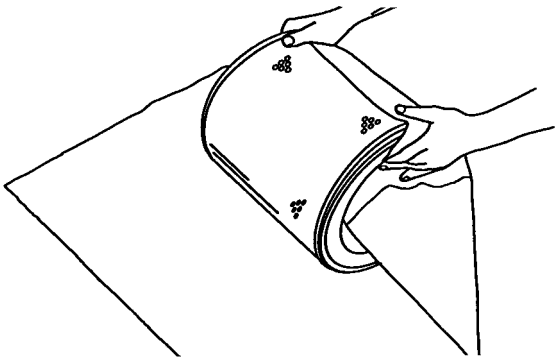

Illustration 59 g00281694

Do not use paint, a waterproof cover, or plastic as a protective covering for storage. An airflow restriction may result. To protect against dirt and damage, wrap the air cleaner elements in Volatile Corrosion Inhibited (VCI) paper.

Place the air cleaner element into a box for storage. For identification, mark the outside of the box and mark the air cleaner element. Include the following information:

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

i03212992

Engine Air Cleaner Service Indicator - Inspect

SMCS Code: 7452-040

A service indicator may be mounted on the air cleaner element or in a remote location.

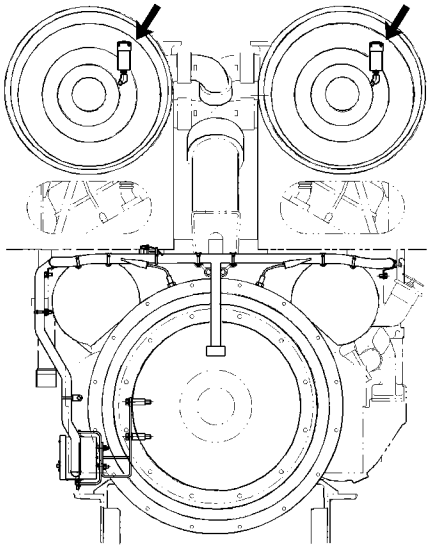

Illustration 60 g01640335

A typical location for the air cleaner service indicators

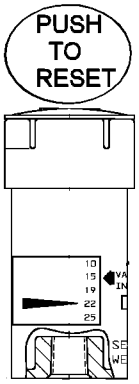

Illustration 61 g01640336

Typical air cleaner service indicator

Some engines may be equipped with a different service indicator.

Observe the service indicator. Clean the air cleaner element or replace the air cleaner element when the following conditions occur:

- The yellow diaphragm enters the red zone.
- The red piston locks in the visible position.
- The air restriction reaches 6 kPa (25 inches of H_2O).

Test the Service Indicator

Service indicators are important instruments.

- Check for ease of resetting. The service indicator should reset in less than three pushes.
- Check the movement of the yellow core when the engine is accelerated to the engine rated rpm. The yellow core should latch approximately at the greatest vacuum that is attained.

If the service indicator does not reset easily, or if the yellow core does not latch at the greatest vacuum, the service indicator should be replaced. If the new service indicator will not reset, the fitting for the service indicator may be plugged.

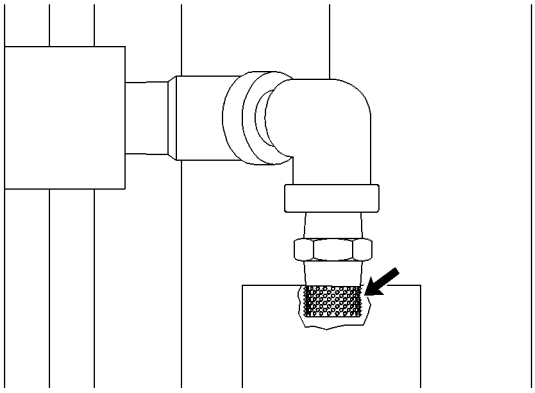

Illustration 62 g00351792

Porous filter

A porous filter is part of a fitting that is used for mounting of the service indicator. Inspect the filter for cleanliness. Clean the filter, if necessary. Use compressed air or a clean, nonflammable solvent.

The service indicator may need to be replaced frequently in environments that are severely dusty, if necessary. Replace the service indicator annually regardless of the operating conditions. Replace the service indicator when the engine is overhauled, and whenever major engine components are replaced.

Note: When a new service indicator is installed, excessive force may crack the top of the service indicator. Tighten the service indicator to a torque of 2 N·m (18 lb in).

i07140883

Engine Crankcase Breather - Clean/Replace

SMCS Code: 1317-510; 1317-070

Engine Crankcase Breather

If the crankcase breather is not maintained regularly, the crankcase breather will become plugged. A plugged crankcase breather will cause excessive crankcase pressure that may cause crankshaft seal leakage.

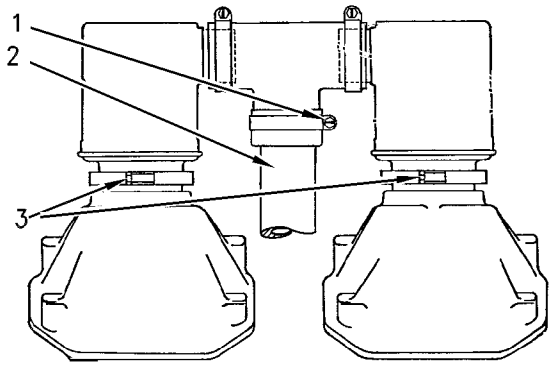

Illustration 63 g00597463

1. Loosen clamp (1). Slide the clamp down on tube (2).

2. Loosen clamps (3). Remove both breathers as a unit.

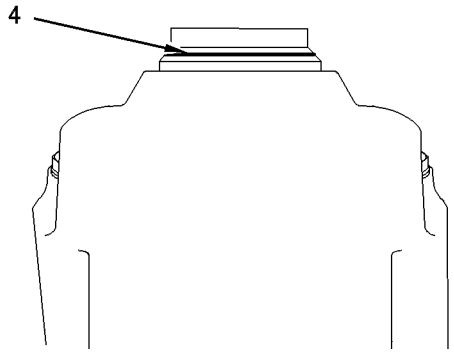

Illustration 64 g00597465

3. Remove O-ring seals (4) from the valve covers. Inspect the O-ring seals for good condition. Obtain new O-ring seals, if necessary.

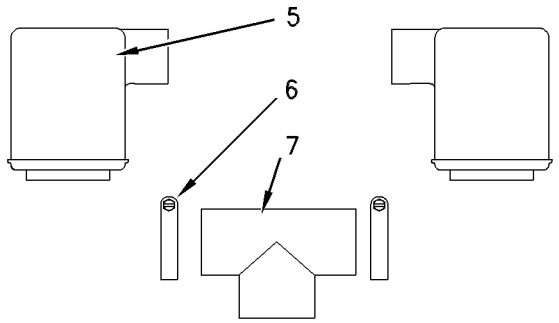

Illustration 65 g00597466

4. Remove two clamps (6). Remove both breathers (5) from hose tee (7).

Inspect the hose tee for cracks. If the tee is cracked, discard the old tee and obtain a new tee for installation.

5. Turn the breathers upside-down to inspect the condition of the breather elements.

Clean the breather elements with clean, nonflammable solvent. If the breather elements remain contaminated after the cleaning, discard the breathers and obtain new breathers. Do not attempt to disassemble the breathers.

Allow the breather elements to dry before installation.

Note: Coat the rubber parts with clean engine oil or petroleum jelly to provide easier installation.

6. Place clamps (6) over the parts of hose tee (7) that will receive breathers (5). Install the breathers into the tee. Tighten the clamps to the torque that is listed in the Service Manual, “Specifications”.

7. Coat O-ring seals (4) with clean engine oil. Place the O-ring seals on the valve covers.

8. Place clamps (3) around the parts of the breathers that will be attached to the valve covers. Install both breathers as a unit. Tighten the clamps.

9. Place clamp (1) on the part of the hose tee that will receive tube (2). Install the tube into the hose tee. Tighten the clamp to the torque that is listed in the Service Manual, “Specifications”.

Open Crankcase Ventilation (OCV) System - (If Equipped)

The OCV system is an optional high-efficiency fumes disposal system utilizing a separator assembly that is non-serviceable. For more information, refer to Systems Operation, Testing and Adjusting, M0082965.

i04605029

Engine Mounts - Inspect

SMCS Code: 1152-040; 1152

Misalignment of the engine and the driven equipment will cause extensive damage. Excessive vibration can lead to misalignment. Excessive vibration of the engine and the driven equipment can be caused by the following conditions:

- Improper mounting
- Loose bolts
- Deterioration of the isolators

Ensure that the mounting bolts are tightened to the proper torque. For standard torques, see Specifications, SENR3130, “Torque Specifications”.

Ensure that the isolators are free of oil and contamination. Inspect the isolators for deterioration. Ensure that the bolts for the isolators are tightened to the proper torque.

Replace any isolator that shows deterioration. For more information, see the literature that is provided by the OEM of the isolators. Also see the Application and Installation Guide for the engine. Consult your Cat dealer for assistance.

i07140177

Engine Oil Level - Check

SMCS Code: 1348-535-FLV

The most accurate check of the oil level is performed when the engine is stopped. Perform this maintenance on a surface that is as level as possible.

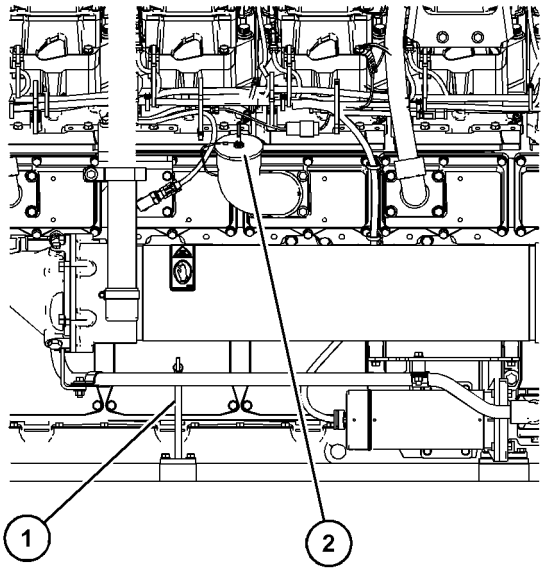

Illustration 66 g06233786

(1) Engine oil level gauge
(2) Engine oil filler

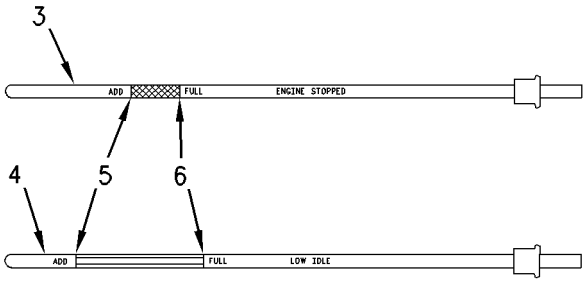

Illustration 67 g00736607

(3) “ENGINE STOPPED” side. (4) “LOW IDLE” side. (5) “ADD” mark. (6) “FULL” mark.

1. Ensure that oil level gauge (2) is seated.

a. If the engine is stopped, remove oil level gauge (2). Observe the oil level on “ENGINE STOPPED” side (3). The oil level should be between “ADD” mark (5) and “FULL” mark (6).

b. If the engine is operating, reduce the engine speed to low idle. Remove oil level gauge (2) and observe the oil level on “LOW IDLE” side (4). The oil level should be between “ADD” mark (5) and “FULL” mark (6).

NOTICE
Operating your engine when the oil level is above the “FULL” mark could cause your crankshaft to dip into the oil. The air bubbles created from the crankshaft dipping into the oil reduces the oil's lubricating characteristics and could result in the loss of power or engine failure.

2. If necessary, remove oil filler cap (1) and add oil. For the correct oil to use, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic in the Maintenance Section. Do not fill the crankcase above “FULL” mark (6). Clean the oil filler cap. Install the oil filler cap.

i04237495

Engine Oil Sample - Obtain

SMCS Code: 1348-554-SM

In addition to a good preventive maintenance program, Caterpillar recommends using S·O·S oil analysis at regularly scheduled intervals. S·O·S oil analysis provides infrared analysis, which is required for determining nitration and oxidation levels.

Obtain the Sample and the Analysis

⚠ WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Before you take the oil sample, complete the Label, PEEP5031 for identification of the sample. In order to help obtain the most accurate analysis, provide the following information:

- Engine model
- Service hours on the engine
- The number of hours that have accumulated since the last oil change
- The amount of oil that has been added since the last oil change

To ensure that the sample is representative of the oil in the crankcase, obtain a warm, mixed oil sample.

To avoid contamination of the oil samples, the tools and the supplies that are used for obtaining oil samples must be clean.

Caterpillar recommends using the sampling valve in order to obtain oil samples. The quality and the consistency of the samples are better when the sampling valve is used. The location of the sampling valve allows oil that is flowing under pressure to be obtained during normal engine operation.

The 169-8373 Fluid Sampling Bottle is recommended for use with the sampling valve. The fluid sampling bottle includes the parts that are needed for obtaining oil samples. Instructions are also provided.

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

If the engine is not equipped with a sampling valve, use the 1U-5718 Vacuum Pump. The pump is designed to accept sampling bottles. Disposable tubing must be attached to the pump for insertion into the sump.

For instructions, see Special Publication, PEGJ0047, “How To Take A Good S·O·S Oil Sample”. Consult your Cat dealer for complete information and assistance in establishing an S·O·S program for your engine.

i07140199

Engine Oil and Filter - Change

SMCS Code: 1318-510

The oil change interval will be affected by the following items:

- Engine application
- Size of the oil sump
- Fuel type
- Oil type
- Ambient air conditions
- Air/fuel ratio

The S·O·S oil analysis program analyzes used oil to determine if the oil change interval is suitable for your specific engine. In the absence of S·O·S oil analysis, change the engine oil and engine oil filters according to the service interval. The service interval is listed in this Operation and Maintenance Manual, “Maintenance Interval Schedule”.

⚠ WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Drain the Oil

Do not drain the oil when the engine is cold. As the oil cools, suspended waste particles settle on the bottom of the oil pan. The waste particles are not removed when the cold oil is drained. Drain the crankcase when the oil is warm. This method allows proper draining of the waste particles that are suspended in the oil.

Failure to follow this recommended procedure will allow the waste particles to be recirculated through the engine lubrication system with the new oil.

1. After the engine has been operated at normal operating temperature, STOP the engine.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Dealer Service Tool Catalog” for tools and supplies suitable to collect and contain fluids on Cat ® products.

Dispose of all fluids according to local regulations and mandates.

2. Drain the oil according to the equipment on the engine.

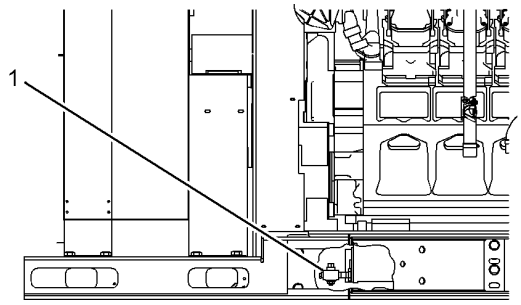

Illustration 68 g01410768

(1) Oil drain

a. Open oil drain (1). After the oil has drained, close the oil drain.

b. If a suction device is inserted into the oil pan, ensure that the suction device is clean. This procedure will prevent dirt from entering into the oil pan. Be careful not to strike the engine oil suction tubes or the piston cooling jets.

c. If a suction device that attaches to the oil drain is used, ensure that the suction device is clean. Attach the suction device to the oil drain. Open the oil drain. After the oil has drained, close the oil drain and remove the suction device.

d. If the oil drain valve has a “quick connect” coupling, attach the coupling. Open the drain valve to drain the crankcase. After the oil has drained, close the drain valve. Disconnect the coupling.

3. Replace the engine oil filter elements before you fill the crankcase with new oil.

Replace the Oil Filter Elements

Replace the engine oil filters when any of the following conditions occur:

- Every oil change
- The engine oil filter differential pressure reaches 150 kPa (22 psi).

Note: Do not attempt to clean the used oil filters. Used oil filters will retain waste particles. The used oil filters would not filter the oil properly.

Service tools are available to aid in the service of oil filters. Consult your Caterpillar dealer for the part names and the part numbers. Follow the instructions that are supplied with the service tools. If the service tools are not used, perform the following appropriate procedure.

Replacing the Engine Oil Filters With the Engine Stopped

Perform the following procedure after the oil has been drained.

Note: Use this procedure if the engine oil filters do not have a control valve.

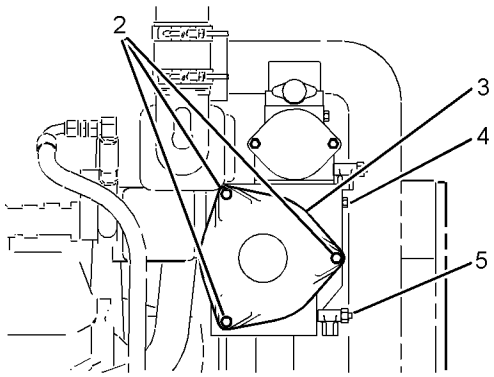

Illustration 69 g01410770

(2) Bolts
(3) Cover
(4) Plug
(5) Drain valve

Note: Drain the oil into a suitable container. Dispose of the oil according to local regulations.

1. Connect a hose to drain (1). Place the other end of the hose into a suitable container to collect the oil.

2. Open drain valve (5). Remove plug (4). Allow the oil to drain. Clean the plug and install the plug. Close the drain valve. Remove the hose from the drain.

Note: Some oil will remain in the housing after the oil has been drained. This oil will pour out of the housing when cover (3) is removed. Prepare to catch the oil in a suitable container. Clean up any spilled oil with absorbent towels or pillows. DO NOT use absorbent particles to clean up the oil.

⚠ WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

3. The oil filter may contain a spring behind the cover. Be alert to the spring force. Gradually loosen but do not remove bolts (2). Before you remove the bolts, pry the cover (3) loose or tap the cover with a rubber mallet to relieve any spring pressure. Remove cover (3).

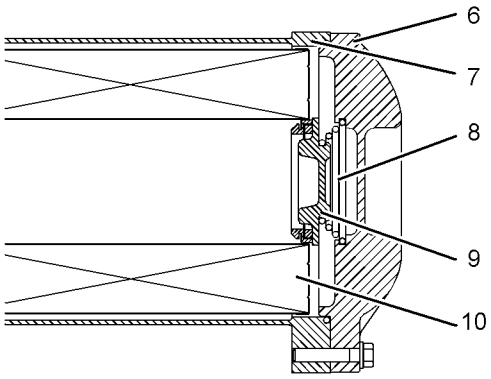

Illustration 70 g01410771

Section view of the engine oil filter

(6) Cover
(7) O-ring seal
(8) Spring
(9) Retainer
(10) Oil filter element

4. Remove cover (6) and spring (8). Remove O-ring seal (7), retainer (9), and oil filter elements (10).

5. Clean cover (6), spring (8), O-ring seal (7), and retainer (9). Clean theinside theoil filter housing.

NOTICE
Caterpillar oil filters are built to Caterpillar specifications. Use of an oil filter not recommended by Caterpillar could result in severe engine damage to the engine bearings, crankshaft, etc., as a result of the larger waste particles from unfiltered oil entering the engine lubricating system. Only use oil filters recommended by Caterpillar.

6. Ensure that the new oil filter elements are in good condition. Install the new oil filter elements.

7. Inspect the O-ring seal (7). Ensure that the surfaces for the O-ring seal are clean. Install a new O-ring seal if the old O-ring seal is damaged or deteriorated.

8. Install retainer (9), spring, (8) and cover (6). Ensure that the retainer and the spring are properly seated between the oil filter elements and the cover.

9. Start the engine according to this Operation and Maintenance Manual, “Starting The Engine” procedure (Operation Section). Check for oil leaks.

Replacing the Engine Oil Filters During Engine Operation

If the engine is equipped with duplex oil filters, the engine oil filter elements can be changed while the engine is operation. This procedure is useful if the oil filter elements require more frequent replacement than the engine oil.

⚠ WARNING

If the filter is changed during rapid air movement, an explosive vapor may be created. The explosive vapor may result in personal injury or in death.

If rapid air movement exists, stop the engine in order to change the filter.

⚠ WARNING

Filter contains hot pressurized fluid when engine is running.

Follow instructions on control valve to avoid personal injury.

1. Move the control valve to the “AUX RUN” position to change the main oil filter elements. Move the selector valve to the “MAIN RUN” position to change the auxiliary oil filter elements.

2. Allow the oil pressure gauge for the oil filter that is being changed to reach a “ZERO” pressure reading.

3. Perform Step 1 through Step 8 of “Replacing the Engine Oil Filters With the Engine Stopped”.

4. Open the “FILL” valve for a minimum of 5 minutes to fill the new oil filter elements.

5. Close the “FILL” valve. Rotate the control valve to the “RUN” position for the oil filter that was serviced.

Inspect the Used Oil Filter Elements

Cut the used oil filter element open with a utility knife. Remove the metal wrap. Cut the filter element free from the end caps. Spread apart the pleats and inspect the element for metal debris. An excessive amount of debris in the element indicates possible wear or a pending failure.

Use a magnet to differentiate between the ferrous metals and the nonferrous metals that are found in the element. Ferrous metals indicate possible wear on the steel and the cast iron parts of the engine. Nonferrous metals indicate possible wear on the aluminum parts, the brass parts, or the bronze parts of the engine. Parts that may be affected include the following components: main bearings, rod bearings, turbocharger bearings, and cylinder heads.

Aluminum debris may indicate problems with the bearings of the front gears. If aluminum debris is found, inspect the crankshaft vibration damper and the bearings of the front idler gear.

Due to normal wear and friction, finding small amounts of debris in the oil filter element is not uncommon. If an excessive amount of debris is found in the oil filter element, consult your Cat dealer to arrange for further oil analysis.

Fill the Crankcase

NOTICE
Only use oils that are recommended by Caterpillar. For the proper oil to use, refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic (Maintenance Section).

NOTICE
If the engine is equipped with an auxiliary oil filter system, extra oil must be added when filling the crankcase. If equipped with an auxiliary oil filter system that is not supplied by Caterpillar, follow the recommendations of the OEM.

NOTICE
Engine damage can occur if the crankcase is filled above the “FULL” mark on the oil level gauge (dipstick).

An overfull crankcase can cause the crankshaft to dip into the oil. This will reduce the power that is developed and also force air bubbles into the oil. These bubbles (foam) can cause the following problems: reduction of the oil's ability to lubricate, reduction of oil pressure, inadequate cooling, oil blowing out of the crankcase breathers and excessive oil consumption.

Excessive oil consumption will cause deposits to form on the pistons and in the combustion chamber. Deposits in the combustion chamber lead to the following problems: guttering of the valves, packing of carbon under the piston rings and wear of the cylinder liner.

If the oil level is above the “FULL” mark on the oil level gauge, drain some of the oil immediately.

1. Remove the oil filler cap. Fill the crankcase through the oil filler tube only. For the amount of oil to use, refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” (Maintenance Section). Clean the oil filler cap. Install the oil filler cap.

NOTICE
To prevent engine damage, crank engine with fuel off to fill all filters before starting.

Do Not crank engine for more than 30 seconds.

2. Close the fuel supply line and crank the engine until the oil pressure gauge indicates 70 kPa (10 psi). Open the fuel supply line. Allow the starting motor to cool for 2 minutes before cranking again.

3. Follow this Operation and Maintenance Manual, “Starting The Engine” procedure (Operation Section). Operate the engine at low idle for 2 minutes. This procedure will ensure that the lubrication system has oil and that the oil filters are filled with oil. Inspect the engine for oil leaks. Ensure that the oil level is at the “FULL” mark on the “LOW IDLE” side of the oil level gauge.

4. Stop the engine and allow the oil to drain back into the sump for a minimum of 10 minutes.

5. Remove the oil level gauge and check the oil level. Maintain the oil level to the “FULL” mark on the “ENGINE STOPPED” side of the oil level gauge.

i05264151

Engine Protective Devices - Check

SMCS Code: 7400-535

Alarms and shutoffs must function properly. Alarms provide timely warning to the operator. Shutoffs help to prevent damage to the engine. Determining if the engine protective devices are in good working order during normal operation is impossible. Malfunctions must be simulated in order to test the engine protective devices.

A calibration check of the engine protective devices will ensure that the alarms and shutoffs activate at the setpoints. Ensure that the engine protective devices are functioning properly.

NOTICE
During testing, abnormal operating conditions must be simulated.

The tests must be performed correctly in order to prevent possible damage to the engine.

To prevent damage to the engine, only authorized service personnel or your Cat dealer should perform the tests.

Visual Inspection

Visually check the condition of all gauges, sensors, and wiring. Look for wiring and components that are loose, broken, or damaged. Damaged wiring or components should be repaired or replaced immediately.

i03457267

Engine Speed/Timing Sensor - Clean/Inspect

SMCS Code: 1905-040; 1905-070; 1907-040; 1907-070

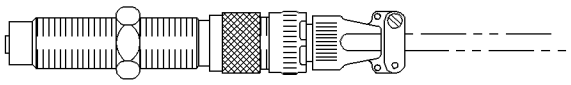

Illustration 71 g00293337
Typical speed sensor

1. Remove the speed sensor from the flywheel housing. Check the condition of the end of the speed sensor. Check for signs of wear and contaminants.

2. Clean the metal shavings and other debris from the face of the magnet.

3. Install the speed sensor according to the information in the Service Manual, “Specifications”.

i07140208

Engine Valve Lash - Check

SMCS Code: 1105-535

⚠ WARNING

Ensure that the engine cannot be started while this maintenance is being performed. To help prevent possible injury, do not use the starting motor to turn the flywheel.

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/adjusting valve lash clearance.

NOTICE
Only qualified service personnel should perform the maintenance procedure.

Note: Operation of Cat engines with improper valve adjustments can reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component life.

The initial valve lash adjustment on new engines, rebuilt engines, or remanufactured engines is recommended at the first scheduled oil change. The adjustment is necessary due to the initial wear of the valve train components and to the seating of the valve train components.

Note: For procedures on adjusting the valve lash, see System Operation Testing and Adjusting, M0082965, “Valve Lash - Adjust”. Consult your Cat dealer for assistance.

i07140239

Fan Drive Bearing - Inspect

SMCS Code: 1359-040-BD

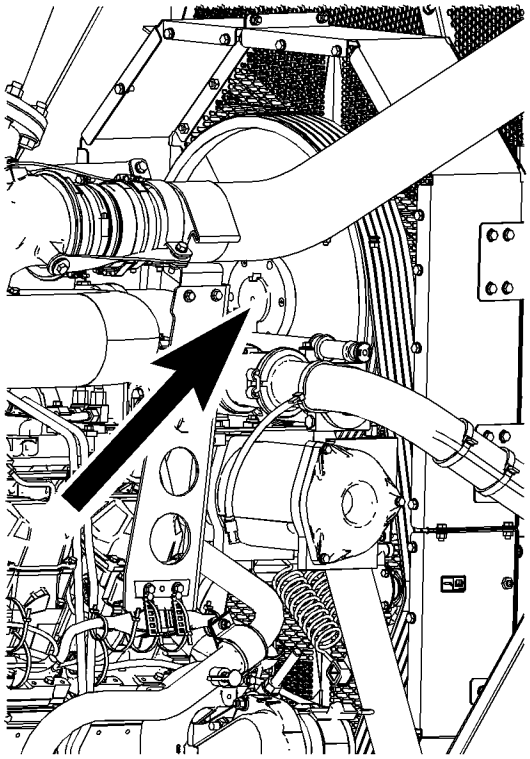

Illustration 72 g06233884
Fan drive pulley with guards removed

1. Inspect the fan drive pulley assembly. If the shaft is loose, an inspection of the internal components should be made.

i07140220

Fan Drive Bearing - Lubricate

SMCS Code: 1359-086-BD

1. Inspect the fan drive pulley assembly. If the shaft is loose, an inspection of the internal components should be made.

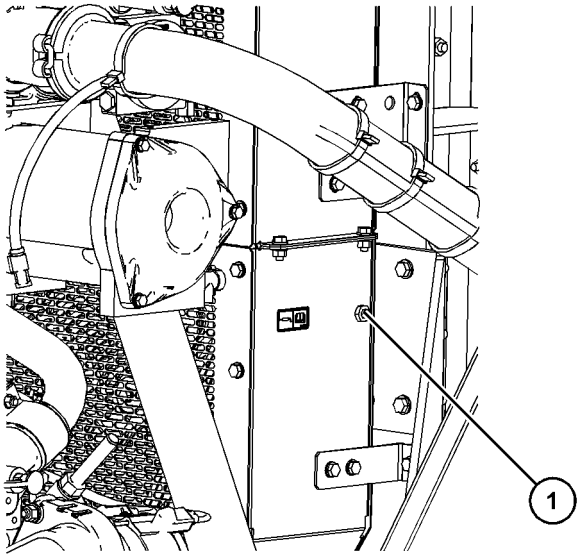

Illustration 73 g06233820

(1) Grease fittings for the fan bearings

Note: If the engine is operated in hot environments, dirty environments, or humid environments, lubricate the fan bearings more frequently.

2. Lubricate the grease fittings for the fan bearings with Bearing Lubricant , or with an equivalent grease.

i01565926

Fuel Injector - Inspect/Adjust

SMCS Code: 1290-040; 1290-025

Note: Perform this procedure when the engine valve lash is inspected.

NOTICE
The camshafts must be correctly timed with the crankshaft before an adjustment of the lash for the fuel injector is made. The timing pins must be removed from the camshafts before the crankshaft is turned or damage to the cylinder block will be the result.

Inspect the adjustment of the lash for the fuel injector according to the Testing And Adjusting, “Fuel Injector Adjustment”. Adjust the lash for the fuel injector, if necessary.

i07140334

Fuel System - Prime

SMCS Code: 1250-548; 1258-548

1. Open the fuel supply valve. Ensure that the engine will not start during the priming procedure. Turn the start switch to the OFF position.

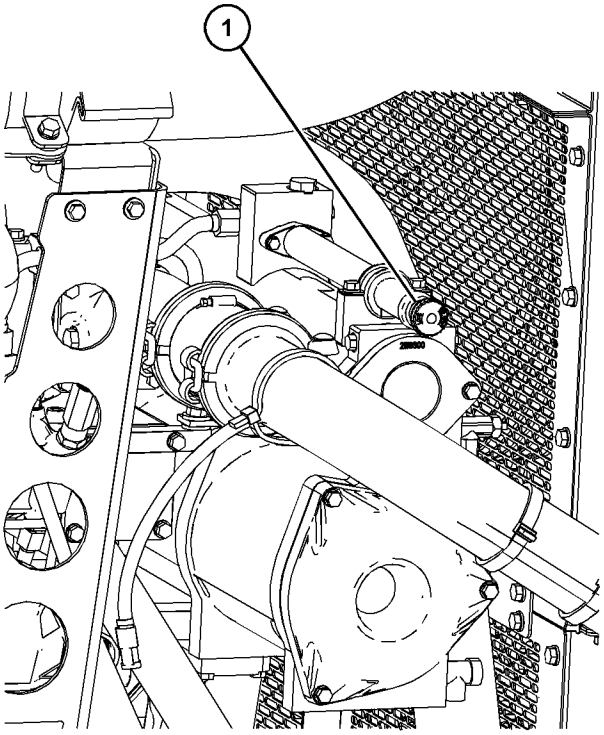

Illustration 74 g06233919

(1) Fuel priming pump plunger

2. Turn the fuel priming pump plunger counterclockwise to release the lock plate from the retainer.

3. Operate the fuel priming pump until the air in the fuel system has been pumped through the fuel return line back to the fuel tank.

4. Press the fuel priming pump plunger to the locking position. Turn the fuel priming pump plunger clockwise to engage the lock plate in the retainer.

Note: Enable the starting system only after all maintenance has been completed.

Priming Procedure for Dry Starting

If the air cannot be purged from the fuel system and the engine will not start, see Special Instruction, SEHS9586, “3500 EUI Fuel Priming Procedure”.

i02180086

Fuel System Primary Filter (Water Separator) Element - Replace

SMCS Code: 1260-510-FQ; 1263-510-FQ

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

1. Stop the engine. Ensure that the engine will not start during this procedure.
2. Shut off the fuel supply valve to the engine.

NOTICE
Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

NOTICE
Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

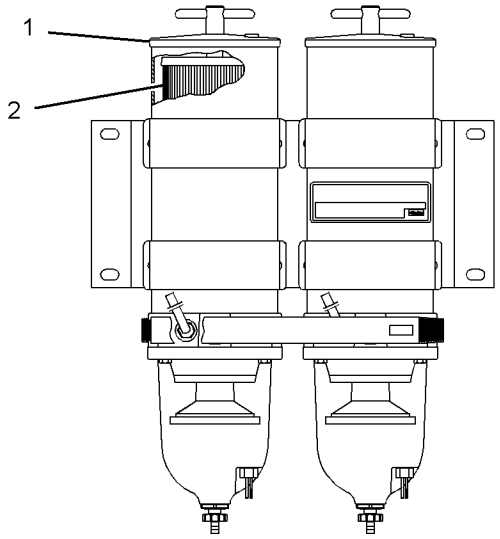

Illustration 75 g01103365

(1) Filter case
(2) Nut

3. Loosen nut (2). Hold filter case (1) and remove nut (2). Prepare to catch the fuel that is inside of the filter case with a suitable container. Remove the filter case from the mounting bolt.
4. Remove the element and wash the element in clean, nonflammable solvent. Allow the element to dry. Inspect the element. Install a new element if the old element is damaged or deteriorated.
5. Clean the inside of the filter case. Allow the filter case to dry.
6. Inspect the O-ring seals. Obtain new seal rings if the old seal rings are damaged or deteriorated. Ensure that the sealing surfaces for the seals are clean. Install the seals.

NOTICE
Do not fill the fuel filters with fuel before installing the fuel filters. The fuel will not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

7. Place the element in the filter case. Slide the filter case over the mounting bolt.
8. Install the nut.
9. Open the fuel supply valve.
10. Prime the fuel system. See this Operation and Maintenance Manual, “Fuel System - Prime” topic.

i02310280

Fuel System Primary Filter/ Water Separator - Drain

SMCS Code: 1260-543; 1263-543

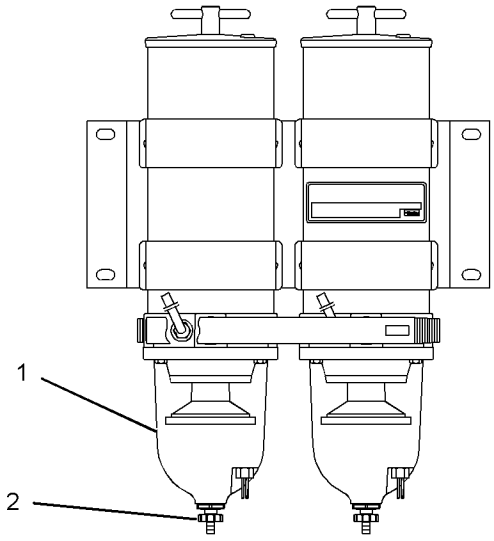

Illustration 76 g01157156

(1) Bowl
(2) Drain

Bowl (1) should be monitored daily for signs of water. If water is present, drain the water from the bowl.

1. Open drain (2). The drain is a self-ventilated drain. Catch the draining water in a suitable container. Dispose of the water properly.

2. Close the drain.

NOTICE
The water separator is under suction during normal engine operation. Ensure that the drain valve is tightened securely to help prevent air from entering the fuel system.

i06274476

Fuel System Secondary Filter - Replace

SMCS Code: 1261-510-SE

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Dealer Service Tool Catalog” for tools and supplies suitable to collect and contain fluids on Cat ® products.

Dispose of all fluids according to local regulations and mandates.

NOTICE
Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

Replace the secondary fuel filter elements according to the following:

- The fuel filter differential pressure gauge registers 103 kPa (15 psi).
- The scheduled maintenance interval has been reached. Refer to this Operation and Maintenance Manual, “Maintenance Interval Schedule”

Replacing the Fuel Filter Elements with the Engine Stopped

1. Stop the engine. Ensure that the engine will not start during this procedure.

2. Shut off the fuel supply valve to the engine.

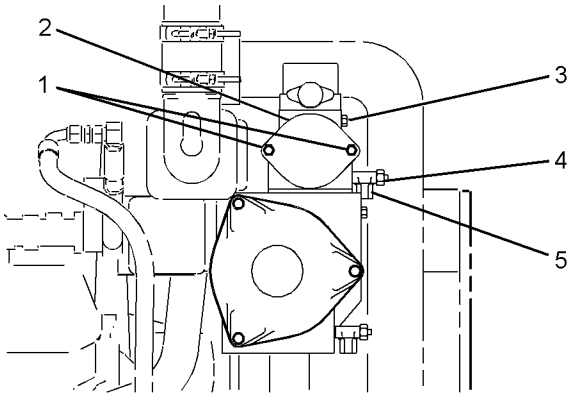

Illustration 77 g01411122

(1) Bolts
(2) Cover
(3) Plug
(4) Drain valve
(5) Drain

3. Connect a hose to drain (5). Place the other end of the hose into a suitable container in order to collect the fuel.

4. Open drain valve (4). Remove plug (3). Allow the fuel to drain. Clean the plug and install the plug. Close the drain valve. Remove the hose from the drain.

Note: Some fuel will remain in the housing after the fuel has been drained. This fuel will pour out of the housing when cover (2) is removed. Prepare to catch the fuel in a suitable container. Clean up any spilled fuel with absorbent towels or pillows. DO NOT use absorbent particles to clean up the fuel.

⚠ WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

5. Be alert to the spring force. Gradually loosen but do not remove bolts (1). Before removing bolts (1), pry cover (2) loose in order to relieve any spring pressure. Remove cover (2). Remove the O-ring seal on the inside of the cover. Remove the fuel filter elements.

6. Clean cover (2) and clean the O-ring seal. Clean the inside of the fuel filter housing.

7. Install new fuel filter elements.

8. Inspect the O-ring seal. Ensure that the surfaces for the O-ring seal are clean. Install a new O-ring seal if the old O-ring seal is damaged or deteriorated.

9. Install cover (2). Ensure that the springs are seated properly between the cover and the fuel filter elements.

10. Open the fuel supply valve. Reconnect the battery.

11. Prime the fuel system. Refer to this Operation and Maintenance Manual, “Fuel System - Prime” topic (Maintenance Section).

i06104305

Fuel Tank Water and Sediment - Drain

SMCS Code: 1273-543-M&S

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Fuel Tank

Fuel quality is critical to the performance and to the service life of the engine. Water in the fuel can cause excessive wear to the fuel system. Condensation occurs during the heating and cooling of fuel. The condensation occurs as the fuel passes through the fuel system and the fuel returns to the fuel tank. This causes water to accumulate in fuel tanks. Draining the fuel tank regularly and obtaining fuel from reliable sources can help to eliminate water in the fuel. The fuel tank utilizes a fuel tank vent to prevent an air lock or vacuum. Ensure that the vent is free of debris and not damaged.

Drain the Water and the Sediment

Fuel tanks should contain some provision for draining water and draining sediment from the bottom of the fuel tanks.

Prepare to catch water and sediment in an appropriate container. Connect a hose (if necessary) to the valve prior to opening the valve.

Open the drain valve on the bottom of the fuel tank in order to drain the water and the sediment. Close the drain valve.

Note: Failure to close the drain properly could result in fuel leakage, which could have detrimental results to performance.

Check the fuel daily. Drain the water and sediment from the fuel tank after operating the engine. Drain the water and sediment from the fuel tank after the fuel tank has been filled. Allow 5 to 10 minutes before performing this procedure.

Fill the fuel tank after operating the engine in order to drive out moist air. This procedure will help prevent condensation. Do not fill the tank to the top. The fuel expands as the fuel gets warm. The tank may overflow.

Some fuel tanks use stand pipes that allow water and sediment to settle below the end of the fuel stand pipe. Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

Fuel Storage Tanks

Drain the water and the sediment from the fuel storage tank during the following conditions:

- Weekly
- Refill of the tank

This procedure will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank. A four micron(c) absolute filter for the breather vent on the fuel tank is also recommended.

If a bulk storage tank has been refilled or moved recently, allow adequate time for the sediment to settle before filling the engine fuel tank. Internal baffles in the bulk storage tank will also help trap sediment. Filtering fuel that is pumped from the storage tank helps to ensure the quality of the fuel. When possible, water separators should be used.

i03214248

Generator - Dry

SMCS Code: 4450-569

NOTICE
Do not operate the generator if the windings are wet. If the generator is operated when the windings are wet, damage can occur due to insulation breakdown.

⚠ WARNING

Personal injury or death can result from improper troubleshooting and repair procedures.

The following troubleshooting and repair procedures should only be performed by qualified personnel familiar with this equipment.

Refer to Safety Section, “Generator Isolating for Maintenance” for information regarding the procedure to safely isolate the generator.

When moisture is present or when moisture is suspected in a generator, the generator must be dried before being energized.

If the drying procedure does not restore the insulation resistance to an acceptable value, the winding should be reconditioned.

Drying Methods

The following methods can be used for drying a generator:

- Self-circulating air method
- Oven method
- Controlled current method
- Energize the optional space heaters.

NOTICE
Do not allow the winding temperature to exceed 85 °C (185.0 °F). Temperatures that are greater than 85 °C (185.0 °F) will damage the winding insulation.

Self-Circulating Air Method

Run the engine and disconnect the generator load. This will help circulate air. Operate the generator space heaters.

Oven Method

Place the entire generator inside a forced air drying oven for four hours at 65 °C (149 °F).

NOTICE
Use a forced air type oven rather than a radiant type oven.

Radiant type ovens can cause localized overheating.

Controlled Current Method

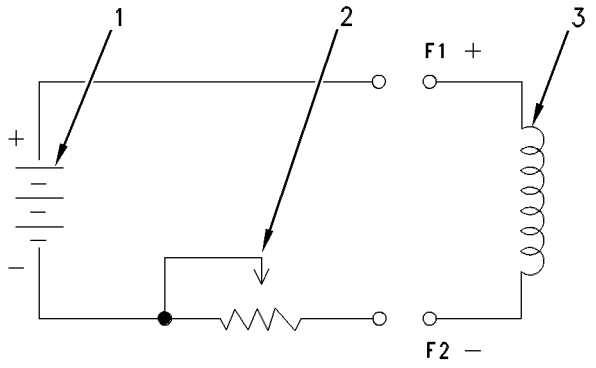

Illustration 78 g00614674

External Power Source Circuit

(1) Battery (12 VDC)
(2) Rheostat (15 ohm 25 watt)
(3) Exciter Field (Stator “L1”)

Table 22

TOOLS NEEDED		
Quantity	**Part Number**	**Description**
1	225-8266	Clamp-on ammeter (1200 amperes)
1		External power source circuit

Heat can be used in order to dry the generator windings. This heat can be created by allowing a controlled current to flow through the generator. No high voltages are generated during the following procedure. Therefore, insulation breakdown will not occur.

1. Make an external power source. Refer to Illustration 78 .

2. Disconnect F1+ from the voltage regulator. Disconnect F2- from the voltage regulator. Disconnect the generator load. Connect the generator output leads T0, T1, T2, and T3 together. Install the clamp-on ammeter to generator output lead T1.

Note: When the line current is measured on multiple lead units, measure the current in each conductor per phase. The currents can then be added.

3. Refer to Illustration 78 . Adjust the rheostat to the maximum resistance value. Connect the external power source to wires F1+ and F2-.

4. Start the generator set. Run the generator set at IDLE speed.

NOTICE
Do not exceed the rated phase current that is listed on the generator nameplate. Exceeding the rated phase current will easily damage the generator windings.

5. Monitor the phase current. In order to maintain use of the circuits for the protection of safety, use the control panel for the “EMCP 3” to gradually increase the engine rpm. Increase the engine rpm until one of the following conditions are met:

- The rated phase current is obtained.
- The full generator set speed is obtained.

6. If more phase current is necessary, slowly turn the rheostat. Turn the rheostat until the rated phase current is reached.

7. On an hourly basis, stop the drying procedure. Check the insulation resistance. Repeat the above steps until the insulation resistance is acceptable.

Guidelines for Space Heaters

1. Energize the space heaters when the generator is not operating.

2. Maintain the winding temperature at least 5 °C (9 °F) over the ambient temperature. In order to maintain the desired temperature in some conditions, a supplemental heat source or temporary covers may be required.

3. Check the insulation resistance until the resistance is acceptable.

Note: For more information on drying methods, refer to Special Instruction, SEHS9124, “Cleaning and Drying of Electric Set Generators”.

i05728320

Generator - Inspect

SMCS Code: 4450-040

⚠ WARNING

Personal injury or death can result from improper troubleshooting and repair procedures.

The following troubleshooting and repair procedures should only be performed by qualified personnel familiar with this equipment.

Refer to Safety Section, “Generator Isolating for Maintenance” for information regarding the procedure to isolate the generator safely.

Proper maintenance of electrical equipment requires periodic visual examination of the generator and periodic visual examination of the windings. Proper maintenance of electrical equipment also requires appropriate electrical checks and appropriate thermal checks. Insulation material should be examined for cracks. The insulation material should be examined for accumulations of dirt and dust. If there is an insulation resistance value that is below normal, a conductive path may be present. This conductive path may be made of one of the following materials:

- Carbon
- Salt
- Metal dust
- Dirt that is saturated with moisture

These contaminants will develop a conductive path which may produce shorts. Cleaning is advisable if heavy accumulations of dirt can be seen or if heavy accumulations of dust can be seen. If excess dirt is the cause of a restriction in the ventilation, cleaning is also advisable. Restricted ventilation will cause excessive heating.

NOTICE
To avoid the possibility of deterioration to the generator windings, do not clean the generator unless there is visual, electrical, or thermal evidence that dirt is present.

If harmful dirt accumulations are present, various cleaning techniques are available. The cleaning procedure that is used may be determined by one of the items on the following list:

- The extent of the cleaning procedure that is being attempted
- The type of enclosure of the generator
- The voltage rating of the generator
- The type of dirt that is being removed

Cleaning (Assembled Generators)

Cleaning may be required at the point of installation. If complete disassembly of the generator is not necessary or feasible, a vacuum cleaner should be used to pick up the following items: dry dirt, dust and carbon. Vacuuming dust and dirt will prevent the spreading of these contaminants.

If necessary, connect a small nonconductive tube to the vacuum cleaner. A nonconductive tube will allow the vacuum cleaner to clean the surfaces that are not exposed. After most of the dust has been removed, a small brush may be attached to the vacuum hose in order to loosen firmer dirt.

After the initial cleaning with a vacuum, compressed air may be used to remove the remaining dust and dirt. Compressed air that is used for cleaning should be free of moisture and free of oil. Air pressure should be a maximum of 210 kPa (30 psi) in order to prevent mechanical damage to the insulation. If the above cleaning procedures are not effective, consult a Cat dealer.

Cleaning (Disassembled Generators)

An initial insulation resistance check should be made on the generator in order to confirm electrical integrity. A minimum reading of 1 megohm would be expected with severely contaminated generators. A zero megohm reading may indicate an insulation breakdown. An insulation breakdown requires more than cleaning. An insulation breakdown requires repair.

A high-pressure wash is normally an effective way to clean windings. Windings that have been exposed to flooding, or windings that have been contaminated by salt can be high-pressure washed as well. A solution of hot water and detergent is used for this method of cleaning.

A high-pressure wash sprays a high velocity fluid stream of this solution over the generator that is being cleaned. This detergent washing is followed by multiple sprays of clean water. The clean water is used in order to remove the detergent or the clean water is used in order to dilute the detergent.

Allow the generator to dry at room temperature. Check the insulation resistance. The insulation resistance should now be normal. If the insulation resistance is not normal, repeat the procedure. Use of solvents may be necessary if the generator is contaminated with oil or if the generator is contaminated with grease.

Note: For more information on drying methods, refer to Special Instructions, SEHS9124, “Cleaning and Drying of Electric Set Generators”.

i06171677

Generator Bearing - Inspect

SMCS Code: 4471-040

SR5

The ball bearings that are used in LC5, LC6, and SR5 generators contain grease. This grease is subject to deterioration. If the generator is stored more than 1 year, without rotating the rotor, new ball bearings may be required. These bearings are greased at the factory. These bearings do not require any additional greasing in the field. Remove any necessary covers in order to inspect the rear bearings of the generators. Front bearings may be inspected through the fan screen. Perform a visual inspection for obvious damage, for corrosion, or for an excessive amount of purged grease around the bearing sleeves. Small amounts of purged grease are expected. Grease that covers the brackets or the windings is excessive.

Bearing inspection should include the collection of vibration data. Refer to this Operation and Maintenance Manual, “Generator Set Vibration - Test/Record” for further information concerning checking the vibration levels.

Bearing temperature should also be measured and recorded as a part of this inspection. Refer to this Operation and Maintenance Manual, “Generator Bearing Temperature - Test/Record” for further information concerning checking the vibration levels.

If inspection indicates that bearings are free of rust or corrosion, and no noise or excessive vibration occur on start-up, replacement is not necessary.

SR4

Remove the bearing bracket. Inspect the following items: bracket bore, bearing outer race and rolling elements. On standby power units, the bearing must be inspected and the grease must be replaced at 3 year intervals. The sleeve in the bearing bracket should be inspected for out of roundness, excessive wear, and a bracket step that is less than 0.0762 mm (0.0030 inch). If there is no sleeve in the bearing bracket, inspect the bore of the bearing bracket. The bearing should be inspected for damage to the outer race, severe fretting, and smoothness of operation. When possible, the bearing elements should be inspected. Some double shielded ball bearings prevent visual inspection of the elements of the bearing. Other double shielded ball bearings have a retaining ring. This retaining ring can be removed in order to allow access for a visual inspection of the elements of the bearing.

On two-bearing generators, the front bearing can only be removed after the drive coupling is removed. Refer to the Systems Operation Testing and Adjusting Disassembly and Assembly, “Coupling - Remove” for the generator for instructions for removing the drive coupling.

i07275450

Generator Bearing - Lubricate

SMCS Code: 4471-086

Procedure for Bearing Service

Perform periodic bearing lubrication at the intervals that are shown in Table 23 . Use the following instructions as the suggested procedure to service the bearings of the generator.

Note: If the generator already has a visible grease point, go to Step 4.

1. Stop the generator set. Remove the required external cover plates, grills, and louvers of the generator to access the bearings.
2. Remove the top grease pipe plug and the lower grease pipe plug. If no grease pipes can be found, then locate the insert for the grease pipe. The insert is on the bearing brackets. Remove the inserts. Install the grease pipes.
3. Install a grease fitting in the top grease pipe.
4. Use a Cat ® 8F - 9866 Grease Gun or equivalent grease gun to grease the bearings. Use the appropriate type of grease and the quantity that is listed in Table 23 . Avoid the use of alternate types of grease. Usage of alternate types of grease could cause premature bearing failure.

Note: Add only the amount of grease listed in Table 23 . Do not continue to add grease until purging is observed. Purging of grease will not always be observed.

5. If grease fittings are permanently installed, ensure that the protective caps for the grease fittings are installed on the fittings when finished. If a grease fitting was installed in Step 2, remove the top grease fitting and install the plug that was removed. If applicable, do not install the plug on the bottom grease location yet. Wipe off the excess grease.

Note: Do not allow grease to drip on the stator windings of the generator. The stator windings that are exposed to grease could suffer degraded insulation. The degraded insulation would cause a reduction in the life of the windings.

6. Operate the generator set at rated speed for approximately 1 hour. When running the engine more than 30 minutes, the recommended engine load to apply is a minimum of 50%. The procedure will allow the grease to expand. The expanding grease will force the excess grease from the cavity. The internal pressure will be reduced as the excess grease is forced from the cavity. Operate the generator until no grease is forced out of the cavity.

7. Stop the generator set. Inspect the generator windings, grease tubes, and bearing housings. Wipe off any excess grease. If a grease pipe plug was removed in Step 2, install the plug in the bottom grease pipe. Wipe off any excess grease.

Note: Do not allow grease to drip on the stator windings of the generator. The stator windings that are exposed to grease could suffer degraded insulation. The degraded insulation would cause a reduction in the life of the windings.

8. Install all the external cover plates, grills, and louvers of the generator that were removed to access the bearings.

Table 23

Bearing Part Number	Bearing Type	Frame Size	Temperature Maximum(1)	Grease Part Number	Interval	Weight	Volume	Shaft Diameter
5P-2448 Ball Bearing	315 BC 160 mm (6.3 inch) OD 75 mm (3 inch) ID	580 590	85° C (185° F)	Refer to Special Instruction, REHS4892, “Generator Bearing Service”	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	75 mm (3 inch)
6Y-3955 Ball Bearing	220 BC 180 mm (7.1 inch) OD 100 mm (3.9 inch) ID	450	85° C (185° F)	Refer to Special Instruction, REHS4892, “Generator Bearing Service”	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	100 mm (3.9 inch)
6Y-6488 Ball Bearing	318 BC 190 mm (7.5 inch) OD 90 mm (3.5 inch)	597	85° C (185° F)	Refer to Special Instruction, REHS4892, “Generator Bearing Service”	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	90 mm (3.5 inch)
108-1760 Ball Bearing	321 BC 225 mm (8.9 inch) OD 105 mm (4.1 inch) ID	680	85° C (185° F)	Refer to Special Instruction, REHS4892, “Generator Bearing Service”	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	105 mm (4.1 inch)

(continued)

(Table 23, contd)

Bearing Part Number	Bearing Type	Frame Size	Temperature Maximum(1)	Grease Part Number	Interval	Weight	Volume	Shaft Diameter
108-1761 Ball Bearing	322 BC 240 mm (9.4 inch) OD 110 mm (4.3 inch) ID	690 800	85° C (185° F)	Refer to Special Instruction, REHS4892, “Generator Bearing Service”	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	110 mm (4.3 inch)
109-7687 Ball Bearing	316 BC 170 mm (6.7 inch) OD 80 mm (3.15 inch) ID	580	85° C (185° F)	Refer to Special Instruction, REHS4892, “Generator Bearing Service”	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	80 mm (3.15 inch)
139-0349 Roller Bearing	Roller	2900 2800	85° C (185° F)	1p0808	Every 250 service hours	2.8 g (0.1 oz)	N/A	127 mm (5 inch)
139-0350 Roller Bearing	Roller	2900 2800	85° C (185° F)	1p0808	Every 250 service hours	2.8 g (0.1 oz)	N/A	127 mm (5 inch)
154-3032 Ball Bearing	326 BC 280 mm (11 inch) OD 130 mm (5.1 inch) ID	820 1800(2)(3) 2600(3) 2700(3)	85° C (185° F) 95° C (203° F) 85° C (185° F) 85° C (185° F)	Refer to Special Instruction, REHS4892, “Generator Bearing Service”	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	130 mm (5.1 inch)
193-4070 Ball Bearing	018 BC 140 mm (5.5 inch) OD 90 mm (3.5 inch) ID	498 499	85° C (185° F)	Refer to Special Instruction, REHS4892, “Generator Bearing Service”	Every 2000 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	90 mm (3.5 inch)
241-4644 Bearing	320 BC 215 mm (8.5 inch) OD 100 mm (3.9 inch) ID	LC7	95° C (203° F)	UNIREX N3	Every 4500 service hours or 12 months	60 g (2.1 oz)	N/A	100 mm (3.9 inch)
243-5220 Bearing	315 BB 160 mm (6.3 inch) OD 75 mm (3.0 inch) ID	LC6100 LC5000	95° C (203° F)	UNIREX N3	Sealed(4)	Sealed	Sealed	75 mm (3.0 inch)
253-9789 Bearing	320 BC 215 mm (8.5 inch) OD 100 mm (3.9 inch) ID	1400	85° C (185° F)	UNIREX N3	Grease cannot be added to this bearing.	N/A	N/A	100 mm (3.9 inch)

(continued)

(Table 23, contd)

Bearing Part Number	Bearing Type	Frame Size	Temperature Maximum[1]	Grease Part Number	Interval	Weight	Volume	Shaft Diameter
253-9792 Bearing	226BC 230 mm (9.05 inch) OD 130 mm (5.12 inch) ID	1400	95° C (203° F)	EA6	Grease cannot be added to this bearing.	Grease cannot be added to this bearing.	Grease cannot be added to this bearing.	140 mm (5.5 inch)
261-3545 Bearing	307 BB 80 mm (3.1 inch) OD 35 mm (1.4 inch) ID	LC2000	95° C (203° F)	UNIREX N3	Sealed[4]	Sealed	Sealed	35 mm (1.4 inch)
262-5921 Bearing	307 BC 80 mm (3.1 inch) OD 35 mm (1.4 inch) ID	LC2000	95° C (203° F)	UNIREX N3	Sealed[4]	Sealed	Sealed	35 mm (1.4 inch)
263-0161 Bearing	309 BC 100 mm (3.9 inch) OD 45 mm (1.8 inch) ID	LC3000	95° C (203° F)	UNIREX N3	Sealed[4]	Sealed	Sealed	45 mm (1.8 inch)
281-3091 Ball Bearing	328 BC 300 mm (11.8 inch) OD 140 mm (5.5 inch) ID	3010[2] 3020[2] 3042[2] 3044[2] 3045[2]	95° C (203° F)	EA6	Grease cannot be added to this bearing.	Grease cannot be added to this bearing.	Grease cannot be added to this bearing.	140 mm (5.5 inch)
311-0843 Ball Bearing	326 BC 280 mm (11 inch) OD 130 mm (5.1 inch) ID	1800[2]	95° C (203° F)	EA6	Grease cannot be added to this bearing.	N/A	N/A	130 mm (5.1 inch)
311-0844 Ball Bearing	322 BC 240 mm (9.4 inch) OD 110 mm (4.3 inch) ID	1600	95° C (203° F)	EA6	Grease cannot be added to this bearing.	N/A	N/A	110 mm (4.3 inch)

(continued)

(Table 23, contd)

Bearing Part Number	Bearing Type	Frame Size	Temperature Maximum(1)	Grease Part Number	Interval	Weight	Volume	Shaft Diameter
341-7383 Ball Bearing	330 BC 320 mm (12.6 inch) OD 150 mm (5.9 inch) ID	3055(5) 3066(5) 3068(5)	95° C (203° F)	Exxon Polyrex EMBase material is Polyurea.	Every 1800 service hours or 12 months	51.2 g (1.8 oz)	14.9 mL (0.5 oz)	150 mm (5.9 inch)
375-3715 Ball Bearing	328 BC 300 mm (11.8 inch) OD 140 mm (5.5 inch) ID	3010(2) (3) 3020(2) (3) 3042(2) (3) 3044(2) (3) 3045(2) (3)	95° C (203° F)	Refer to Special Instruction, REHS4892, “Generator Bearing Service”	Every 2400 service hours or 12 months	51.2 g (1.8 oz)	59 mL (2 oz)	140 mm (5.5 inch)
522-5924 Ball Bearing	240 mm (9.4 inch) OD 110 mm (4.3 inch) ID	SR500 E3800L4	95° C (203° F)	458-0955	Every 4000 service hours	60 gram (2.1 ounce)		110 mm(4.3 inch)

(1) Indicates the alarm temperature set point that the bearing should be continuously operated at on the specified generator frame size. Shutdown set points are typically 10° C (18° F) higher.

(2) 1800 frame generators and 3000 frame generators shipped before 2012 use double-shielded bearings with EA6 grease. There are no threaded holes in the bearing brackets for the grease tubes that are used to add grease. Therefore, no grease can be added to the bearings. Beginning in 2012, 1800 frame generators and 3000 frame generators that are shipped will use a single-shielded bearing, Refer to Special Instruction, REHS4892, “Generator Bearing Service” grease. The front and rear brackets contain factory installed grease fittings, therefore, single-shielded bearings must be lubricated periodically. Reference the Parts Manual with package serial number to identify the bearing part number and to determine bearing lubrication requirements.

(3) All 2600, 2700, 1800, and 3000 frame generators shipped beginning in 2012, use a single-shielded bearing design. Replacement bearings received from the Parts Division will have a shield on each side of the bearing. The shield facing the outside of the generator must be removed when the new bearing is installed.

(4) Grease cannot be added to this bearing. Refer to the Operation and Maintenance Manual, “Generator Bearing - Replace” article for information concerning the replacement of these bearings.

(5) The generator uses a non-shielded bearing design. Although replacement bearings may have a shield on each side, both shields must be removed when the new bearing is installed. Replacement bearings are shipped as dry bearings and must be packed to 50% grease fill at time of installation.

Bearing Replacement

Refer to the appropriate publication for each specific generator for bearing replacement procedures.

Replace both bearings of a two-bearing generator.

Replace any bearing wear sleeves and lip seals when the bearings are replaced.

Except for the 341-7383 Ball Bearing, replacement bearings are pre-lubricated. The pre-lubricated bearings do not require additional grease at time of replacement. The 341-7383 Ball Bearing is shipped as a dry bearing. The 341-7383 Ball Bearing must be packed to 50% grease fill at time of installation.

Old grease must be removed at the time of bearing replacement from the bearing bracket cavity. After the bearing bracket cavity is cleaned, the bearing bracket cavity must be packed with new grease from one-third to one-half full.

Note: Generator set alignment is required after the bearings are replaced.

Additional Information

Refer to Special Instruction, REHS4892, “Generator Bearing Service” for further information.

i06238558

Generator Bearing - Replace

SMCS Code: 4471-510

SR5

Standby

The generator bearings are shielded and greased for the life of the bearing. Some purging of the grease occurs normally with the bearings. Carefully adhere to the recommendations for the following conditions: temperature, vibration, contamination and alignment. Over time, the bearing grease may deteriorate. This deterioration may cause the grease to loose lubricating properties.

Caterpillar recommends the replacement of the bearing after 10 years of service in a standby application in normal conditions. If the bearing is installed in the following conditions, Caterpillar recommends replacement of the bearing in 5 years.

- High temperature environment (Refer to the temperature chart in this Operation and Maintenance Manual, “Generator Bearing - Lubricate” article.
- Condensing humidity
- Coastal environment
- Chemical environment
- Abrasive environment

i05952022

Generator Bearing Temperature - Test/Record

SMCS Code: 4471-081-TA

The monitoring of bearing temperature may prevent premature bearing failure. A generator set should never operate above the recommended set points. Keep records in order to monitor the changes in the temperature of the bearing.

Note: Measure the bearing temperature after the generator reaches normal operating temperature.

Resistive Temperature Detectors (RTDs)

Cat Generators may be equipped with resistance temperature detectors for generator bearings. These detectors are 100 ohm resistance temperature detectors. A resistance temperature detector may be monitored by the optional monitor for the EMCP resistance temperature detector. A resistance temperature detector may be monitored by equipment that is provided by the customer. Consult with your Cat dealer about other methods of measuring the bearing temperature.

The EMCP may be configured to “ALARM” or the EMCP may be configured to “SHUTDOWN” . An alarm is activated if the temperature of the bearing reaches 85 °C (185 °F). A shutdown occurs if the temperature of the bearing reaches 95 °C (203 °F).

Infrared Thermometers

Bearing temperatures can also be recorded with the use of an infrared thermometer. Refer to Special Publication, NENG2500, “Cat Dealer Service Tools Catalog” for various infrared thermometers. Follow the instructions that come with your infrared thermometer.

i05325030

Generator Lead - Check

SMCS Code: 4450-535

Check for signs of wear along the generator leads. Pay particular attention to the leads at the housing for the breaker and the generator terminal box.

If the rubber mats or the insulation on the leads show signs of wear at points of contact with other surfaces, replace immediately. If your generator set does not have rubber mats in place, contact your Cat dealer.

i03215110

Generator Load - Check

SMCS Code: 4450-535-LA

During normal operation, monitor the power factor and monitor generator loading.

When a generator is installed or when a generator is reconnected, ensure that the total current in any one phase does not exceed the nameplate rating. Each phase should carry the same load. This allows the generator to work at the rated capacity. If one phase current exceeds the nameplate amperage, an electrical imbalance will occur. An electrical imbalance can result in an electrical overload and an electrical imbalance can result in overheating.

The power factor can be referred to as the efficiency of the load. This can be expressed as the ratio of kVA to actual kW. The power factor can be calculated by dividing kW by kVA. Power factor is expressed as a decimal. Power factor is used to mean the portion of current that is supplied to a system that is doing useful work. The portion of the current that is not doing useful work is absorbed in maintaining the magnetic field in motors. This current (reactive load) can be maintained without engine power.

Electric sets normally have a low idle setting that is higher than industrial engines. Low idle will be approximately 66 percent of the full speed that is achieved by 60 Hz units. This would be equal to 80 percent of the full speed that is achieved by 50 Hz units.

The ADEM III system functions as the governor for this engine.

Note: Operating the electric set at low idle speed for an extended time will cause some voltage regulators to shut off. The electric set must be completely shut down and the electric set must be restarted. This will allow the voltage regulator to again produce an output.

i03292462

Generator Set - Test

SMCS Code: 4450-081

⚠ WARNING

Personal injury or death can result from high voltage.

When power generation equipment must be in operation to make tests and/or adjustments, high voltage and current are present.

Improper test equipment can fail and present a high voltage shock hazard to its user.

Make sure the testing equipment is designed for and correctly operated for high voltage and current tests being made.

When servicing or repairing electric power generation equipment:

- **Make sure the unit is off-line (disconnected from utility and/or other generators power service), and either locked out or tagged DO NOT OPERATE.**
- **Make sure the generator engine is stopped.**
- **Make sure all batteries are disconnected.**
- **Make sure all capacitors are discharged.**

⚠ DANGER

DANGER: Shock/Electrocution Hazard-Do not operate this equipment or work on this equipment unless you have read and understand the instructions and warnings in the Operation and Maintenance Manual. Failure to follow the instructions or heed the warnings will result in serious injury or death.

Table 24

Tools Needed		
Part Number	**Part**	**Quantity**
237-5130	Digital Multimeter	1
	12 VDC Battery	1
	Potential Transformer	1

The generator set functional test is a simplified test that can be performed in order to determine if the generator is functional. The generator set functional test should be performed on a generator set that is under load.

The generator set functional test determines if the following statements happen:

- A phase voltage is being generated.
- The phase voltages are balanced.
- The phase voltages change relative to engine speed.

The generator set functional test consists of the following steps:

1. Stop the generator. Connect the potential transformer's high voltage winding to the generator terminals (T1) and (T2). Connect the voltmeter to the low voltage winding. If two transformers are available, connect the high voltage winding of the second transformer to the generator terminals (T1) and (T3). Connect the secondary terminals that correspond to generator terminal (T2) of both transformers together.
2. Disconnect wires “F1+” and “F2-” from the voltage regulator. Disconnect the generator from the load.
3. Connect a 12 VDC automotive battery to wires “F1 +” and “F2-” .

NOTICE
Do not operate the generator set at a speed that is higher than one-half of the rated speed.

Higher speeds under these test conditions can cause damage to the system.

4. Operate the generator set at half the rated speed.

5. Measure the AC voltage across the low voltage terminals of the transformer that correspond to the following generator terminals: “T1” and “T2” , “T2” and “T3” and “T3” and “T1” . Record the voltages.

6. Monitor the voltage between any two of the locations in step 5. Decrease the generator set speed by 10 percent. Increase the generator set speed by 10 percent.

7. The voltages that were measured in Step 5 should be nearly equal. These voltages should measure a minimum of 85 VAC.

8. When the generator set speed is decreased by 10 percent, the voltages that were measured in Step 6 should decrease by 10 percent. When the generator set speed is increased by 10 percent, the voltages that were measured in Step 6 should increase by 10 percent.

i03956450

Generator Set Alignment - Check
(Generator Sets)

SMCS Code: 7002-024

The genset must be aligned when the genset is installed or moved into a different position. If the generator set is run at the full continuous rating, the alignment of the generator to the engine must be checked annually.

Properly maintain the alignment between the engine and the driven equipment in order to minimize the following problems:

- Bearing problems
- Vibration of the engine crankshaft
- Vibration of the driven equipment

Refer to the following information for more information about the alignment of the generator set:

- Special Instruction, SEHS7654, “Alignment - General Instructions”
- Special Instruction, SEHS7259, “Alignment of Single Bearing Generators”
- Special Instruction, REHS0177, “Alignment of the Close Coupled Two Bearing Generators”

Keep a record of the measurement of the alignment. The record may be used to check the trend of the alignment. The record may be used to analyze the trend of the alignment.

i05264208

Generator Set Vibration - Test/ Record

SMCS Code: 4450-081-VI

Check for vibration damage.

Vibration may cause the following problems:

- Coupling wear
- Loose fittings
- Fatigue of the metal components of the engine
- Cracks in the cabinet which surrounds the generator
- Cracks in welds
- Excessive noise
- Cracked insulation

The following areas are susceptible to vibration damage:

- Coupling for the generator set
- Generator bearings
- Stator output leads
- Protective sleeving
- Insulation
- Exposed electrical connections
- Transformers
- Fuses
- Capacitors
- Lightning arresters

When a generator set is installed, a vibration plot should be recorded in order to assist in diagnosing potential problems. This vibration plot should be updated yearly. The vibration plot should also be updated when the generator set is moved and when the engine is overhauled. This will allow the trend of the vibration to be monitored and analyzed. A potential problem may be prevented by monitoring the trend of the vibration. If the vibration is approaching the limit of the specification of the component, the problem may be more imminent. Refer to Data Sheet, LEKQ4023, “Linear Vibration” for the allowable limits of vibration.

Caterpillar also recommends recording the vibration of the bearing at the generator bearing bracket.

If the vibration exceeds the EDS limits for vibration, check the alignment. Refer to this Operation and Maintenance Manual, “Generator Set Alignment - Check” for the alignment procedure.

Contact the Cat Dealer Service Tools group for information on ordering a vibration analyzer that will meet your needs.

i03736530

Generator Winding - Test

SMCS Code: 4453-081; 4454-081; 4457-081; 4470-081

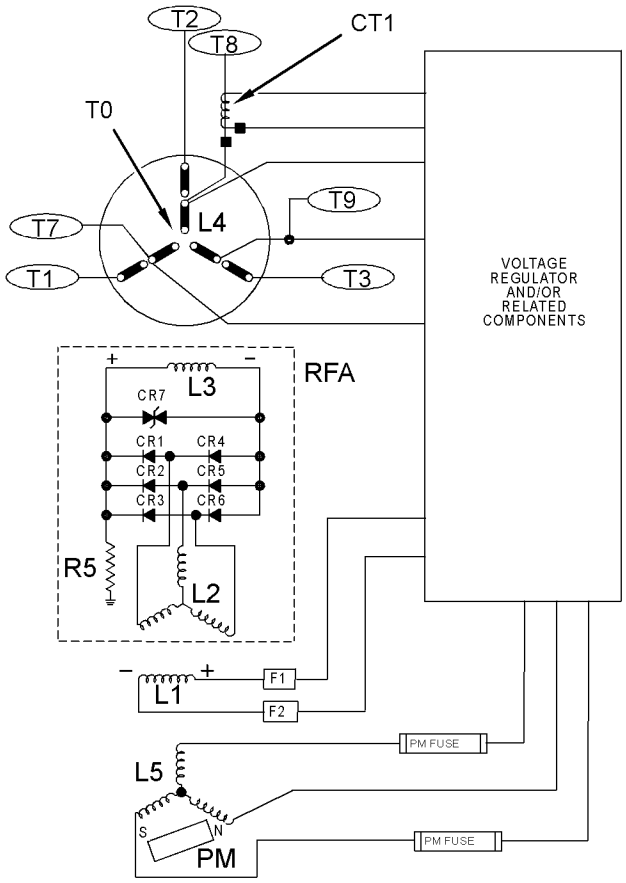

Illustration 79 g01388839

PMPE Generator wiring diagram for the family of 1800 frames

(CR1-C6) Diodes

(CR7) Varistor

(L1) Exciter stator

(L2) Exciter rotor

(L3) Main rotor

(L4) Main stator

(L5) Permanent magnet generator stator

(PM) Permanent magnet

(RFA) Rotating field assembly

(CT1) Optional voltage droop transformer

(T0, T1, T2, T3, T7, T8, T9) Generator terminals

Table 25

Quantity	Needed Tool
1	Low ohmmeter

Measure the resistance of the following windings: (L1), (L2), (L3), (L4) and (L5). The winding that is being tested must be disconnected from the other components before the resistance can be measured.

Note: The winding temperature affects the resistance. When the winding temperature increases, the winding resistance increases. When the winding temperature decreases, the winding resistance decreases. Therefore, a correct measurement can be performed only when the winding is at room temperature.

The following resistance measurements are approximations. If the measured value is not near the listed approximation, the winding is probably damaged. For a more precise resistance value, consult the Technical Marketing Information (TMI). Refer to the generator arrangement that is in question.

The following windings have very little resistance: (L2), (L4) and (L5). The resistance of these windings will measure near 0 ohms. Use a milliohmmeter to measure the resistance of the windings.

Exciter rotor (L2) – Refer to Table 26 .

Main stator (L4) – less than 0.1 ohm

Pilot exciter stator (L5) – less than 0.1 ohm

Use a multimeter in order to measure the resistance of field windings (L1) and (L3).

Exciter field (stator) (L1) – Refer to table 26 .

Main field (rotor) (L3) – approximately 0.35 ohms to 1.2 ohms

Note: There should be no continuity between any winding and ground. There should be no continuity between any winding and another winding.

Table 26

	L1 Exciter Field	L2 Exciter Rotor	Main Field for the Rotor
1800 Frame	10.9 ohms	0.05 ohms	.9 ohms
1600 Frame	10 ohms	0.06 ohms	.5 ohms
1400 Frame	11 ohms	0.06 ohms	.35 ohms

i03736629

Generator Winding Insulation - Test

SMCS Code: 4453-081; 4454-081; 4457-081; 4470-081

Recommended Periodic Insulation Tests

⚠ WARNING

The high voltage that is produced by an operating generator set can cause severe injury or death. Before performing any maintenance or repairs, ensure that the generator will not start.

Place the engine control switch in the “OFF” position. Attach “DO NOT OPERATE” tags to all starting controls. Disconnect the batteries or disable the starting system. Lock out all switchgear and automatic transfer switches that are associated with the generator.

Table 27

Tools Needed		
Part Number	**Part Name**	**Quantity**
300-8648	Insulation Testing Gp	1

Periodically, use an insulation tester to check the insulation resistance of the generator's main stator winding. The frequency of this test is determined by the generator's environment. Previous insulation tester readings will also determine the frequency of this test.

Test the main stator windings with an insulation tester in the following situations:

- The generator set is started for the first time.
- The generator set is removed from storage.
- The generator set is operating in a humid environment. Test every three months.
- The generator set is not protected from the elements in an enclosed area. Test every three months.
- The generator set is installed in an enclosed area. This area needs to be low in humidity and this area needs to have steady temperatures. Test every twelve months (minimum).

- The generator set has not been run under load for three months. Test the generator set weekly. Use space heaters around the generator set if the generator is exposed to a sea water environment or if the humidity is above 75 percent. Also use space heaters if a test result was below 3 megohms.

Space heaters must be used whenever the generator set is not under load. Space heaters must also be used whenever salt is present or whenever high humidity is present. Using a space heater in this fashion is the only way to maintain insulation tester readings above one megohm. Use space heaters only when the generator is not running.

For additional information, refer to Special Instruction, SEHS9124, “Cleaning and Drying of Electric Set Generators”.

Recommended Procedure for the Insulation Test

⚠ WARNING

Personal injury or death can result from electrocution.

The megohmmeter is applying a high voltage to the circuit.

To avoid electrocution, do not touch the instrument leads without first discharging them. When finished testing also discharge the generator windings.

1. Take the generator out of service.

2. Visually inspect the generator for moisture. If moisture exists, do not perform this insulation test. Dry the unit first. Refer to Special Instruction, SEHS9124, “Cleaning and Drying of Electric Set Generators”.

3. Inspect the installation. Determine the equipment that will be tested by the insulation tester.

4. Discharge the capacitance of the windings.

5. Disconnect “T0” from ground.

6. Disconnect the sensing lead wires for the regulator. This may be accomplished by unplugging the harness connectors.

7. Disconnect the PT leads of the load share module.

8. Connect the insulation tester's Black lead to ground.

9. Connect the insulation tester's RED lead to “T0” .

10. Set the voltage to the rated voltage of the generator.

11. Use the 30/60 Time Resistance Method:

a. Apply voltage.

b. Observe the readings at 30 seconds. Observe the readings at 60 seconds.

c. Record the 60 second reading. This reading must be corrected for temperature.

d. Record temperature.

e. Record humidity.

f. Remove voltage.

12. Evaluate the readings. The actual value of the resistance may vary greatly between generators. For this reason, the insulation's condition must be evaluated. Base this evaluation on the comparison between the 60 second resistance readings and the readings that were taken on previous dates. These two readings must be taken under similar conditions. If a 60 second resistance reading has a 50 percent reduction from the previous reading, the insulation may have absorbed too much moisture.

Switch the insulation tester to the “OFF” position. This will discharge the insulation tester's leads. Disconnect the insulation tester's leads.

Note: The results from the insulation resistance checks indicate when cleaning and/or repairing is becoming critical. Generally, insulation resistance will vary greatly with temperature. Therefore, always test at the same temperature and humidity. Refer to Illustration 80 .

Engine Serial Number_____

Serial Number for the Generator_____

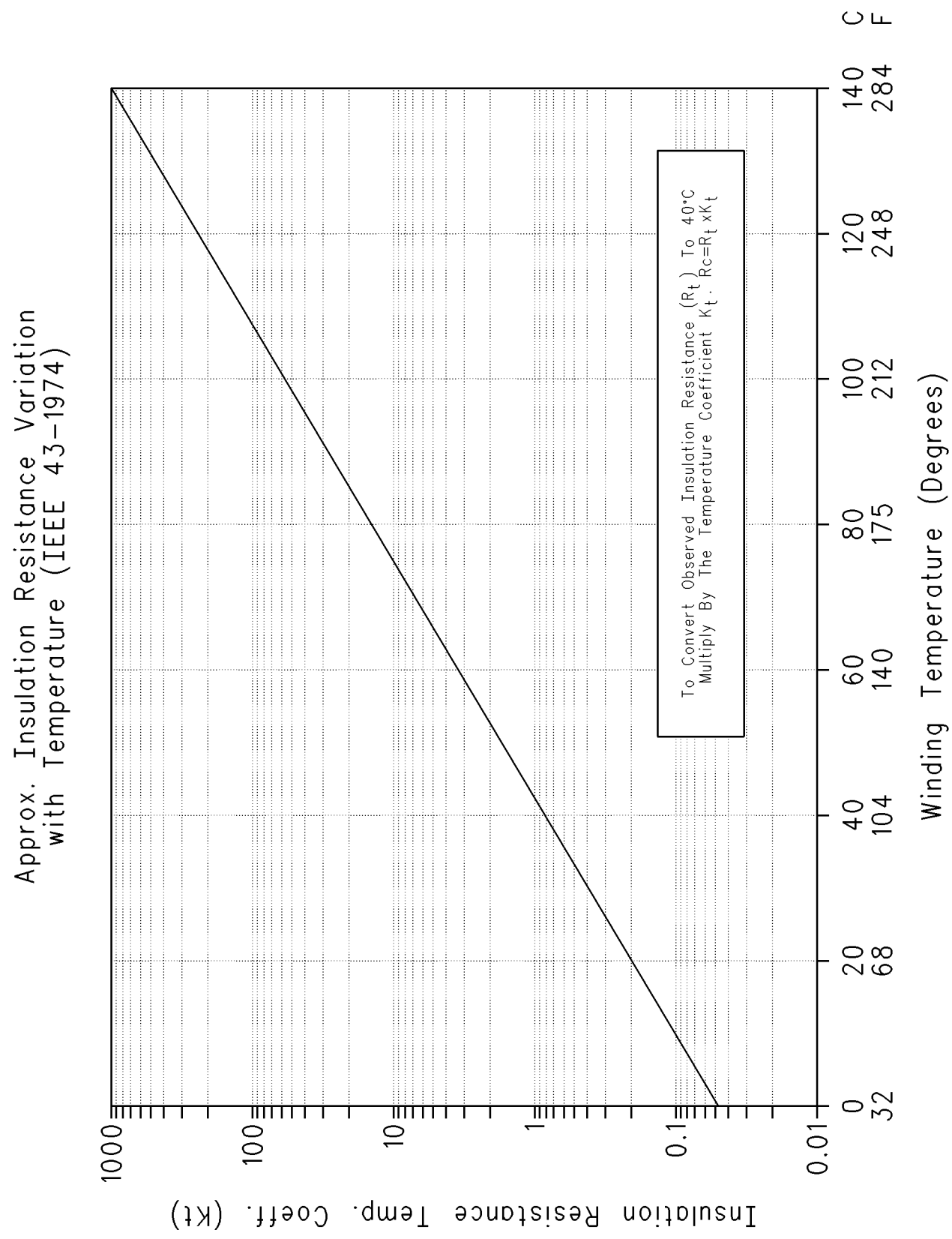
Approx. Insulation Resistance Variation
with Temperature (IEEE 43-1974)
Insulation Resistance Temp. Coeff. (Kt)
1000
100
10
1
0.1
0.01
0
32
20
68
40
104
60
140
80
175
100
212
120
248
140
284
C
F
Winding Temperature (Degrees)
To Convert Observed Insulation Resistance (Rt) To 40°C
Multiply By The Temperature Coefficient Kt. Rc=Rt xKt

Illustration 80 g00633226

i06825542

Hoses and Clamps - Inspect/ Replace

SMCS Code: 7554-040; 7554-510

Hoses and clamps must be inspected periodically and replaced at the recommended interval to ensure safe and continuous operation of the engine. Failure to replace a fuel hose at the recommended change interval may result in a hazardous situation. Take proper safety precautions before inspecting or replacing hoses and clamps.

Note: Always use a board or cardboard when the engine components are checked for leaks. Leaking fluid that is under pressure can cause serious injury or possible death. Leaks that are the size of a pin hole are included. Refer to Operation and Maintenance Manual, “General Hazard Information” for more information.

Note: Ensure that the hose is compatible with the application.

Inspect Tubes, Hoses, Bellows, and Clamps

Inspect all tubes and hoses for leaks that are caused by the following conditions. Replace any tube or hose which exhibits any of the following conditions. Failure to replace a tube or hose which exhibits any of the following conditions may result in a hazardous situation.

- Hoses which are cracked
- Hoses which are soft
- Outer covering that is chafed or cut
- Exposed wire that is used for reinforcement
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering
- Exhaust bellows for leaks or damage
- Hoses which exhibit signs of leakage which are not the result of loose couplings or clamps

Inspect all clamps for the following conditions. Replace any clamp which exhibits signs of any of the following conditions.

- Cracking
- Looseness
- Damage

Inspect all couplings for leaks. Replace any coupling which exhibits signs of leaks.

Each installation application can be different. The differences depend on the following factors:

- Type of hose
- Type of fitting material
- Anticipated expansion and contraction of the hose
- Anticipated expansion and contraction of the fittings

Due to extreme temperature changes, the hose will heat set. Heat setting causes hose clamps to loosen which can result in leaks. A constant torque hose clamp will help to prevent loose hose clamps.

Replace hoses that are cracked or soft. Replace hoses that show signs of leakage. Replace hoses that show signs of damage. Replace hose clamps that are cracked or damaged. Tighten or replace hose clamps which are loose.

Replace the Hoses and the Clamps

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Cat Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Cat Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Cat products.

Dispose of all fluids according to local regulations and mandates.

Cooling System

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

⚠ WARNING

Personal injury can result from removing hoses or fittings in a pressure system.

Failure to relieve pressure can cause personal injury.

Do not disconnect or remove hoses or fittings until all pressure in the system has been relieved.

1. Stop the engine.

2. Allow the engine to cool.

3. Before servicing a coolant hose, slowly loosen the filler cap for the cooling system to relieve any pressure.

4. Remove the filler cap for the cooling system.

5. Drain the coolant from the cooling system to a level that is below the hose that is being replaced. Drain the coolant into a suitable clean container. The coolant can be reused.

6. Remove the hose clamps.

7. Disconnect the old hose.

8. Replace the old hose with a new hose.

9. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, “Torque Specifications” “Hose Clamps” for information about selecting and installing the proper hose clamps.

10. Refill the cooling system.

11. Clean the coolant filler cap. Inspect the gaskets on the filler cap. Inspect the gasket seat. Inspect the vacuum valve and seat for debris or damage. Replace the filler cap if the gaskets are damaged. Install the filler cap.

12. Start the engine. Inspect the cooling system for leaks.

Fuel System

⚠ WARNING

Personal injury can result from removing hoses or fittings in a pressure system.

Failure to relieve pressure can cause personal injury.

Do not disconnect or remove hoses or fittings until all pressure in the system has been relieved.

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

NOTICE
Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses. Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires. Inspect all lines, tubes and hoses carefully. Tighten all connections to the recommended torque.

NOTICE
Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over any disconnected fuel system components.

Note: High-pressure fuel lines may be installed between the high-pressure fuel pump and the fuel injectors. High-pressure fuel lines are constantly charged with high pressure. Do not check the high-pressure fuel lines with the engine or the starting motor in operation. Wait for 10 minutes after the engine stops before you perform any service or repair on high-pressure fuel lines. Waiting for 10 minutes will allow the pressure to be purged.

1. Drain the fuel from the fuel system to a level that is below the hose that is being replaced.

2. Remove the hose clamps.

3. Disconnect the old hose.

Note: When servicing fuel system, use cap/s or cover/s as required to protect the system and maintain fuel system cleanliness.

4. Replace the old hose with a new hose.

5. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, “Torque Specifications” “Hose Clamps” for information about selecting and installing the proper hose clamps.

6. Carefully inspect the engine for any spilled fuel. Make sure that no fuel remains on or close to the engine.

Note: Fuel must be added to the fuel system ahead of the fuel filter.

7. Refill the fuel system. Refer to this Operation and Maintenance Manual, “Fuel System - Prime” for information about priming the engine with fuel.

8. Start the engine. Inspect the fuel system for leaks.

Lubrication System

WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

1. Drain the oil from the lubrication system to a level that is below the hose that is being replaced.

2. Remove the hose clamps.

3. Disconnect the old hose.

4. Replace the old hose with a new hose.

5. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, “Torque Specifications” “Hose Clamps” for information about selecting and installing the proper hose clamps.

6. Refill the lubrication system. Refer to this Operation and Maintenance Manual, “Engine Oil Level - Check” to ensure that the lubrication system is filled with the proper amount of engine oil.

7. Start the engine. Inspect the lubrication system for leaks.

Air System

1. Remove the hose clamps.

2. Disconnect the old hose.

3. Replace the old hose with a new hose.

4. Install hose clamps which have been inspected or install new hose clamps. Refer to Specifications, SENR3130, “Torque Specifications” “Hose Clamps” for information about selecting and installing the proper hose clamps.

Note: The bellows and the V-clamps that are used on the exhaust bellows should never be reused.

5. Start the engine. Inspect the air lines for leaks.

i03230758

Jacket Water Heater - Check

SMCS Code: 1383-535

Jacket water heaters help to improve startability in ambient temperatures that are below 21 °C (70 °F). All installations that require automatic starting should have jacket water heaters.

Check the operation of the jacket water heater. Check the operation of the circulation pump, if equipped. For an ambient temperature of 0 °C (32 °F), the heater should maintain the jacket water coolant temperature at approximately 32 °C (90 °F).

i01216962

Power Factor - Check

SMCS Code: 4450-535-PWR

The power factor of a system can be determined by a power factor meter or by calculations. The power factor can be calculated by dividing kW by kVA. Power factor is expressed as a decimal.

i06274828

Prelube Pump - Inspect

SMCS Code: 1319-040

Inspect the prelube pump for the following conditions:

- Cracks
- Pin holes
- Proper operation
- Wear

Inspect the prelube pump for leaks. Replace all of the seals if a leak is observed.

Inspect the wiring for the following conditions:

- Damage
- Fraying

Ensure that the wiring is in good condition.

Inspect the electrical connections. Ensure that the electrical connections are secure.

If repair or replacement is necessary, refer to the engine Disassembly and Assembly manual. Consult your Cat dealer for assistance.

Electric Prelube Pump

Inspect the brushes. Replace the brushes, if necessary.

i04020194

Radiator - Clean

SMCS Code: 1353-070

Note: Adjust the frequency of cleaning according to the effects of the operating environment.

Inspect the radiator for these items: damaged fins, corrosion, dirt, grease, insects, leaves, oil and other debris. Clean the radiator, if necessary.

⚠ WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

The maximum air pressure for cleaning purposes must be reduced to 205 kPa (30 psi) when the air nozzle is deadheaded.

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction of the air flow. Hold the nozzle approximately 6 mm (0.25 inch) away from the fins. Slowly move the air nozzle in a direction that is parallel with the tubes. This movement will remove debris that is between the tubes.

Pressurized water may also be used for cleaning. The maximum water pressure for cleaning purposes must be less than 275 kPa (40 psi). Use pressurized water in order to soften mud. Clean the core from both sides.

Use a degreaser and steam for removal of oil and grease. Clean both sides of the core. Wash the core with detergent and hot water. Thoroughly rinse the core with clean water.

After cleaning, start the engine and accelerate the engine to high idle rpm. This procedure will help in the removal of debris and drying of the core. Stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

Inspect the fins for damage. Bent fins may be opened with a “comb”. Inspect these items for good condition: welds, mounting brackets, air lines, connections, clamps and seals. Make repairs, if necessary.

i06686946

Rotating Rectifier - Check

SMCS Code: 4465-535

Discrete Diode Test

Check the Windings and Rotating Diodes by use of Separate Excitation

NOTICE
Ensure that the generator is disconnected from any external load and inspect the terminal box to check that the connections are fully tightened.

1. Stop the unit, disconnect, and isolate the CDVR wires.

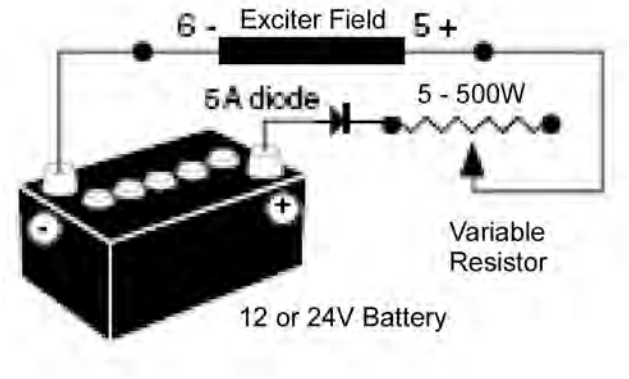

Illustration 81 g01327528

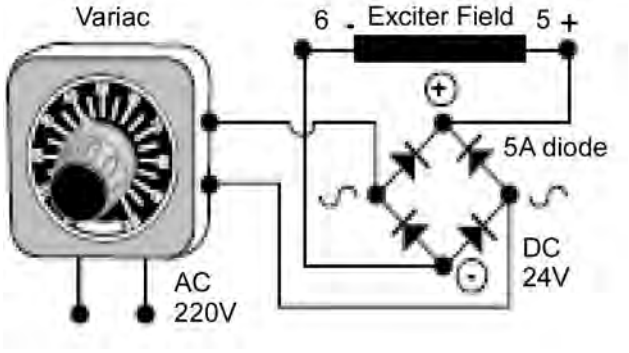

Illustration 82 g01327530

2. There are two ways of creating an assembly with separate excitation. Assemble one of the following test circuits.

Note: The voltage from a 12 V or a 24 V battery is too high regarding the required excitation voltage when running at rated engine speed. A rheostat must be used to adjust the required excitation current for the nominal voltage at no load. Refer to Illustration 81 . Refer also to Illustration 82 .

As an alternative, a 12 V battery that is directly connected may be used if running the engine at low idle speed. Refer to “Dynamic” flashing.

Both these systems should have characteristics which are compatible with the machine field excitation power. Refer to the nameplate.

3. Run the generator at the recommended speed that is used during normal operations.

4. Gradually increase the exciter field current by adjusting the rheostat and measure the output voltages on “L1- L2 - L3” . Checking the excitation voltage and current at no load and on load. Refer to the machine nameplate or ask for the factory test report.

5. When the output voltage is at rated value and is balanced within 1% for the rated excitation level, the machine is in working order. The fault therefore comes from the CDVR or associated wiring (that is sensing or auxiliary windings).

Full Wave Rectifier and Rectifier/ Varistor Rotating Heat Sink Assembly

Refer to the “Varistor - Test” section of this document for information about testing procedures.

1800 Generators Only

The full wave rectifier module including internal varistor and the external varistor module should be inspected and should be tested according to the following guidelines:

All leads, terminals, and connections should be inspected for damage and correct torque.

All test measurements should be documented to establish trending data.

Rectifier Diode Test

The following procedure tests each of the six diodes within the rectifier diode module. If any meter reading does not fall within the given ranges, replace the heat sink assembly. Refer to the “Removal/Installation” instructions.

⚠ DANGER

High voltage may be present. The power source must be disconnected before working on the equipment. Failure to disconnect the power source could result in injury or death. Verify that the equipment is not energized before performing any maintenance. This work must be performed by trained personnel with correct tools and procedures. Bodily contact with electrical potential will cause personal injury or death.

1. Remove all leads from the rectifier diode module.

2. Set the digital multimeter to the diode range.

3. Place the black test lead of the multimeter on the positive “+” rectifier diode module terminal.

4. Place the red test lead of the multimeter on each of the following rectifier diode module terminals. Begin with “AC1” , then “AC2” , and finally “AC3” .

Note: All the meter readings must be between 0.4 VDC and 1.0 VDC.

5. Place the red test lead on the negative “-” rectifier diode module terminal.

6. Place the black test lead of the multimeter on each of the following rectifier diode module terminals. Begin with “AC1” , then “AC2” , and finally “AC3” .

Note: All the meter readings should be between 0.4 VDC and 1.0 VDC.

7. Place the red test lead of the multimeter on the positive “+” rectifier diode module terminal.

8. Place the black test lead of the multimeter on each of the following rectifier diode module terminals. Begin with “AC1” , then “AC2” , and finally “AC3” .

Note: In all cases, the meter should read “OL” (overload).

9. Place the black test lead of the multimeter on the negative “-” rectifier diode module terminal.

10. Place the red test lead of the multimeter on each of the following rectifier diode module terminals. Begin with “AC1” , then “AC2” , and finally “AC3” .

Note: In all cases, the meter should read “OL” (overload).

Note: A shorted diode can damage the exciter rotor. If a diode is shorted, then check the exciter rotor. Refer to the Testing and Adjusting, KENR5284, “Winding - Test” and the Testing and Adjusting, “Insulation - Test” sections for more testing information. Perform the tests that are shown in “KENR5284” .

11. Install all the leads to the rectifier diode module. Torque the screws. The torque for the connections can range from 2.35 N·m (20.8 lb in) to 3.35 N·m (29.7 lb in).

i04524988

Standby Generator Set Maintenance Recommendations

SMCS Code: 4450-041

A standby generator set may be intermittently used. However, the generator set is needed for operation in an emergency situation. Maintenance of the standby generator set is important for the following reasons:

- The generator set must always be in excellent operating condition.
- The generator set must be ready to work under load at any time.

Establishing a Preventive Maintenance Program will provide these benefits:

- Maximum availability of the standby generator set
- Longer service life for the generator set
- Minimum of expensive repairs

Your Cat dealer can help you to establish an effective Preventive Maintenance Program for your generator set. Consult your Cat dealer for details.

Maintenance and Operation Procedures

⚠ WARNING

The high voltage that is produced by an operating generator set can cause severe injury or death. Before performing any maintenance or repairs, ensure that the generator will not start.

Place the engine control switch in the “OFF” position. Attach “DO NOT OPERATE” tags to all starting controls. Disconnect the batteries or disable the starting system. Lock out all switchgear and automatic transfer switches that are associated with the generator.

The recommended maintenance for the generator set is listed in this Operation and Maintenance Manual, “Maintenance Interval Schedule (Standby Generator Sets)” (Maintenance Section).

Maintenance and Repair

The maintenance that is recommended for Every Week can be performed by an authorized operator. The maintenance that is recommended for the subsequent maintenance intervals must be performed by an authorized service technician or by your Cat dealer.

Unless other instructions are provided, perform maintenance and repairs under the following conditions:

- The engine is stopped.
- The starting system is disabled.
- The generator does not pose an electrical shock hazard.
- The generator is disconnected from the load.

Operation

To ensure proper operation, the generator set must be exercised regularly. For instructions on operating the generator set, see the Operation and Maintenance Manual for the generator set control panel.

For these operation procedures, follow the instructions that are provided in this Operation and Maintenance Manual, “Operation Section”: starting the engine, engine operation and stopping the engine.

Record Keeping

Maintain a record in order to document these items: gauge readings, maintenance that is performed, problems and repairs.

Space Heaters

Moisture can damage generators and other electrical equipment. Make every effort to keep the generator set as dry as possible.

Generators can operate without problems in humid environments. However, problems can occur when the generator is inactive. Moisture can condense on the windings. This condition can result in poor performance. Also, damage to the windings can occur.

Use space heaters in order to help keep the windings dry. When the generator is not active, ensure that the space heaters are operating. When the generator is operating, turn OFF the space heaters.

i06274508

Starting Motor - Inspect

SMCS Code: 1451-040; 1453-040

Electric Starting Motor

If the starting motor fails, the engine may not start in an emergency situation. A scheduled inspection of the starting motor is recommended.

The starting motor pinion and the flywheel ring gear must be in good condition in order for the engine to start properly. The engine will not start if the starting motor pinion does not engage the flywheel ring gear. The teeth of the starting motor pinion and the flywheel ring gear can be damaged because of irregular engagement.

Inspect the starting motor for proper operation. Listen for grinding when the engine is started. Inspect the teeth of the starting motor pinion and the flywheel ring gear. Look for patterns of wear on the teeth. Look for teeth that are broken or chipped. If damaged teeth are found, the starting motor pinion and the flywheel ring gear must be replaced.

Problems with the electric starting motor can be caused by the following conditions: malfunction of the solenoid and malfunction of the electric starting system.

Inspect the electrical system for the following conditions:

- Loose connections
- Corrosion
- Wires that are worn or frayed
- Cleanliness

Removal and Installation of the Starting Motor

Refer to the Service Manual, “Disassembly and Assembly” module for information on removing the starting motor and installing the starting motor.

Consult your Cat dealer for assistance and/or options on replacement of the starting motor.

i03230840

Stator Lead - Check

SMCS Code: 4459-535

Ensure that the stator output leads are routed out of the generator in a manner that prevents the leads from rubbing against metal objects.

Visually inspect the following areas for cracking and physical damage:

- stator output leads
- protective sleeving
- insulation

i03725200

Stator Winding Temperature - Test

SMCS Code: 4453-081-TA

Some generators are provided with optional 100 Ohm Resistance Temperature Detectors (RTD). When the temperature of the stator winding is suspected to be high, measure the temperature. If the generator is furnished with Resistance Temperature Detectors, the detectors are installed in the slots of the main armature (stator). The detectors are used with equipment that is available from the factory. This equipment is used in order to measure the main armature's winding temperature.

i05965726

Turbocharger - Inspect

SMCS Code: 1052-040

Periodic inspection and cleaning are recommended for the turbocharger compressor housing (inlet side). Any fumes from the crankcase are filtered through the air inlet system. Therefore, by-products from oil and from combustion can collect in the turbocharger compressor housing. Over time, this buildup can contribute to loss of engine power, increased black smoke and overall loss of engine efficiency.

If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel can cause additional damage to the pistons, the valves, and the cylinder head.

NOTICE
Turbocharger bearing failures can cause large quantities of oil to enter the air inlet and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of a turbocharger housing under extended low idle operation should not cause problems as long as a turbocharger bearing failure has not occurred.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine rpm up at no load), do not continue engine operation until the turbocharger is repaired or replaced.

An inspection of the turbocharger can minimize unscheduled downtime. An inspection of the turbocharger can also reduce the chance for potential damage to other engine parts.

Note: Turbocharger components require precision clearances. The turbocharger cartridge must be balanced due to high rpm. Severe Service Applications can accelerate component wear. Severe Service Applications require more frequent inspections of the cartridge.

Removal and Installation

For options regarding the removal, installation, repair, and replacement, consult your Cat dealer. Refer to the Service Manual for this engine for the procedure and specifications.

Cleaning and Inspecting

1. Remove the exhaust outlet piping and remove the air inlet piping from the turbocharger. Visually inspect the piping for the presence of oil. Clean the interior of the pipes in order to prevent dirt from entering during reassembly.
2. Turn the compressor wheel and the turbine wheel by hand. The assembly should turn freely. Inspect the compressor wheel and the turbine wheel for contact with the turbocharger housing. There should not be any visible signs of contact between the turbine wheel or compressor wheel and the turbocharger housing. If there is any indication of contact between the rotating turbine wheel or the compressor wheel and the turbocharger housing, the turbocharger must be reconditioned.
3. Check the compressor wheel for cleanliness. If only the blade side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system. If oil is found only on the back side of the wheel, there is a possibility of a failed turbocharger oil seal.

   The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the inlet air (plugged air filters), which causes the turbocharger to slobber.
4. Inspect the bore of the turbine housing for corrosion.
5. Clean the turbocharger housing with standard shop solvents and a soft bristle brush.
6. Fasten the air inlet piping and the exhaust outlet piping to the turbocharger housing.

i03291822

Varistor - Check

SMCS Code: 4466-535

The varistor must be checked at regular intervals. Refer to Systems Operation/Testing and Adjusting, KENR5284, “Varistor - Test” for instructions.

i06686997

Varistor - Inspect

SMCS Code: 4466-040

The varistor must be visually inspected at regular intervals. For generator sets with 1800 frames, physical signs of failure indicate that replacement of the varistor is necessary.

i01189996

Voltage and Frequency - Check

SMCS Code: 4450-535-EL

Check for proper voltage and frequency setting. Check for stability.

Refer to the generator set Serial Plate for correct voltage and frequency.

i05264229

Walk-Around Inspection

SMCS Code: 1000-040

⚠ WARNING

Personal injury or death can result from improper troubleshooting and repair procedures.

The following troubleshooting and repair procedures should only be performed by qualified personnel familiar with this equipment.

Inspect the Engine for Leaks and for Loose Connections

A walk-around inspection should only take a few minutes. When the time is taken to perform these checks, costly repairs and accidents can be avoided.

For maximum engine service life, make a thorough inspection of the engine compartment before starting the engine. Look for items such as oil leaks or coolant leaks, loose bolts, worn belts, loose connections, and trash buildup. Make repairs, as needed:

- The guards must be in the proper place. Repair damaged guards or replace missing guards.
- Wipe all caps and plugs before the engine is serviced in order to reduce the chance of system contamination.

NOTICE
For any type of leak (coolant, lube, or fuel) clean up the fluid. If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more often than recommended until the leak is found or fixed, or until the suspicion of a leak is proved to be unwarranted.

NOTICE
Accumulated grease and/or oil on an engine or deck is a fire hazard. Remove this debris with steam cleaning or high pressure water.

- Ensure that cooling lines are properly clamped. Check for leaks. Check the condition of all pipes.
- Inspect the water pump for coolant leaks.

Note: The water pump seal is lubricated by coolant in the cooling system. It is normal for a small amount of leakage to occur as the engine cools down and the parts contract.

Excessive coolant leakage may indicate the need to replace the water pump seal. For the removal of water pump and the installation of water pump and/or seals, refer to the Service Manual for the engine or consult your Cat dealer.

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters, and the valve cover.
- Inspect the Closed Crankcase Ventilation (CCV) filter, if equipped. If the restriction indicator is visible, service the CCV.
- Inspect the fuel system for leaks. Look for loose fuel line clamps.
- Inspect the piping for the air inlet system and the elbows for cracks and for loose clamps.
- Inspect the alternator belt and the accessory drive belts for cracks, breaks, or other damage.

Belts for multiple groove pulleys must be replaced as matched sets. If only one belt is replaced, the belt will carry more load than the belts that are not replaced. The older belts are stretched. The additional load on the new belt could cause the belt to break.

- Drain the water and the sediment from fuel tanks on a daily basis in order to ensure that only clean fuel enters the fuel system.
- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires.
- Inspect the ground strap for a good connection and for good condition.
- Inspect the engine-to-frame ground strap for a good connection and for good condition.
- Disconnect any battery chargers that are not protected against the current drain of the starting motor. Check the condition and the electrolyte level of the batteries, unless the engine is equipped with a maintenance free battery.
- Check the condition of the gauges. Replace any gauges that are cracked. Replace any gauges that cannot be calibrated.

Inspect the Generator

Refer to Safety Section, “Generator Isolating for Maintenance” for information regarding the procedure to isolate the generator safely.

A visual inspection should be initially directed at the areas that are most prone to damage and deterioration. The most prone areas to damage and deterioration are listed below:

Ground insulation – Ground insulation is insulation that is intended to isolate components that are carrying current from components that are not carrying current.

Support insulation – Support insulation is made from one of the following items: a compressed lamination of fibrous materials, polyester, or felt pads that have been impregnated with various types of bonding agents.

There are many different types of damage that can occur in these areas. Several of the different types of damage are listed below:

Thermal aging – Thermal aging can cause the degradation of insulation or the deterioration of insulation. An examination of the coils may reveal that the insulation has expanded into the ventilation ducts. This is the result of a loss of bond which will cause the insulation material to separate. The insulation material could also separate from the conductors on the windings.

Abrasion – The surfaces of coils and the surfaces of connectors may be damaged by abrasion. These surfaces may also be damaged by contamination from other sources. An example of these sources would be chemicals or abrasive substances.

Cracking – Cracking of insulation may result from mechanical stress. The structure that is used to brace the stator winding will become loose if the problem is not corrected. Further mechanical damage or electrical damage may also result.

Erosion – Erosion can be caused when foreign substances rub against the insulation that is on the surface of the coil .

i05264233

Water Pump - Inspect

SMCS Code: 1361-040

A failed water pump might cause severe engine overheating problems that could result in the following conditions:

- Cracks in the cylinder head
- A piston seizure
- Other potential damage to the engine

A failed water pump might cause severe engine overheating problems. Overheating could result in cracks in the cylinder head, a piston seizure, or other potential damage to the engine.

Visually inspect the water pump for leaks. If leaking of the water pump seals is observed, replace all of the water pump seals. Refer to two articles in the Disassembly and Assembly Manual, “Water Pump - Disassemble and Water Pump - Assemble” for the disassembly and assembly procedure. If necessary to remove the water pump, refer to two articles in the Disassembly and Assembly Manual, “Water Pump - Remove and Water Pump - Install”.

Inspect the water pump for wear, cracks, pin holes, and proper operation. Refer to the Parts Manual for the correct part numbers for your engine or consult your Cat dealer if repair is needed or replacement is needed.

Warranty Section

Warranty Information

i04342956

Warranty Information

SMCS Code: 1000

Engine Protection Plans

Extended Warranties and Service Contracts

A wide variety of protection plans are available for Cat Engines. Consult your Cat dealer for detailed information on the specific programs and coverages that are available.

Consult your Cat dealer for information on a plan that is tailored in order to fit your requirements.

i01237445

Emissions Warranty Information

SMCS Code: 1000

This engine may be certified to comply with exhaust emission standards and the engine may be covered by an Emissions Warranty. A detailed explanation of the Emissions Warranty that is applicable to emissions certified engines is found in Supplement, SMBU6981, “Federal Emissions Control Warranty Information For U.S., Canada, and California”. Consult your authorized Caterpillar dealer in order to determine if your engine is emissions certified and if the engine is subject to an Emissions Warranty.

Reference Information Section

Engine Ratings

i00727327

Engine Rating Conditions

SMCS Code: 1000

All engine ratings are in compliance with the following standard ambient air conditions of “SAE J1349”:

- 99 kPa (29.3 inches of Hg)
- 30 percent relative humidity
- A temperature of 25 °C (77 °F)

Ratings relate to the standard conditions of “ISO8665”, of “ISO3046/1”, of “DIN6271”, and of “BS5514”.

The engine ratings are based on the following fuel specifications:

- Low heat value (LHV) of the fuel of 42 780 kJ/kg (18,390 Btu/lb) at 29 °C (84 °F)
- Gravity (API) of 35 degrees at 15 °C (60 °F)
- Specific gravity of .849 at 15 °C (60 °F)
- Density of 850 kg/m^3 (7.085 lb/US gal)

The engine ratings are gross output ratings.

Gross Output Ratings – The total output capability of the engine that is equipped with standard accessories.

Standard accessories include the following components:

- Oil pumps
- Fuel pumps
- Water pumps

Subtract the power that is required to drive auxiliary components from the gross output. This will produce the net power that is available for the external load (flywheel).

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Engine Rating Definitions

SMCS Code: 1000

Table 28

	Power Rating			
	Emergency Standby Power (ESP)[1]	Standby[1]	Prime	Mission Critical Standby
Average power output	70% of ESP rating	70% of standby power	70% of prime power rating	85% of Standby
Load[2]	Varying	Varying	Varying	Varying
Typical hours per year	50	200	Unlimited	200
Maximum expected usage (hours per year)	200	500	n/a	500
Typical peak demand	n/a	n/a	100% of prime rated ekW with 10% overload capability for emergency use for a maximum of 1 hour in 12. The generator set cannot be operated at overload for more than 25 hours per year.	100% of continuous rated ekW for 100% of operating hours.
Typical application	Building service standby	Standby	Industrial, pumping, construction, rental generator set, or cogeneration	Base load, utility, or cogeneration

(1) Power is available during an emergency outage.
(2) The typical load factor is the sum of the loads a generator set experiences during operation under load divided by the number of hours the generator set operates under those loads. Extended idling time does not enter into the calculation for the load factor. Time that the generator set is not operating does not enter into the calculation for the load factor.

Operating units above these rating definitions results in a shorter life before an overhaul.

Customer Service

i05133089

Customer Assistance

SMCS Code: 1000; 4450

USA and Canada

If a problem arises concerning the operation or service of an engine, the problem will be managed by the dealer in your area.

Your satisfaction is a primary concern to Caterpillar and to Cat dealers. If you have a problem that has not been handled to your complete satisfaction, follow these steps:

1. Discuss your problem with a manager from the dealership.

2. If your problem cannot be resolved at the dealer without additional assistance, use the phone number below to talk with a Field Service Coordinator:

1-800-447-4986

The normal hours are from 8:00 to 4:30 Monday through Friday Central Standard Time.

3. If your needs have not been met still, submit the matter in writing to the following address:

Caterpillar Inc.
Electric Power North America
Attn: Product Support Manager
AC 6109
Mossville, Illinois 61552

Keep in mind: probably, your problem will ultimately be solved at the dealership, using the dealership facilities, equipment, and personnel. Therefore, follow the steps in sequence when a problem is experienced.

Outside of USA and of Canada

If a problem arises outside of USA and outside Canada, and if the problem cannot be resolved at the dealer level, consult the appropriate Caterpillar office.

Latin America, Mexico, Carribean
Caterpillar Americas Co.
701 Waterford Way, Suite 200
Miami, FL 33126-4670
USA
Phone: 305-476-6800
Fax: 305-476-6801

Europe, Africa, and Middle East
Caterpillar Overseas S.A.
76 Route de Frontenex
P.O. Box 6000
CH-1211 Geneva 6
Switzerland
Phone: 22-849-4444
Fax: 22-849-4544

Far East
Caterpillar Asia Pte. Ltd.
7 Tractor Road
Jurong, Singapore 627968
Republic of Singapore
Phone: 65-662-8333
Fax: 65-662-8302

China
Caterpillar China Ltd.
37/F., The Lee Gardens
33 Hysan Avenue
Causeway Bay
G.P.O. Box 3069
Hong Kong
Phone: 852-2848-0333
Fax: 852-2848-0440

Japan
Caterpillar Japan Ltd.
SBS Tower
10-1, Yoga 4-Chome
Setagaya-Ku, Tokyo 158-8530
Japan
Phone: 81-3-5717-1150
Fax: 81-3-5717-1177

Australia and New Zealand
Caterpillar of Australia Ltd.
1 Caterpillar Drive
Private Mail Bag 4
Tullamarine, Victoria 3043
Australia
Phone: 03-9953-9333
Fax: 03-9335-3366

i07254661

Ordering Replacement Parts

SMCS Code: 4450; 7567

WARNING

When replacement parts are required for this product Caterpillar recommends using Caterpillar replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.

Failure to heed this warning can lead to premature failures, product damage, personal injury or death.

Quality Caterpillar replacement parts are available from Caterpillar dealers throughout the world. Caterpillar dealers' parts inventories are up-to-date. The parts stocks include all of the parts that are normally needed to protect your Caterpillar engine investment.

When you order parts, please specify the following information:

- Part number
- Part name
- Quantity

If there is a question concerning the part number, please provide your dealer with a complete description of the needed item.

When a Caterpillar engine requires maintenance and/or repair, provide the dealer with all the information that is stamped on the Information Plate. This information is described in this Operation and Maintenance Manual (Product Information Section).

Discuss the problem with the dealer. Inform the dealer about the conditions of the problem and the nature of the problem. Inform the dealer about when the problem occurs. This will help the dealer in troubleshooting the problem and solving the problem faster.

Reference Materials

i05264255

Maintenance Records

SMCS Code: 1000; 4450

Caterpillar Inc. recommends the retention of accurate maintenance records. Accurate maintenance records can be used for the following purposes:

- Determine operating costs.
- Establish maintenance schedules for other engines that are operated in the same environment.
- Show compliance with the required maintenance practices and maintenance intervals.

Maintenance records can be used for various other business decisions that are related to engine maintenance.

Maintenance records are a key element of a maintenance program that is managed. Accurate maintenance records can help your Cat dealer to fine-tune the recommended maintenance intervals in order to meet the specific operating situation. This should result in a lower engine operating cost.

Records should be kept for the following items:

Fuel Consumption – A record of fuel consumption is essential in order to determine when the load sensitive components should be inspected or repaired. Fuel consumption also determines overhaul intervals.

Service Hours – A record of service hours is essential to determine when the speed sensitive components should be inspected or repaired.

Documents – These items should be easy to obtain, and these items should be kept in the engine history file. All of the documents should show this information: date, service hours, fuel consumption, unit number and engine serial number. The following types of documents should be kept as proof of maintenance or repair for warranty:

Keep the following types of documents as proof of maintenance for warranty. Also, keep these types of documents as proof of repair for warranty:

- Dealer work orders and itemized bills
- Owner repair costs
- Owner receipts
- Maintenance log

i01176304

Maintenance Log

SMCS Code: 1000; 4450

Table 29

Engine Model	Customer Identifier
Serial Number	Arrangement Number

Service Hours	Quantity Of Fuel	Service Item	Date	Authorization

i05975063

Reference Material

SMCS Code: 1000; 4450

Additional literature regarding your product may be purchased from your local Cat dealer or by visiting www.cat.com. Use the product name, sales model, and serial number in order to obtain the correct information for your product.

i03696960

Decommissioning and Disposal

SMCS Code: 1000

When the generator set is removed from service, local regulations for the generator set decommissioning will vary. Disposal of the generator set will vary with local regulations. Consult the nearest Caterpillar dealer for additional information.

i02342531

Symbols

SMCS Code: 1000; 4450; 4480; 4490

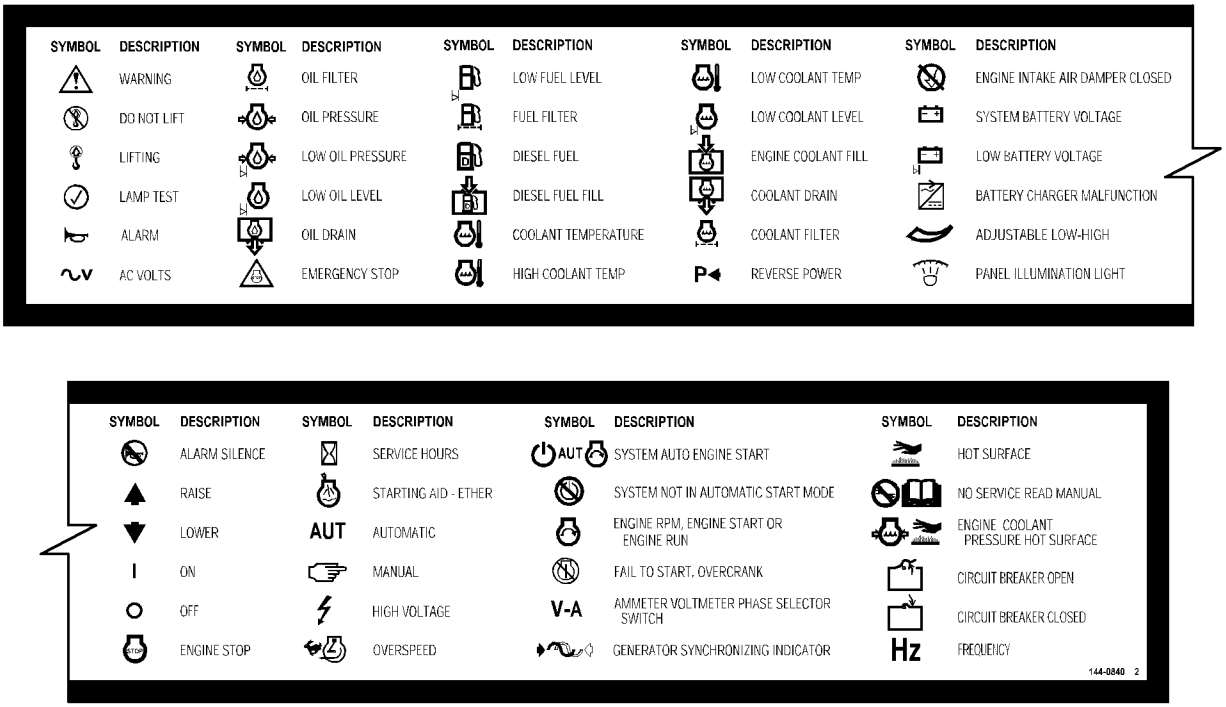


Illustration 83 g01168026

The control panel and modules utilize International Graphic Symbols to identify functions.

A typical list of the symbols that are used is shown above.

i07174155

Glossary

SMCS Code: 4450

Actuate – Actuation relates to putting something in motion.

Alternating Current (AC) – Alternating Current is an electric current that reverses direction at regular intervals. The intervals are (50 times per second in 50 Hz or 60 times per second in 60 Hz).

Anode – An anode is the positive end of a diode or an anode is the positive end of a rectifier.

Blocking Rectifier – A blocking rectifier permits direct current flow in only one direction.

Bolted – A bolted device uses a bolt to hold two or more parts together.

Bridge – A bridge is a circuit that is used to measure small quantities of current, voltage, or resistance.

Bridge Rectifier – A bridge rectifier is a circuit that is used to change alternating current (AC) to direct current (DC).

Buildup – A buildup is a gradual increase in voltage.

Cathode – A cathode is the negative end of a diode or a cathode is the negative end of a rectifier.

Capacitance – Capacitance is the ability to store an electrical charge.

Capacitor – A capacitor is a device that will store an electrical charge.

Circuit Breaker – A circuit breaker is an automatic switch that is used to open a circuit.

Circulating Current – Circulating current is the flow of current between two or more generators that are working in parallel. Circulating current is also the flow of current between two or more generators that are parallel with a utility line.

Conduct – Conducting relates to allowing the flow of current.

Constant Voltage Regulation – Constant Voltage Regulation is one of the two methods of voltage regulation. To maintain the line voltage, Constant voltage regulators allow the field to be forced to the saturation point. This process allows the engine to be overloaded. On large block load applications, the engine may not recover.

Continuity – Continuity provides a path for current flow.

Control – A control is a device that controls another device. A control is also a circuit that controls a device.

Cross Current Compensation – Cross current compensation is a method that is used for reactive power equalization.

Current Transformer (CT) – A current transformer is used to step down higher line current.

Direct Current (DC) – Direct current is current flow that moves in only one direction in a given circuit.

Damping – Damping refers to decreasing the amplitude of a signal.

DEAC – Diesel Engine Antifreeze/Coolant

De-energized – A de-energized input refers to stopping the current that is going to a component.

Distribution Winding – Distribution windings go from one end of the core to the other end of the core. These windings are arranged in groups that are located in several slots.

Droop – Droop refers to a decrease.

Electrostatic Charge – Electrostatic charge is electricity that is caused by induced voltage and stored charge.

Energized – An energized input refers to activating a device.

Engine Load Factor – Used to read and program an engine load percentage at the current engine speed. Calculation is based on current fuel rate, idle (no load) fuel rate, and rated fuel rate.

Exciter – An exciter supplies direct current (DC) to the field windings of the generator.

Excitation – Excitation is controlled direct current (DC) that is used to make a magnetic field.

Field – A field is a magnetic line of force that surrounds a conductor. This force is caused by current flow in the conductor.

Field Windings – Field windings are many turns of wire that are wrapped around an iron core. When direct current (DC) flows through the field windings, a magnetic field is produced. This magnetic field is comparable to the magnetic field of a bar magnet.

Flashing – Flashing is a process of putting direct current from an external source into the field windings. This process causes the generator to produce an output voltage.

Flux – Flux is magnetic lines of force.

Frequency – Frequency is the number of cycles that are completed in a one second period. The unit of frequency is the Hertz (Hz). 1 Hz is equal to 1 cycle per second.

Fuel Rate Based Percent Engine Load Factor – This parameter is used to measure the engine load based on fuel usage. This engine load indicates the total load on the engine. When the engine is running in diesel only mode at rated speed, the engine load factor will equal the fuel rate-based percent engine load factor.

Full-Wave Rectifier – A full-wave rectifier changes the positive phase and the negative phase of alternating current to direct current.

Gain – Gain relates to the ratio of input magnitude to output magnitude.

Gate – A gate is an electronic part of a controlled rectifier (thyristor).

Generate – The production of electricity.

Generator Load Factor – The ratio of the average load to the peak load in a specified period. The average load is divided by the peak load.

Generator Total Apparent Power – The product of the voltage times the total current flow which is expressed in terms of VA or kVA.

Generator Total Real Power – The product of the voltage times the component of the total current that is in phase with the voltage is expressed in W or kW.

Grounded – A device is grounded by making a connection to ground. A device could also be grounded by making a connection to a component that is connected to ground.

Hertz (Hz) – Hertz is the unit of measurement for frequency. 1 Hz is equal to 1 cycle per second.

Humidity – Humidity is the water content that is present in the air.

Impedance – Impedance is the resistance to alternating current.

Impulse Modulation – Impulse modulation changes the following characteristics of a wave: amplitude, frequency, and phase. Impulse modulation is accomplished by impressing one wave on another wave that has constant properties.

Induce – Induce refers to the transfer of power from one device to another device. The transfer is done via a magnetic field or via an electric field.

Interference – Interference is an unwanted mixture of electrical signals. Interference is associated with electrical noise.

Internally Excited (IE) – Is an excitation system based on two auxiliary windings integrated into the main stator winding suppling power to the voltage regulator only.

Instrumentation – Instrumentation is a group of instruments that are used for measuring a system function.

Insulated – An insulated device is a device that is covered with a nonconductive material.

kVA – Abbreviation for Kilovolt Amperes. kVA is a term that is used when electrical devices are rated. To calculate the kVA rating of a device, multiply the rated output (amperes) by the rated operating voltage.

KVAR – Kilovolt Amperes Reactive is abbreviated as KVAR. KVAR is associated with the reactive power that flows in a power system. Reactive power does not load the generator set engine. Reactive power will cause thermal loss in the generator.

KVAR Regulation – KVAR Regulation is one of the two methods that are used to regulate the reactive power output. Regardless of the generator real power output, the voltage regulator causes the generator to produce a constant value of KVAR. In this case, the power factor of the generator will change when the real power output changes. KVAR regulation is used when the generator is connected in parallel with an

infinite bus (utility). KVAR regulation is used when changing the system voltage is not possible.

Kilowatts (kW) – Kilowatt is the electrical rating of the generator. 1 kW equals 1000 W. Actual power is measured in kilowatts.

Lead – A lead is a wire.

Line Voltage – Line voltage is the output voltage of the generator that is measured between the generator leads (phases).

Lock In – Lock-in occurs when a contact closes to keep a device in an energized state.

Lock Out – Lockout occurs when a contact opens to keep a device in a de-energized state.

Magnetic – A magnetic device is a device that has the characteristics of a magnet.

Magnification – Magnification refers to the enlargement of an item.

Module – A module is an assembly of electronic components and electronic circuits.

Moisture – Moisture is the presence of water.

Open Crankcase Ventilation (OCV) – A method to remove oil mist from engine fumes, and return the liquid oil back to the pan. OCV uses a specific type of filter

Oscillation – Oscillation is the flow of electricity that periodically changes direction and/or magnitude.

Permanent Magnet (PM) – A permanent magnet supplies the initial magnetism that is required to start a PMPE generator.

Permanent magnet pilot excited (PMPE) – A PMPE generator receives power for the voltage regulator from a pilot exciter. A PMPE generator consists of a permanent magnet and a pilot exciter.

PF Regulation – PF Regulation is one of the two ways to regulate the reactive power output. PF regulation is used when the generator is connected in parallel with an infinite bus (utility). PF regulation is used when controlling the system voltage is not possible.

Phase Winding – A phase winding is a group of generator stator coils. Electric power for one phase of the load is induced in the phase winding.

Polarity – Polarity is the positive characteristics or the negative characteristics of two poles.

Power Factor (PF) – Power factor is the ratio of apparent power (kVA) to total power (kW). The power factor represents the portion of the current that is doing useful work. Power factor is expressed as a decimal number between 0 and 1.

Pulsating – Pulsating relates to the characteristics of current that are like mechanical vibration.

Radio Suppression – Radio suppression reduces the amplitude of radio frequency interference.

Reactive Droop Compensation – Reactive Droop Compensation is one of the two methods that are used for reactive power equalization. In reactive droop compensation, the voltage regulator causes an individual generator output to change in proportion to the reactive current. This reactive current is measured with a current transformer.

Reactive Power – Reactive power flows back and forth between the inductive windings of the generator. These windings are part of the electrical load. The reactive power does not perform any useful work in the electrical load. The reactive power only applies load to the generator which limits the capacity of the generator .

Reciprocating – Reciprocating motion is motion that first moves in a straight line in one direction. The direction of this motion then varies by 180 degrees.

Rectifier – A rectifier is a diode circuit that converts alternating current (AC) to direct current (DC).

Regenerative Power – Regenerative power works against primary power.

Reset – A reset returns a switch to a ready condition. In addition, a reset returns a circuit to a ready condition.

Residual Magnetism – Residual magnetism is a small amount of magnetism that is remaining in a device after excitation is removed.

RFA – An RFA is a rotating field assembly.

Rotating Rectifier – A rotating rectifier is mounted to a plate on a generator shaft. This plate then rotates with the generator shaft.

Rotor – A rotor is the rotating windings of a generator.

Saturable Reactor – A saturable reactor has characteristics that are like a valve. As the load changes, a valve opens to give more current to the output. A valve closes to give less current to the output.

Saturated – A device has been saturated when the device has been magnetized in excess. When saturation occurs, a large increase in current results in a small increase in magnetic force.

SCR – An SCR is a silicon-controlled rectifier. An SCR is a semiconductor.

SE – An SE generator is a self-excited generator. An SE generator uses a small part of the generator output to provide excitation current back to the generator. An SE generator uses residual magnetic field for start-up.

Semiconductor – A semiconductor is a component such as one of the following components: a transistor, a diode, and a thyristor. Semiconductors have electrical characteristics that are between a conductor and insulation.

Series Boost – A series boost is an attachment that allows generator output to continue for a short time during a line failure. This process allows the circuit breaker to trip in sequence.

Short – A short is an undesired electrical connection that exists between two or more components.

Shutdown – A shutdown occurs when the engine is stopped. This shutdown can occur manually or this shutdown can occur automatically.

Simultaneous – A simultaneous occurrence refers to two actions that happen at the same time.

Solid-State – A solid-state component is an electrical component that has no moving parts.

Stator – A stator is the windings of a generator that do not rotate.

Surge – A surge is a sudden increase in voltage or current.

Tap – A tap is a connection at the midpoint of a circuit. From this tap, power is taken from the circuit.

Transfer – A transfer refers to moving something from one point to another point. A transfer also refers to converting something from one state to another state.

Transient Peak Voltage – A transient peak voltage is a high-voltage condition of limited duration.

Turn-on – When a device is turned on, the device is activated or the device is started.

Varistor – A varistor is a device that loses resistance as voltage increases.

Voltage Droop Resistor – A voltage droop resistor is a variable resistor. This resistor is used to control the change of voltage. The change of voltage can occur when a generator is paralleled with another generator. The change of voltage can also occur when the generator is paralleled with a utility.

Voltage Level Rheostat – A voltage level rheostat gives a range of control that is used when the voltage output level is adjusted.

Voltage Regulator – A voltage regulator is a circuit that senses the output voltage of the generator . The field coil current is automatically adjusted to maintain the desired output.

Voltage Spike – A voltage spike is a brief high voltage.

Volts per Hertz Regulation – Under block loading conditions, the Volts per Hertz Regulation provides fast recovery. This regulation maintains close voltage control over the normal load range. This regulation also produces a rapid response of the generator set. This control is maintained by matching the generator output to the engine performance.

Windings – Windings are layers of wire on a core.

Wiring – Wiring relates to the wires of a circuit.

Wound – Wound refers to being circled.

Index

F

G

Product and Dealer Information

Note: For product identification plate locations, see the section “Product Identification Information” in the Operation and Maintenance Manual.

Delivery Date: _____

Product Information

Model: _____

Product Identification Number: _____

Engine Serial Number: _____

Transmission Serial Number: _____

Generator Serial Number: _____

Attachment Serial Numbers: _____

Attachment Information: _____

Customer Equipment Number: _____

Dealer Equipment Number: _____

Dealer Information

Name: _____ Branch: _____

Address: _____

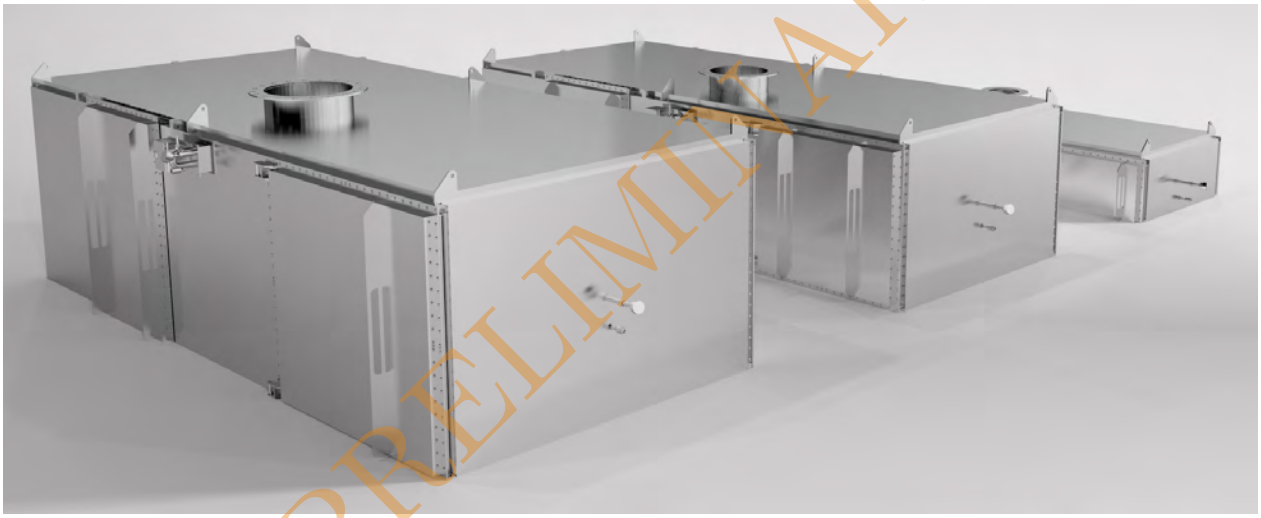
_____

_____

	Dealer Contact	Phone Number	Hours
Sales:	_____	_____	_____
Parts:	_____	_____	_____
Service:	_____	_____	_____

ecoCUBE® Operation and Maintenance Manual

99003002 Rev 2.2.9



Safety Power Project Number: 23268-1
Safety Power Part Number: SERIES 5
Designed For: C175-16
Prepared For: ALTORFER POWER SYSTEMS

safety POWER

This manual is originally written in English. All other language versions of this manual are translations of the original document.

Contents

Abbreviations

BAS	Building Automation System
DEF	Diesel Exhaust Fuild (Urea / AdBlue)
DPF	Diesel Particulate Filter
E-Stop	Emergency Stop
HMI	Human Machine Interface
IDV	Internal Diverter Valve
MSDS	Material Safety Data Sheet
OC	Oxidation Catalyst
O&M	Operation and Maintenance
PPE	Personal Protective Equipment
SCR	Selective Catalytic Reduction
SP	Safety Power Inc.
ULSD	Ultra-Low Sulfur Diesel

Chapter 1

General Information

1.1 Safety Power Inc. Contact Information

Safety Power Inc.
26-5155 Spectrum Way
Mississauga, ON, L4W 5A1, Canada

Phone: 1(800) 657 - 1280
Fax: (416) 477 - 2709
Website: www.safetypower.com
Information Email: info@safetypower.com
Support Email: support@safetypower.com

In this manual, Safety Power Inc. is hereinafter referred to as SP.

1.2 Introduction

This document is the Operation and Maintenance (O&M) Manual for the ecoCUBE® emission control system and ancillary equipment. It consists of instructions and safety notices regarding all stages of the life-cycle of the ecoCUBE® and ancillary equipment. Any individual interacting with the ecoCUBE® and/or ancillary equipment must read and understand the portion(s) of this manual related to the activity

they are conducting. In addition, familiarity with the entirety of the O&M is recommended.

The contents of this document does not constitute or modify any part of a previous or existing agreement, consent, or legal relationship. All of SP's obligations are stipulated in the respective sales contracts, which also include the complete and solely valid warranty provisions. These contractual warranty provisions are neither extended nor restricted through this documentation.

1.3 Copyright and Industrial Property Rights

This manual shall be kept in confidence. It shall only be made accessible to authorized persons. You are not permitted to copy this manual or to release the information therein to any other party without prior explicit written authorization. Offenders shall be liable for damage.

1.4 Operator Notes

''Operator'' is defined as any individual overseeing or responsible for the transportation, installation, operation, troubleshooting, maintenance, or disposal of the ecoCUBE® and/or ancillary equipment.

''Operating staff'' is any individual under the supervision of the operator who carries out tasks associated with the ecoCUBE® and/or ancillary equipment. Operating staff responsible for the transportation, installation, operation, troubleshooting, maintenance, or disposal of the ecoCUBE® and/or ancillary equipment must be appropriately qualified for these tasks. Areas of responsibility, levels of authority and the supervision of the personnel must be precisely defined by the operator.

This O&M Manual is an essential part of the equipment. Since this manual will be frequently used at the job-site, the operator is responsible for:

- keeping the original copy in safe custody,
- ensuring that a copy of this manual is constantly available with the equipment for reference,
- ensuring that all operating staff are familiar with and abides by the stipulations of the manual, with respect to the work they undertake.

The operator is responsible for supplementing this manual by the addition of existing local and federal laws, company-specific rules and regulations pertaining to, but not limited to, accident prevention, environmental protection, and safe workplace policies. Operator must ensure that all job-site safety policies and rules regarding competent work are observed by all operating staff.

The operator or operating staff must not carry out any modifications, additions, or repairs on the ecoCUBE® and/or ancillary equipment, without prior approval of SP. This particularly applies to situations which may compromise the safety of individuals interacting with the ecoCUBE® and/or ancillary equipment.

1.5 Training

All operators and operating staff must attend equipment-specific training conducted by a SP employee or approved SP source, prior to operating the ecoCUBE® and/or ancillary equipment. The training is typically conducted during the comissioning of the ecoCUBE® and/or ancillary equipment by the SP commissioning staff. If required, separate training may be scheduled by contacting SP. It is the responsibility of all training attendees to ensure that they completely understand the training provided, as it is critical for the safe operation of the ecoCUBE® and/or ancillary equipment. Record of training attendance must be captured in 99001018 Operator Training Attendance Sheet.

Additionally, the operator is obliged to train the operating staff on existing statutory provisions and accident prevention regulations, as well as to inform and instruct the staff on existing site-specific safety provisions. During the training, different technical qualifications of the staff shall be considered. Record of training attendance must be documented.

Chapter 2

Health and Safety

2.1 General Safety Information

The ecoCUBE® and/or ancillary equipment, being industrial machinery, may pose a risk of injury or damage in the following situations:

- Unintended or incorrect usage of the ecoCUBE® and/or ancillary equipment
- If transport & storage, installation, commissioning, operation, troubleshooting, maintenance, or decommissioning & disposal-related tasks are performed by unqualified or untrained personnel
- Unauthorized product modification
- Non-compliance with the safety instructions and warning presented in this manual and on the ecoCUBE® and/or ancillary equipment

In order to minimize the risk of injury or damage, it is recommended that all operators and operating staff be familiar with the contents of this manual.

2.2 Intended Use

The ecoCUBE®, CP100 control panel, and all ancillary equipment are designed to reduce any combination of oxides of nitrogen (NOx), particulate matter (PM), volatile organic components (VOC), and sound levels emanating from the exhaust of an internal combustion engine, through a combination of technologies including selective catalytic reduction (SCR), diesel particulate filters (DPF), oxidation catalysts (OC), and silencing modules, respectively.

All transport & storage (Chapter 4), installation (Chapter 5), commissioning (Chapter 6), operation (Chapter 7), troubleshooting (Chapter 8), maintenance (Chapter 9), and decommissioning & disposal-related tasks (Chapter 10) pertaining to the ecoCUBE® and all ancillary equipment must be conducted in compliance with the stipulations of this manual.

Any use of the product deviating from the stipulations within this manual is not in compliance with regulations and SP is not liable for any damages resulting therefrom.

2.3 Product Modification

Unauthorized changes to any product or a deviation from its intended use can compromise safety.

Changes or modifications shall be considered to comply with the intended use of the product only with express written authorization from SP. SP shall not be held liable for any damages resulting from unauthorized changes or modifications.

2.4 Administrative and Organizational Requirements

2.4.1 Customer Responsibilities

It is the responsibility of the customer to ensure that:

1. This manual be provided to the operator so that they may provide it in an accessible manner to all operating staff.
2. The ecoCUBE® and/or ancillary equipment are handled in compliance with all the stipulations of this manual.
3. A safe work environment is provided to the operator and operating staff, including but not limited to:
    - Fire alarms, fire extinguishers, eye rinsing stations, emergency showers, etc., as required
    - An up-to-date emergency procedure in the case of emergency shut-downs, fires, or system failures
    - Regular staff training on the emergency protocol
    - Plant cleanliness (legible warning labels, removing trip/slip hazards, etc.)

2.4.2 Personnel Requirements

All commissioning, operation, troubleshooting, maintenance, and decommissioning work on the ecoCUBE® and/or ancillary equipment are to be conducted by individuals trained by an SP employee or an approved SP source. They must be physically and mentally capable of completing the relevant tasks without creating additional hazards or exacerbating hazards that are already present. They must read, understand, and perform tasks in compliance with the O&M Manual.

Any individuals responsible for the transport, installation, and disposal work must be also be physically and mentally capable of completing the relevant tasks without creating additional hazards or exacerbating hazards that are already present. They must read, understand, and perform tasks in compliance with the O&M Manual.

2.5 Safety Icons

A variety of safety symbols/icons/pictograms are used within this manual and on the ecoCUBE® to facilitate the clear and concise communication of risks. Table 2.1, Table 2.2, and Table 2.3 provide a comprehensive list of symbols used and their meanings.

Table 2.1: Warning Symbols Used

Symbol	Description
	General warning sign
	Hot surface
	Electricity hazard
	Flammable material
	Overhead load
	Falling parts

Table 2.2: Mandatory Action Symbols Used

Symbol	Description
	General mandatory action sign
	Wear foot protection (safety boots)
	Wear eye protection (safety glasses)
	Wear ear protection
	Wear head protection (hardhat)
	Wear high visibility clothing
	Wear a safety harness (fall-arrest equipment)
	Wear protective gloves (heat-resistant gloves)
	Wear protective clothing
	Wear respiratory protection

Table 2.3: Prohibition Symbols Used

Symbol	Description
	General prohibition sign
	Do not walk or stand here
	Do not forklift
	Do not weld

2.5.1 Operation & Maintenance Manual Safety Notices

The following notices are used throughout this manual to indicate hazardous situations that may arise when conducting tasks associated with the ecoCUBE® and/or ancillary equipment. They are categorized into four levels of risk:

DANGER

Indicates a situation involving imminent danger.

- Lists out actions required to eliminate or reduce the risk of hazard
- Ignoring these action items could lead to death, serious, or permanent injury

WARNING

Indicates a situation involving potential danger.

- Lists out actions required to eliminate or reduce the risk of hazard
- Ignoring these action items could lead to serious or permanent injury

CAUTION

Indicates a situation involving potential danger.

- Lists out actions required to eliminate or reduce the risk of hazard
- Ignoring these action items could lead to minor or moderate injuries that are reversible through medical attention or first-aid

NOTICE

Indicates a situation involving potential damage to the ecoCUBE® and/or other material damage.

- Lists out actions required to eliminate or reduce the risk of hazard
- Ignoring this notice could lead to material damage

2.5.2 ecoCUBE® Warning Labels

The following set of warning labels are used on the ecoCUBE®.

Figure 2.1: Found on all surfaces, except bottom

Figure 2.2: If applicable, found on all side surfaces

Figure 2.3: Found on top surface

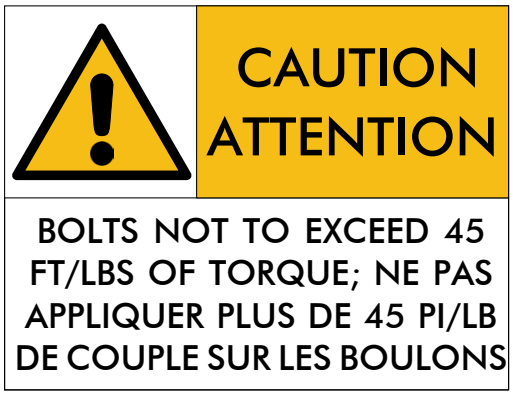


Figure 2.4: Found on all doors

Figure 2.5: Found on all doors and near injection lance

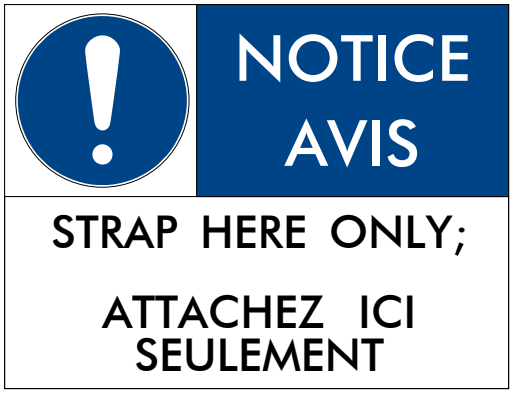


Figure 2.6: Found near all support rails and forklift pockets

Figure 2.7: Found near lifting lugs

Figure 2.8: Found near all support rails and forklift pockets

Figure 2.9: Found near all ecoCUBE® anchor points

2.6 Personal Protective Equipment (PPE)

This O&M Manual recommends the use of specific personal protective equipment (PPE) for various tasks. These recommendations are meant to supplement the workplace requirements governed by local and federal laws (eg. OSHA, Directive 89/656/EEC, etc.), requirements, and best practices. The recommendations within this manual do not nullify the requirement for any other PPE requirement.

The necessary personal protective equipment must be provided by the operator to themselves and all operating staff. The operator and operating staff are obliged to wear personal protective equipment.

2.7 Reasonably Foreseeable Misuse

Misuse of the ecoCUBE® and/or ancillary equipment may result in serious injury or death. SP is not liable for any damages resulting from the misuse of the product. Common reasons for misuse include:

- Incorrect work procedure (e.g. personnel climbing atop ecoCUBE® for access to other components; lifting guidelines not followed)
- Instructions incorrectly followed (e.g. urea lines not flushed after installation; personnel ignoring component failures, faults, or alarms)
- Unauthorized actions taken (e.g. operator conducts unauthorized troubleshooting or product modifications; operator unnecessarily presses the E-Stop)

The consequences of misuse may be severe; thus it is critical that the operator and operating staff be familiar with the contents of this manual.

2.8 Fire Prevention, Fluids Handling, & Environmental Protection

2.8.1 Fire Prevention & Safety

Is it the responsibility of the customer to ensure that means of fire prevention and extinguishing are established and that all personnel are familiar with fire safety protocols (Section 2.4.1).

Toxic substances may be generated during a fire and could be present after the fire. Always wear protective clothing (gloves, mask, etc.) as necessary when handling components during cleanup.

2.8.2 Urea / AdBlue® / DEF

Urea solutions compliant with ISO 22241-1, also referred to as AdBlue® or Diesel Exhaust Fluid (DEF), are critical to the operation of ecoCUBE® SCR systems. Thus, it is important for the operator and all operating staff to be aware of safe practices when working with urea:

- Observe the stipulations within the attached material safety data sheet (Section 11.1.1)
- Do not inhale urea vapours
- If urea solution is swallowed, rinse out mouth and drink plenty of water
- If urea solution contacts skin, wash affected areas with plenty of water
- If urea solution contacts eye, rinse eyes immediately at an eye-wash station or with clean tap water. Seek medical attention as soon as possible.

2.8.3 Environmental Protection

Proper disposal of all components and fluids is required as per local and federal laws, requirements, and best practices (Section 10.2).

2.9 Residual Risks

The ecoCUBE® and ancillary equipment is designed to be as safe as practically possible through the use of the ISO 12100:2010 risk assessment and reduction procedure. However, certain residual risks remain. Residual risks exist at a variety of severity levels, and the level of risk is communicated through the use of the different types of safety notices throughout this manual (Section 2.5.1).

Chapter 3

Product Description

This chapter outlines the principles behind the ecoCUBE® emission control system (Section 3.1), explains the selective catalytic reduction (SCR) technology (Section 3.2), describes the equipment (Section 3.3), and provides the necessary technical details regarding the product(s) (Section 3.4).

3.1 System Fundamentals

SP's ecoCUBE® emission control system is used to reduce any combination of oxides of nitrogen (NOx), particulate matter (PM), volatile organic components (VOC), and sound levels emanating from the exhaust of an internal combustion engine, through a combination of technologies including selective catalytic reduction (SCR), diesel particulate filters (DPF), oxidation catalysts (OC), and silencing modules, respectively. The SCR technology is an active method while all others are technologies listed are passive methods of emission control. The ecoCUBE® can be configured in multiple ways to target the kind of engine being used and the regulatory requirements:

- SCR + OC + Silencing
- SCR + OC + DPF *
- SCR + OC
- SCR + Silencing
- SCR Only
- DPF Only (FOx Module) *

* Applicable for compression-ignition engines only

3.2 Process Overview

A general layout of an ecoCUBE® emission control system (Section 3.3.1) with SCR is presented in Figure 3.1. At a minimum, an ecoCUBE® with SCR requires compressed air from an air compressor (Section 3.3.2) or plant air, and urea to be supplied from a urea tank to the CP100 control panel. The system controller within the CP100 panel determines the required amount of urea to be injected using the proprietary NeuralNOx™ algorithm and pumps the desired amount to the ecoCUBE®, along with prepared air (filtered and pressure regulated inside the CP100) required for the spray. The urea spray is converted to ammonia and then reduces the NOx in the engine exhuast into harmless nitrogen gas and steam.

Optional components such as the urea fill station, urea transfer system, gas cooling system, and pre-heat system are also pictured in Figure 3.1. These components may be necessary depending on the application; contact SP in order to understand what is required based on site-specific requirements and conditions.

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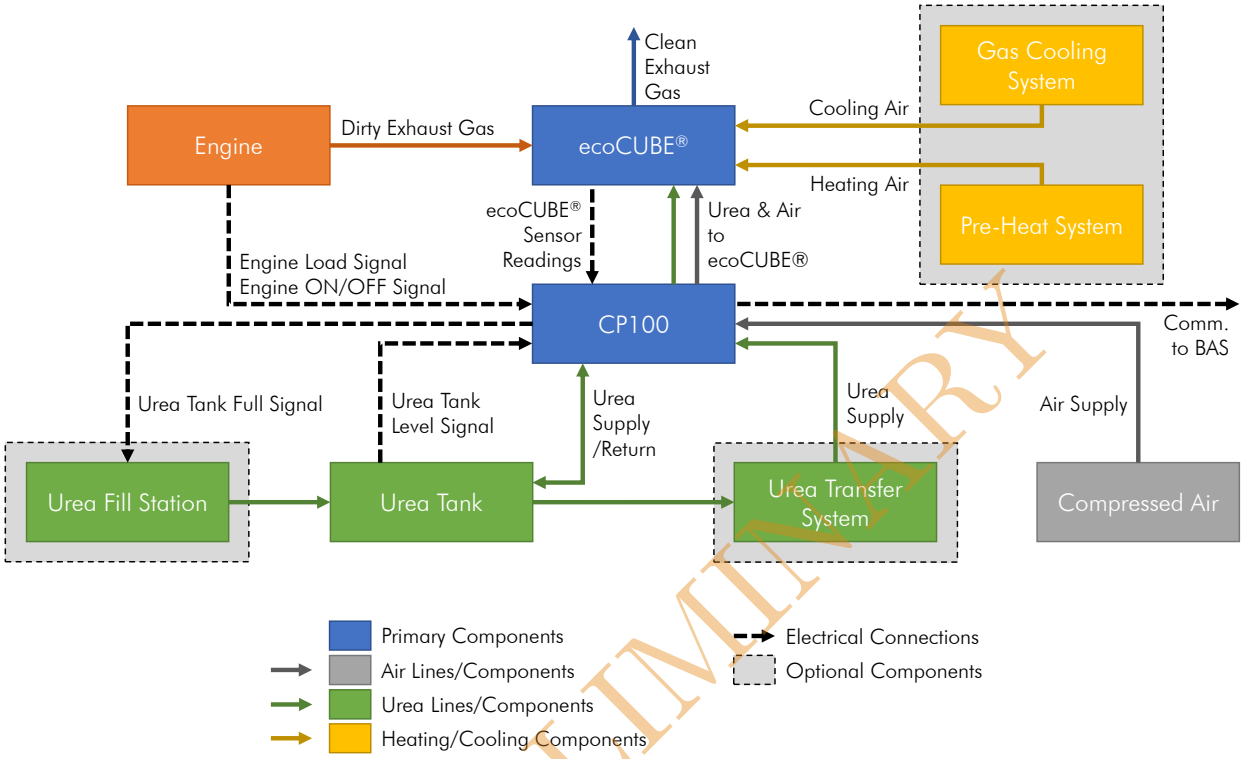


Figure 3.1: Process overview diagram; click on various parts of the diagram to learn more about it.

3.3 Component Overview

The following section provides a description of the various components supplied by SP.

3.3.1 ecoCUBE®

The ecoCUBE® emission control system is an extremely modular product capable of meeting various regulatory requirements by configuring it as required. Each of the modules offered are described below. Additionally, the modular design of the ecoCUBE® allows for various form factors. Primarily, these are the horizontal, side, and vertical mounted configurations (Figure 3.2).

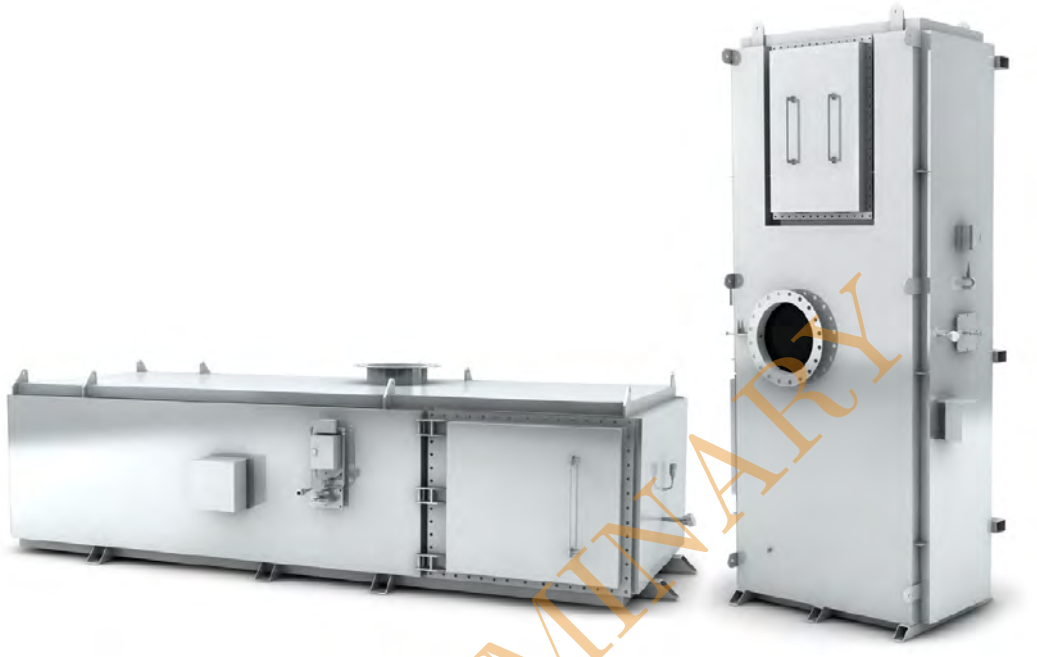


Figure 3.2: Horizontal and vertical mount ecoCUBE® configurations

3.3.1.1 Selective Catalytic Reduction (SCR)

The ecoCUBE® SCR system is used to significantly reduce the NOx content in the exhaust gasses from the engine. This is done through a chemical reaction that starts when a urea and water mixture is injected into the exhaust gas stream. The water evaporates and the urea is decomposed into ammonia. The ammonia reacts with NOx at the catalyst inside the ecoCUBE® to form harmless nitrogen gas and steam.

$$\underset{\text{Urea}}{\mathrm{CO(NH_2)_2}} + \mathrm{H_2O} \xrightarrow{\text{Urea Hydrolysis}} \mathrm{NH_3} + \mathrm{CO_2} + \mathrm{H_2O}$$

$$\mathrm{4\,NH_3 + 4\,NO + O_2 \longrightarrow 4\,N_2 + 6\,H_2O}$$
$$\mathrm{4\,NH_3 + 2\,NO_2 + O_2 \longrightarrow 3\,N_2 + 6\,H_2O}$$

Closed loop control of these reactions is required on systems with high NOx reduction levels. In a closed loop control design, the upstream and downstream NOx, oxygen, temperature, and pressure of

the exhaust gas are constantly monitored to provide peak performance. This information is used by the industrially-hardened system controller to determine the minimum level of urea to be injected to achieve the required NOx reduction; this allows for minimal urea usage and minimizes the ammonia that exits the ecoCUBE®.

3.3.1.2 Oxidation Catalyst (OC)

The oxidation catalyst is a passive catalyst technology that promotes the oxidation of organic compounds present in the engine exhaust stream. Hydrocarbon compounds that have not undergone complete combustion can be oxidized as

$$C_nH_{2m} + (n + \frac{m}{2})\, O_2 \longrightarrow n\, CO_2 + m\, H_2O$$

Carbon monoxide in the exhaust gas can be oxidized as per

$$2\, CO + O_2 \longrightarrow 2\, CO_2$$

3.3.1.3 Silencing Module

The engine exhaust is often the loudest source of noise at a site, generally exceeding 125 dBA of sound power. In an effort to mitigate this, all ecoCUBE® configurations are designed to provide noise attenuation through a combination of reactive and absorptive silencing. Additional silencing modules can be configured within the ecoCUBE® for improved acoustic performance.

3.3.2 Air Compressor

Clean dry compressed air is required atomizing the injected urea during SCR operation. The air supply must meet the quality requirements of ISO 8573-1:2010 Class 1.4.2. SP supplies a complete range of proven air compressors depending on the application (Figure 3.3).

Figure 3.3: Typical simplex air compressor (Section 3.3.2.2)

3.3.2.1 Tankless Compressor

Tankless air compressors are generally used for standby or peaking applications. Their compact size allows for easy installation in space-constrained applications.

3.3.2.2 Simplex Compressor with Receiver

Simplex air compressors with receiver tanks are ideal for prime power applications or multi-engine designs.

3.3.2.3 Duplex Compressor with Receiver

Like the simplex design (Section 3.3.2.2), the duplex air compressor with receiver is ideal for prime power applications or multi-unit designs. However, the duplex design provides redundancy, dramatically improving system reliability and up-time.

3.4 Technical Details

3.4.1 System Details

For system details, please see 99004026 DC-01 ecoCUBE® Design Criteria.

3.4.2 System Setpoints

For system setpoints, please see 99003004 Final Commissioning and Verification Report.

Chapter 4

Transport

This portion of the manual describes the recommended method(s) of transporting the ecoCUBE® in Section 4.1, Section 4.2, and Section 4.3. Transport of all ancillary equipment are described in Section 4.4. Additionally, storage guidelines are found in Section 4.5.

4.1 Lifting Guidelines

DANGER

Crushing or death due to falling load.

- Operator to inspect the lifting lugs for any visible damage prior to attaching crane.
- No personnel to be underneath or near objects being lifted.
- Operator to cordon off the area underneath the ecoCUBE® when it is being lifted in order to prevent persons from entering the space beneath the ecoCUBE® at any point during the lift.
- Follow all local and federal laws, requirements, and best practices for lifting large equipment.

Lifting of the ecoCUBE® during its transport must adhere to the guidelines presented in this section. Failure to comply with these instructions could result in damage to equipment and/or injury to personnel. All rigging and hoisting is to be performed in accordance with local regulations and good rigging practice. SP is not responsible for the hoisting equipment, including the engineering of the spreader bar (Section 4.1.1.2). SP is not responsible for any damages caused as a result of deviating from the instructions below.

Note that the weight of the ecoCUBE® is listed on the system's nameplate near the Safety Power logo (Figure 4.5).

4.1.1 Crane Lifting

Lifting the ecoCUBE® with a crane can be accomplished using either of the two methods presented in Section 4.1.1.1 or Section 4.1.1.2. Lifting lugs are provided for this purpose. The lifting lugs are to be used with 3/4 " diameter nominal shackles.

4.1.1.1 Option A - Central Point

Utilize all lifting lugs (4-8 depending on design) tied to a central pick point located directly above the center of mass of the ecoCUBE®, as depicted in Figure 4.1. Ensure that the vertical sling angle does not exceed 10°.

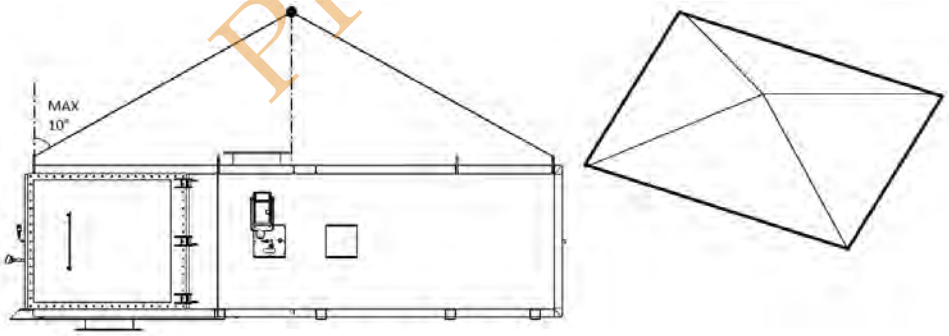


Figure 4.1: Lifting the ecoCUBE® using the central point

4.1.1.2 Option B - Spreader Bar

In order to reduce sling length, the ecoCUBE® may be lifted using a spreader bar, as seen in Figure 4.2. Each pair of lifting lugs must be attached to each end of the spreader bar, as shown. The spreader bar must pick directly in plane with each pair of lifting lugs.

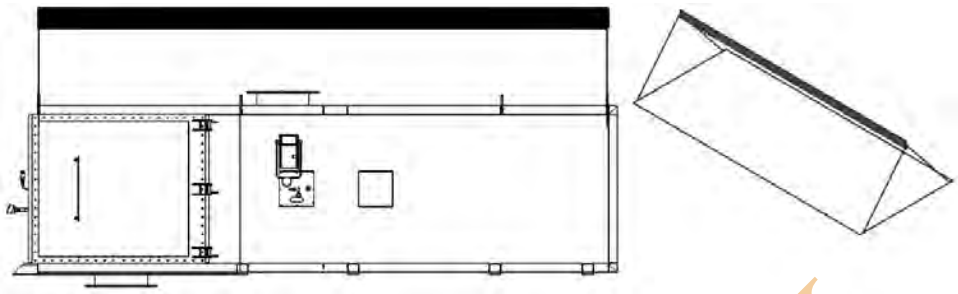


Figure 4.2: Lifting the ecoCUBE® using a spreader bar

4.1.2 Forklift Usage

WARNING

Crushing due to ecoCUBE® slipping off.

- **Do not** forklift ecoCUBE® systems that are not equipped with forklift pockets.

An individual **shall not** forklift any ecoCUBE® reactors that:

1. Do not contain forklift pockets, or
2. Has a ''DO NOT FORKLIFT'' label (Section 2.5.2)

Forklift pockets **should not** be confused for support rails - see Figure 4.3 in order to differentiate the two. Forklift pockets also come in two different styles, depending on the size of the reactor (Figure 4.4). The ecoCUBE® may be lifted by a forklift only when utilizing the forklift pockets. Using any other features such as the support rails or the surface of the ecoCUBE® can result in damage to the equipment and/or injury to personnel. SP is not responsible for any damages caused as a result of not properly using the forklift pockets.

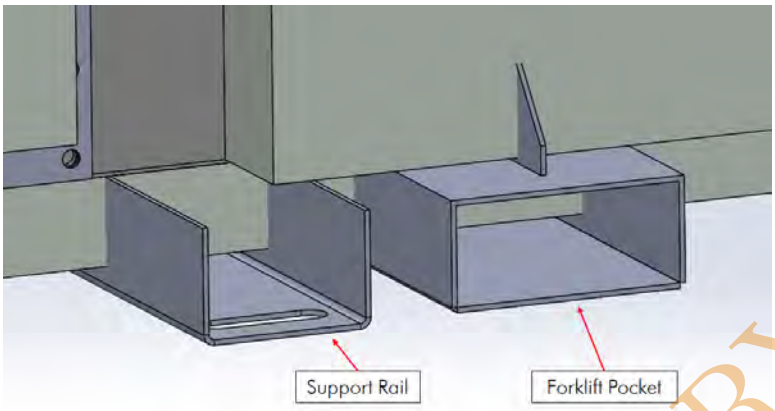


Figure 4.3: Forklift pockets vs. support rails

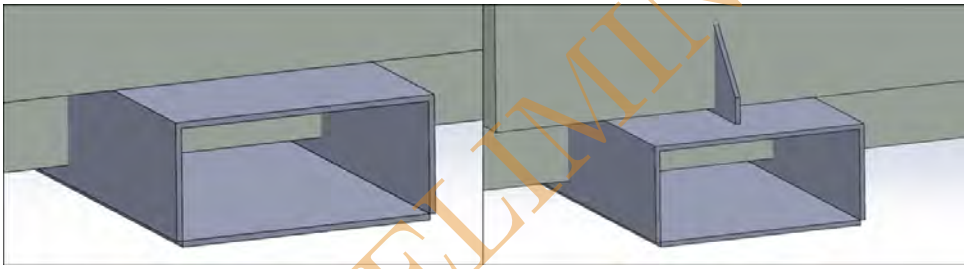


Figure 4.4: Two types of forklift pockets found on the ecoCUBE®

4.2 Loading Guidelines

Prior to shipping the ecoCUBE® reactor from the fabricator, temporary steel members (shipping blocks) are attached at each support rail anchor point (Figure 4.5). The ecoCUBE® is only designed to support its weight from the support rails. Thus, it is critical to ensure that the shipping blocks raise the ecoCUBE® high enough such that any inlet or outlet flanges, sensors, or other protrusions do not touch the ground or are supporting any weight. Additionally, these shipping blocks prevent damage to the cladding/insulation during shipping.

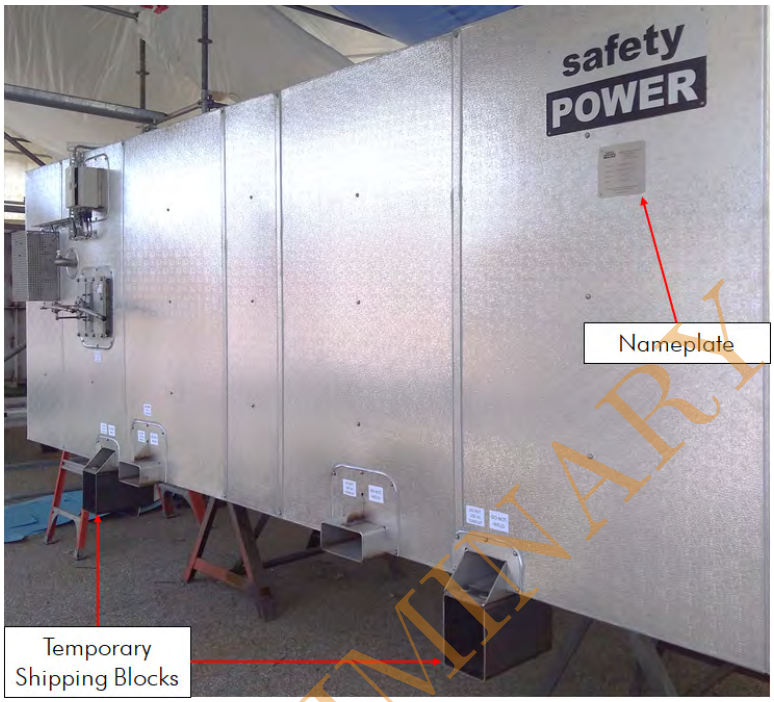


Figure 4.5: Temporary shipping blocks used during shipping.

4.2.1 General Trucking Guidelines

Transport operators are expected to follow all local laws and industry best practices when transporting the ecoCUBE® to ensure the safety of personnel and equipment. SP is not responsible for any damages, direct or indirect, sustained as a result of improper transportation.

4.2.2 Flatbed Trailers

The ecoCUBE® reactor is easily secured to a flatbed trailer utilizing load straps/tie downs through the support rails that span the width of the reactor:

1. Position the ecoCUBE® on the trailer following proper lifting guidelines (Section 4.1) and trucking guidelines (Section 4.2.1).
2. For transport on flatbed trailers without covering/roof, ensure that the ecoCUBE® is protected from damage during shipping with a temporary tarp (for less than 4 hours of travel) or poly-wrapped (for greater than 4 hours of travel) (Figure 4.10).

3. Insert tie down/load straps through a support rail which goes across the width of the ecoCUBE®, and attach & tighten the strap to the truck using hooks, bolts, rails, or rings provided on the truck for this purpose.
    - The operator must ensure that all equipment used for securing the ecoCUBE® is rated for the load and in proper working condition.
    - SP recommends the combined strength of all load tie downs to be 1.0 to 1.5 times the total weight of the content being secured.
    - **DO NOT** strap over the cladding in any circumstance as this could warp or dent the surface of the ecoCUBE®.
    - **DO NOT** insert tie down/load strap through the forklift pockets or support blocks. These components are not designed to handle transportation loads.
4. Repeat previous step for each support rail that goes across the width of the ecoCUBE®.

Figure 4.6 shows the recommended method of securing the ecoCUBE® to a flatbed trailer.

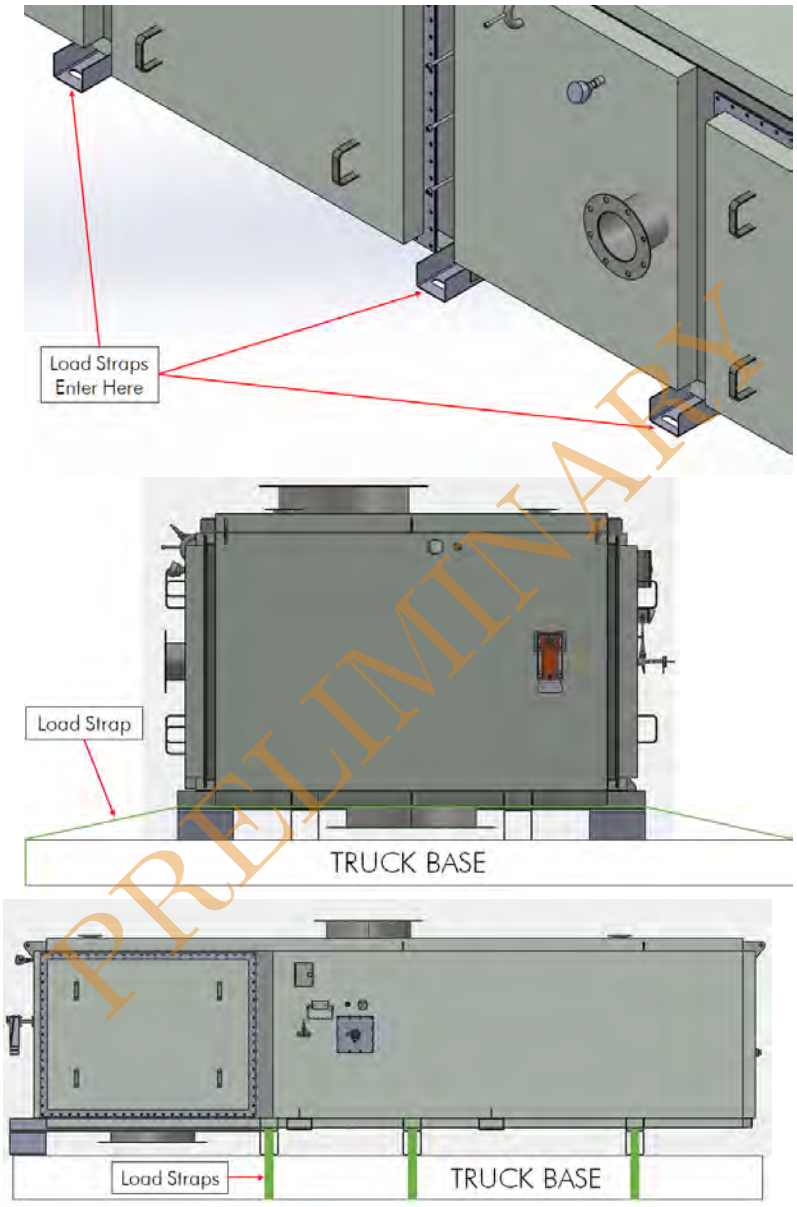


Figure 4.6: Securing the ecoCUBE® to a flatbed trailer for transport

4.2.3 ISO Containers

For transport in an ISO container (intermodal container), the transport operator must use proper blocking and bracing techniques to secure the ecoCUBE® successfully, especially for transport on water. The ecoCUBE® must be restrained from motion in all translational and rotational degrees of freedom; the following procedure outlines the required blocking and bracing technique necessary to accomplish this.

These instructions are primarily based on Circular No. 43-F/Pamphlet No. 45/BOE Pamphlet No. 6C published by the The Association of American Railroads / Transportation Technology Center Inc.

NOTE: Position, size, and amount of all blocking shown below is for basic reference only. The transport operator must use their judgment along with industry best practices in order to determine the complete block and brace layout.

1. Position the ecoCUBE® within the ISO container following proper lifting guidelines (Section 4.1) and trucking guidelines (Section 4.2.1).
2. **Floor blocking:** Blocking is to be installed on the floor of the container as pictured in Figure 4.7, securing the ecoCUBE® at the support rails or shipping blocks.
    a. In addition, load straps/tie downs should be utilized through the support rails, as seen in Section 4.2.2 (support rails are the best anchor points for securing the ecoCUBE®)
    b. Secure all floor blocking by nailing the blocking to the container's floor
    c. All floor blocking **must be** flush against the support rails or shipping blocks, ensuring good contact
    d. Back-up cleats are meant to reinforce the floor blocking
    e. Size and amount of lumber and nails is determined by the transport operator based on the weight and the size of the ecoCUBE®, following all industry best practices

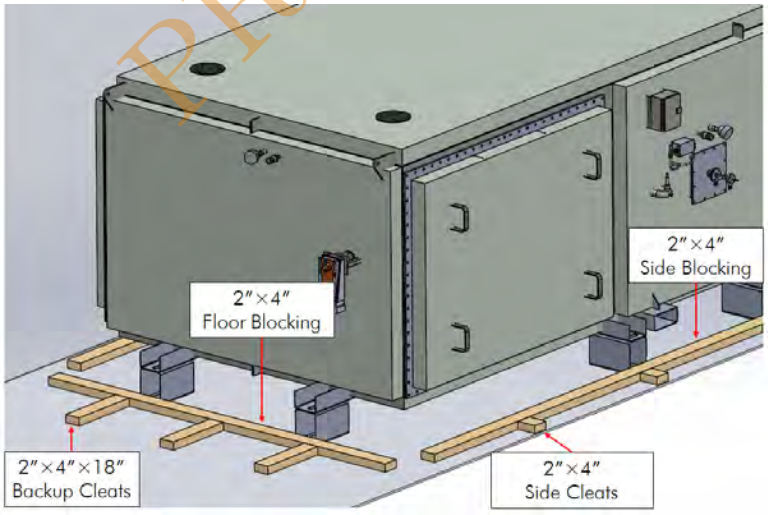


Figure 4.7: Floor blocking technique

3. **Surface blocking:** Surface blocking must be applied to all surfaces except the bottom surface, as shown in Figure 4.8.

a. When making direct contact with the cladding, ensure that 1 " thick A-Grade plywood is placed on the cladding to allow even distribution of forces

b. The larger the surface area that the plywood covers, the lower the risk of insulation damage

c. Ensure that the blocking or plywood **does not** come in contact with any components protruding from the ecoCUBE®, such as sensors, injection lance, or wiring.

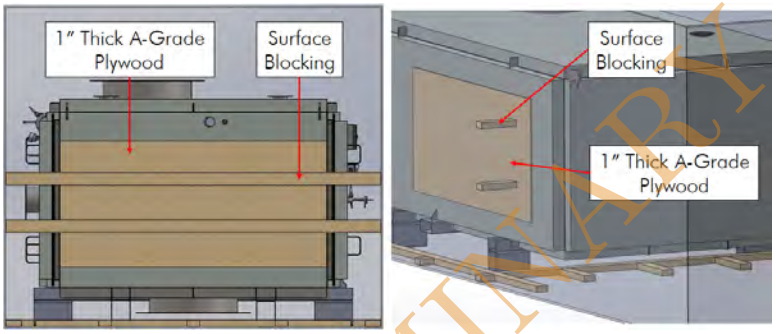


Figure 4.8: Surface blocking technique on two different surfaces of the ecoCUBE®

4. **Lengthwise reinforcement:** In addition to floor blocking, the transport operator must reinforce the lengthwise blocking of the ecoCUBE® through diagonal bracing to the container floor, as seen in Figure 4.9.

a. The angle between the diagonal brace and the floor of the container must not exceed 45°; reference Table 4.1 to determine the minimum required length of the diagonal brace

b. If possible, the diagonal brace should meet the vertical portion of the supports in the upper third of the ecoCUBE® ($H > \frac{2}{3}$ ecoCUBE® height)

c. Ensure that the blocking **does not** come in contact with any components protruding from the ecoCUBE®, such as sensors, injection lance, or wiring.

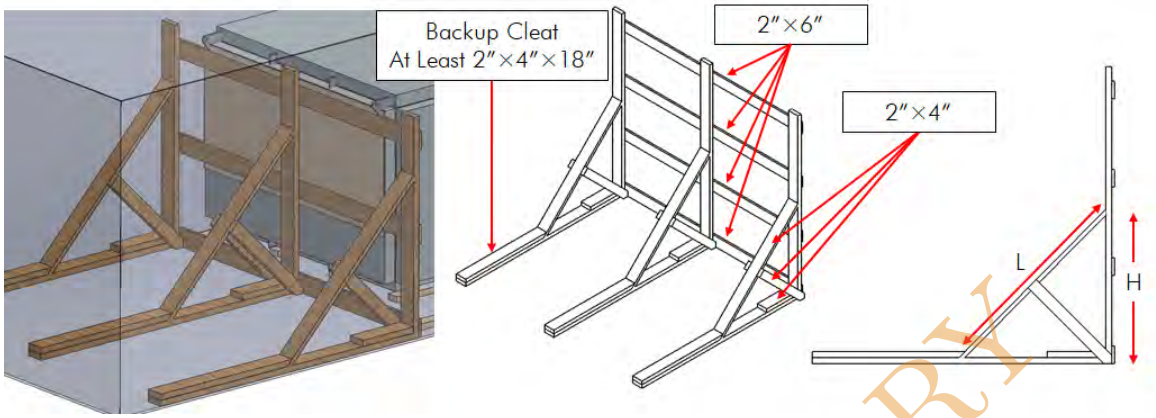


Figure 4.9: Lengthwise reinforcement technique

Table 4.1: Recommended Minimum Length of Diagonal Brace

H (ft)	Minimum L (ft)
1	1.5
1.5	2.25
2	3
2.5	3.5
3	4.2
3.5	5
4	5.75
4.5	6.5
5	7.25
5.5	7.75
6	8.5

4.3 Unloading Guidelines

WARNING

Crushing due to ecoCUBE® slipping unexpectedly.

- Operator **must** inspect the shipping equipment (load straps or block and brace elements) for damage prior to unloading.
- If damage is observed, additional care must be taken before unloading the ecoCUBE®.

The following procedure, along with standard industry best practices, must be followed by the transport operator in order to ensure that the ecoCUBE® is unloaded safely after it has been shipped to its destination. Continuous and clear communication between the operator and all personnel is required to minimize the risk of accidents when unloading.

Firstly, a thorough inspection of the shipping equipment (load straps or block and brace elements) must be conducted to look for any damage or if the reactor's weight has shifted to certain elements in an undesirable manner. If there is damage or the weight has shifted, additional care must be taken when removing these elements as the reactor may shift without warning. The operator must ensure that no/minimal personnel are present in the vicinity of the ecoCUBE® when removing these compromised elements, as described above.

In general, the shipping equipment may be removed as follows. Care must be taken to not scratch or dent the reactor's surface, or damage any components protruding from the reactor, such as sensors, injection lance, or wiring while unloading.

1. If blocking and bracing is used to secure the ecoCUBE®:
    a. Remove lengthwise reinforcement
    b. Remove surface blocking
    c. Remove floor blocking
    d. Double check that all blocking is removed
2. If load straps/tie downs are used to secure the ecoCUBE®:

a. Remove all load straps/tie downs

b. Double check that all load straps/tie downs are removed

3. The ecoCUBE® may now be lifted out of the container following proper lifting guidelines (Section 4.1) and placed for storage as per Section 4.5.

Dispose of all shipping equipment in compliance with local and federal laws, requirements, and best practices.

1. Block and brace material is made almost entirely from natural, non-toxic materials and can be disposed off accordingly
2. Load straps/tie downs may be reused once thoroughly inspected to ensure that no damage exists

4.4 Ancillary Equipment

Lifting of all ancillary equipment to follow the recommended methods outlined in Table 4.2. When multiple lifting options exist, it is left to the transport operator's judgment to determine the appropriate means of lifting. The operator may contact SP for recommendations and guidelines, if necessary. The operator must follow all local and federal laws, requirements, and best practices associated with lifting industrial equipment.

Transport operators are expected to follow all local laws and industry best practices when transporting ancillary equipment to ensure the safety of personnel and equipment. SP is not responsible for any damages, direct or indirect, sustained as a result of improper transportation. All ancillary equipment to be shipped as ''less than load'' (LTL), applying standard industry best practices regarding securing loads during transport.

Table 4.2: Recommended Means of Lifting Ancillary Equipment

Equipment	By Hand	Forklift	Crane*
CP100 control panel	✓†	✓	
Urea tank		✓	✓
Air compressor (Section 3.3.2)	✓‡	✓	
Urea transfer system		✓	
Urea fill station		✓	
Pre-heat system		✓	
Gas cooling system		✓	

* If equipped with lifting lugs

† May exceed 50 lbs (23 kg); use multiple people to lift as necessary, following all local and federal laws, requirements, and best practices associated with lifting

‡ If tankless 'WOB-L' air compressors only

4.5 Storage Guidelines

Prior to storage, all equipment must be visually inspected for any damage that may have been sustained during transport. Inform SP of any damage observed. The ecoCUBE® and all ancillary equipment should be stored under the following conditions for the duration following transportation to site and prior to commissioning:

- Ambient temperature between −25 °C to 60 °C
- Ambient relative humidity between 30 % to 95 %, non-condensing
- In dry conditions, away from any precipitation
- Away from high temperature heat sources
- Protected against dust and vibration
- Non-elevated and level-grounded location
- In a stable orientation

In the event that the ecoCUBE® reactor or other components need to be stored in an outdoor location susceptible to rain or snow, SP strongly recommends that the component is poly-wrapped (additional

cost) (Figure 4.10). Please inform SP if this service is needed. Note that outdoor storage is **not recommended** for non-outdoor rated components, such as the standard CP100 panel.

Figure 4.10: Two poly-wrapped ecoCUBE® reactors on a flatbed trailer

Chapter 5

Installation

CAUTION

Danger due to incorrect installation.

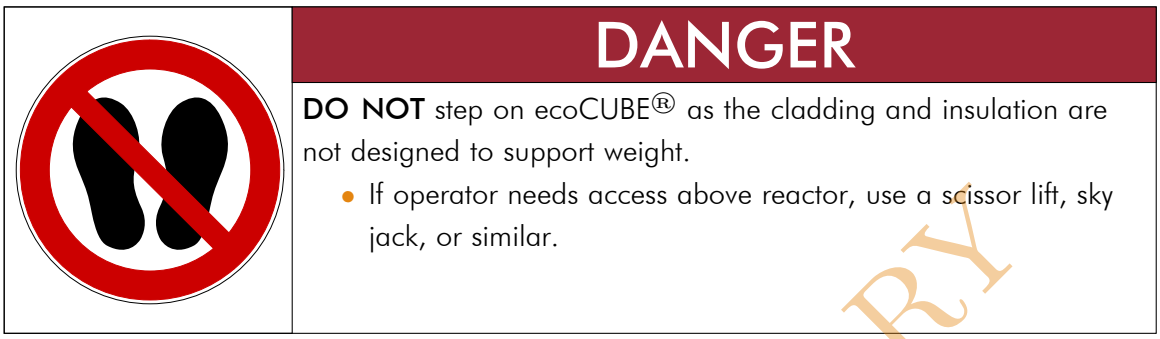
- Installation contractor to follow all stipulations within this manual.
- Installation contractor to abide by all relavant local and federal laws, requirements, and best practices.

CAUTION

Danger due to electric schock resulting from incorrect installation.

- Only certified electrical contractors may perform work related to electrical installation of the components.
- All electrical connections to be made as per the stipulations within this manual.
- All electric connections to abide by all relavant local and federal laws, requirements, and best practices.

5.1 ecoCUBE®



DANGER

DO NOT step on ecoCUBE® as the cladding and insulation are not designed to support weight.

- If operator needs access above reactor, use a scissor lift, sky jack, or similar.

The ecoCUBE® is an integrated system which contains the urea injector, mixing duct, and factory-installed catalyst & sensors. This greatly simplifies the amount of installation work required on-site.

The ecoCUBE® is to be installed as stated on the DM-01, 99004026 DC-01 ecoCUBE® Design Criteria, and 99004004 PI-02 Piping & Instrument Layout drawings. Special care must be given to the connections and interface between the ecoCUBE® and ancillary equipment. In addition, all wiring must adhere to 99004005 PA-01 Interconnect Wiring Details and 99004014 PA-03 Field Instrument Wiring Detail drawings.

The installer must take care to ensure the following:

- The ecoCUBE® is to be stored and installed on level ground only.
- The ecoCUBE® is not to be installed in excessively windy or seismic zones, without express written communication and acceptance by SP, and approval by a professional engineer.
- The ecoCUBE® is to be installed and operated away from public access. If this is not possible, the client must install personnel access restriction in order to achieve aforementioned requirement.
- The installer must remove the blanking plates used on the inlet and outlet of the ecoCUBE® during shipping prior to attaching upstream and downstream ducting.
- Prior to installation, installer to visually check inside the ecoCUBE® for any parts that may have come loose during transport by looking through the inlet flange.
  - For bottom inlet reactors, installer to raise the ecoCUBE® using blocking and ensure it is stable prior to checking for loose parts
  - If any loose parts are discovered, the installer **must** immediately inform SP.

- The installer must use gaskets between the inlet and upstream ducting, and the outlet and downstream ducting.
    - Gaskets used may not contain silica.
- Installer to remove expansion joint transport support after installation.
- Installer to flush and pressure-test urea and air lines **before** connecting them to injection lance
- Installer to ensure weather protection is installed downstream of the ecoCUBE® (no-loss rain guard, weighted flap rain cap, etc.)
- Installer to ensure tightening torque requirements stated on DM-01 are followed when securing the ecoCUBE® to its support structure.
- Installer to implement appropriate yellow smoke mitigation strategies for ecoCUBE® systems with DPF as per 99004026 ecoCUBE® Design Criterion.
- Installer must clean off any combustible material that may have been deposited on the ecoCUBE® during the installation process; this poses a fire risk otherwise.
- The installer is **not** responsible for the wiring from the JB101 Junction Box to the various sensors on the ecoCUBE®. All sensor wiring on the ecoCUBE® are factory-installed and are only to be serviced by SP Certified Technicians. In lieu of labelling, wiring from the JB101 to the sensors on the ecoCUBE® is color coded according to SP specifications – factory wiring is not labelled as part of the standard product offering.

5.2 Air Compressor

The compressor must be installed as stated on the 99004004 PI-02 Piping & Instrument Layout drawing. This includes the installation of all applicable components including the air filter, air dryer, condensate drain, air lines, receiver, and tank drain. Additional installation guidelines are provided in 99003059 Urea System Installation Instructions. All wiring associated with the compressor must adhere to the 99004005 PA-01 Interconnect Wiring Details drawing.

The air compressor must be installed in accordance with its installation instructions supplied with the equipment (Compressor User Manual), if available. In general, the installer must take care to ensure:

- The compressor is stored and installed on level ground only.
- The structure/floor on which the compressor is installed has the capacity to bear the weight of the compressor and provide the necessary vibration reduction.

Chapter 6

Commissioning

Commissioning is the process of tuning the operational parameters and setpoints of the ecoCUBE® and ancillary equipment to ensure optimal performance and reliability, given the site-specific conditions. It is to be completed once the ecoCUBE® and ancillary equipment is installed and prior to it's operation.

6.1 Pre-Commissioning

Prior to the arrival of SP personnel for commissioning, the installer must ensure that the pre-commissioning checklist is completed and submitted to SP (99003003 Startup and Commissioning Checklist). The careful completion of this checklist is crucial in order to avoid delays during commissioning.

6.2 Commissioning

WARNING

Health hazard during first-heat up of the ecoCUBE® due to off-gassing from the insulation material.

- Ensure sufficient ventilation around the ecoCUBE® (required for heat dissipation as well). If insufficient, increase ventilation temporarily.
- Personnel to minimize the amount of time spent near the ecoCUBE® reactor.
- If extended periods of time near the ecoCUBE® is required during first heat-up, wear respiratory protection.

Commissioning of the ecoCUBE® emission control system and/or ancillary equipment is to be conducted by SP employees only. During commissioning, the engine must be operated at a variety of load points (generally 25 %, 50 %, 75 % and 100 %) in order to tune the ecoCUBE® fully. At each load point, emissions upstream and downstream of the ecoCUBE® is measured by a calibrated Testo device to ensure compliance. A record of the commissioning process is available in 99003004 Final Commissioning and Verification Report.

Chapter 7

Operation

7.1 ecoCUBE®

The ecoCUBE® is designed to operate in a fully automatic manner with minimal operator intervention, as long as the ecoCUBE® is installed (Chapter 5) and commissioned (Chapter 6) appropriately and the basic requirements mentioned in Section 7.1.1 are met.

DANGER

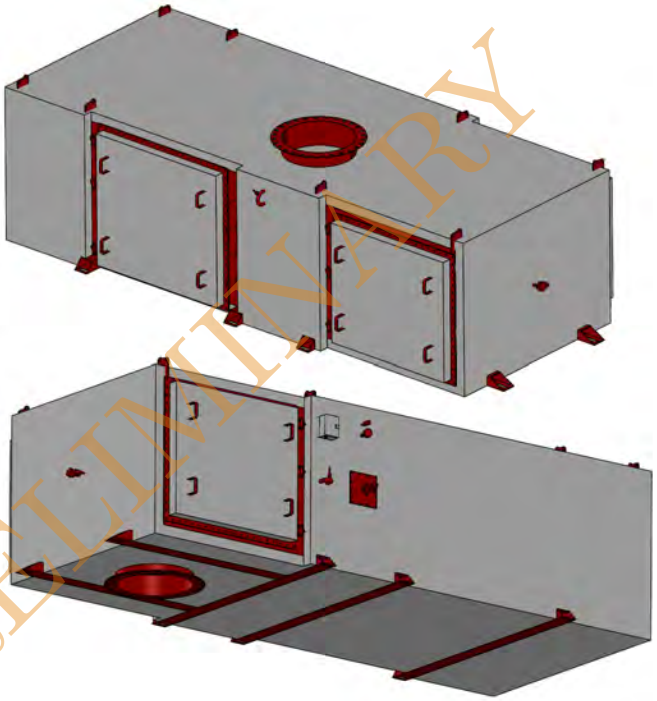
Deflagration or other dangerous situation due to incorrect/incomplete installation and/or commissioning.

- Operation of the ecoCUBE® system should be done only after complete installation and commissioning of the system.
- Ensure that the pre-commissioning and commissioning checklists are completed as required.

CAUTION

Burns due to hot surfaces.

- Avoid touching the uninsulated portions of the ecoCUBE® (highlighted in red) during engine operation, or within 48 hours after engine has been turned off.



NOTICE

Improper use may void warranty.

- Certain components in standard crankcase oil can be catalyst poisons if excessive amounts reach the catalyst. To protect against catalyst and/or filter contamination, ensure that the engine is not consuming oil at a rate higher than specified by the engine manufacturer.
- Fuel additives can also contain elements that can be harmful to the catalyst and/or filter. Review any additives with Safety Power before you use them.

7.1.1 Basic Operational Requirements

The basic requirements necessary for the operation of the ecoCUBE® are:

1. A secure power supply to the CP100 panel
2. E-Stop is not activated (i.e., twist and pull out the E-Stop)
3. Once the CP100 panel boots up, verify that there are no faults indicated by the fault indicator on the HMI

Once these requirements are met, the system will automatically enter into the correct system operating state as determined by the control system.

Operating instructions for the ecoCUBE® are seen in the following sections:

- SCR systems (Section 7.1.2)

7.1.2 SCR System Operation

The ecoCUBE® has four operating states described in Table 7.1. The control system automatically determines the operating state of the system based on the current conditions.

Table 7.1: Overview of System Operating States

Operating State	Description
Standby	Waiting for engine to start. Further detail is given in Section 7.1.2.1.
Startup	Engine is running and ecoCUBE® is waiting for all system run conditions to be met (Section 7.1.2.3.1). Further detail is given in Section 7.1.2.2.
Run	All system run conditions have been met and the system has successfully completed startup. Further detail is given in Section 7.1.2.3.
Shutdown	A shutdown condition has occurred (Section 7.1.2.5.1). The dosing pump is stopped and the urea line is purged with air. Further detail is given in Section 7.1.2.5.
OFF	Emergency Stop (E-Stop) button is pressed or the ecoCUBE® is manually turned OFF using the OFF button. Further detail about the E-Stop is given in Section 7.1.2.6.

7.1.2.1 Standby

In the standby state, all sensors and actuators associated with the ecoCUBE® are powered down, with the exception of the controller, cellular antenna, and WiFi access point. The ecoCUBE® is waiting for a valid engine run signal in this mode.

7.1.2.2 Startup

Once the engine run signal is received, the ecoCUBE® enters startup mode. The following sequence of events takes place:

1. The 3-way valve is cycled for a period of 10 s at a rate of approximately 1 cycle /s
2. Air solenoid valves open, starting the purge of high-pressure air into the injection nozzle.
    - NOTE: the 3-way valve should be in the air position, allowing air flow to the nozzle tip. The system starts up and shuts down with the valve in this position.
3. The air purge will continue for a duration of time set up during commissioning (Section 3.4.2); purge duration will vary based on site conditions.
    - If at any time during the purge, the incoming air pressure is insufficient, the system reverts to Step 2 until sufficient air pressure is available; troubleshooting may be required (Section 8.1.2.2)
4. Once the purge cycle is complete, the 3-way valve switches to the urea injection position

Simultaneously, sensors and actuators are powered up and allowed to stabilize. The ecoCUBE® then waits for all the run conditions (Section 7.1.2.3.1) to be satisfied.

7.1.2.3 Run

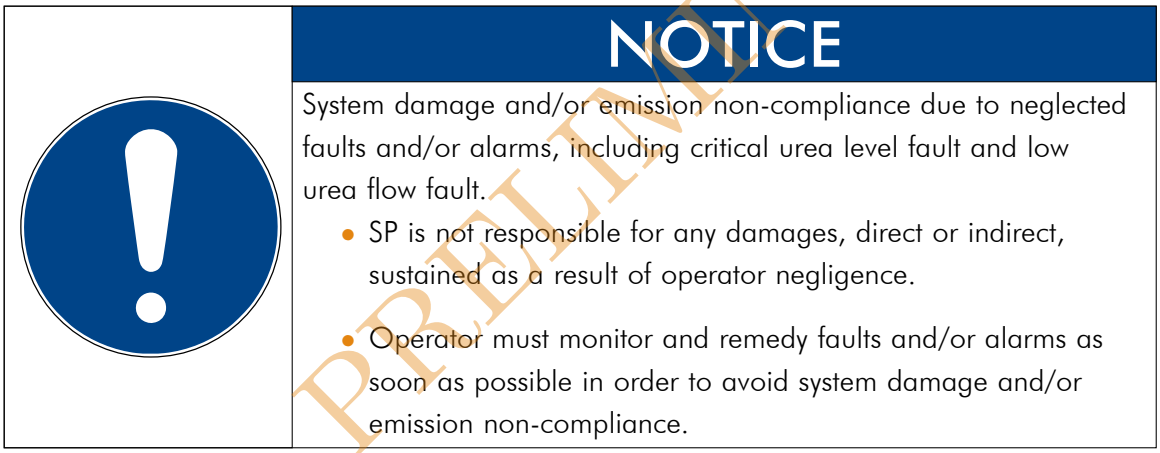
Once the run conditions are satisfied, the ecoCUBE® enters run mode. Run mode begins by injecting urea to pre-fill the lines with fluid. The system then injects urea based on the engine load, before switching to a closed loop control mode where the urea injection rate is automatically adjusted based on the emission sensor readings. In run mode, the green run light on the CP100 control panel is active.

7.1.2.3.1 System Run Conditions The conditions required for the ecoCUBE® system to enter run mode are:

1. Engine run signal is ON
2. Engine exhaust temperature is within the range defined by the minimum and maximum temperature setpoints required for urea injection
3. Engine load is above minimum load setpoint
4. Air pressure as measured by the pressure switch inside the CP100 is above the minimum requirement
5. Urea tank level is above critical urea level setpoint

For specific setpoint information, see Section 3.4.2.

7.1.2.4 Operator Monitoring



It is important for the operator to monitor the ecoCUBE® while it is in run mode for two reasons:

1. To be informed as soon as possible when an alarm or fault is raised by the system
2. The system controller used has a very small chance of malfunctioning. In this situation, the operator must take action, forcing the system to shut down:
    a. Loss of Modbus communication or HMI communication is a symptom of a malfunctioning controller; the status of the communication is something that the operator must monitor.
    b. If loss of communication is observed, operator must open the CP100 control panel and look to see if the red or green LEDs on the controller are flashing (Figure 7.1).
    c. If they are **NOT** flashing, the operator must press the E-Stop button to stop urea injection. A purge cycle will begin, and after approximately 10 minutes of purging, the operator must

reboot the power supply to the entire CP100 control panel. See Section 7.1.2.6 for further details.

d. If they are flashing, the controller is still functioning but communication has failed. Once the engine has stopped running and the ecoCUBE® has completed its shutdown mode (Section 7.1.2.5), the operator must reboot the power supply to the entire CP100 control panel.

e. The operator **must** inform SP of the incident.

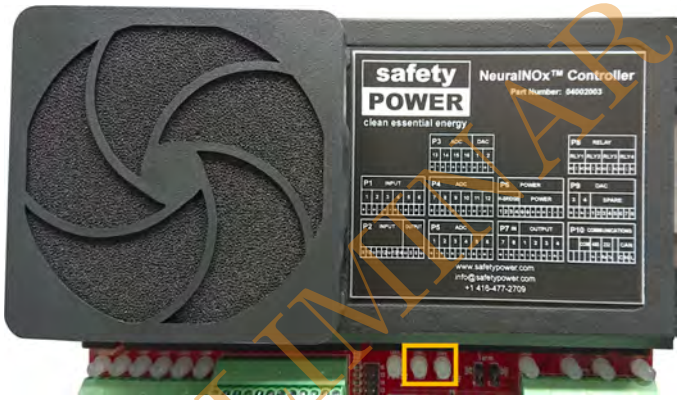


Figure 7.1: System controller status LEDs, shown within the yellow box

7.1.2.5 Shutdown

When any of the shutdown conditions occur (Section 7.1.2.5.1), the system enters shutdown mode. The following shutdown sequence takes place:

1. Urea dosing pump stops
2. 3-way valve switches to the air position
3. The urea injection line is purged for a period of time set up during commissioning (Section 3.4.2); purge duration will vary based on site conditions
4. At the completion of purge cycle, the air valve closes and the ecoCUBE® enters standby mode

7.1.2.5.1 System Shutdown Conditions If any of the following conditions occur, it will trigger shutdown mode:

- OFF button on the CP100 control panel HMI is pressed

- Loss of engine run signal
- Temperature not within operating setpoints defined by the minimum and maximum temperature setpoints required for urea injection
- Engine load drops below minimum load setpoint or load signal fails
- Air pressure as measured by the pressure switch inside the CP100 is below the minimum requirement
- Urea tank level below critical urea level setpoint
- Low urea flow
- Failure of all thermocouples
- Failure of urea level sensor
- Failure of engine load signal / sensor

For specific setpoint information, see Section 3.4.2.

7.1.2.6 Emergency Stop (E-Stop)

CAUTION

E-Stop **does not** turn off compressor or other ancillary equipment.

- Shut off anciliary equipment if necessary using each equipment's E-Stop or other stopping mechanism.
- Compressed air is required for a controlled shutdown of the ecoCUBE®. Do not shut off air supply or air compressor if it is not creating hazards on site.

NOTICE

Use of the E-Stop when the engine is running will likely result in emission non-compliance. SP is not responsible for any damages, direct or indirect, sustained as a result using the E-Stop.

- Only use the E-Stop in an emergency situation.
- **Do not** misuse the E-Stop.

The E-Stop button will trigger a controlled shutdown (Stop Category 1) of the SCR system. It will immediately remove power to all sensors, cut off urea injection, and begin purging the lines with compressed air. The purge continues for the duration determined by the setpoint, following which the controller will shut off the air valve. The ecoCUBE® remains in this state until the E-Stop button is deactivated. Once deactivated, the ecoCUBE® enters standby mode.

- The E-Stop button will turn off the gas cooling system, if applicable.
- **The E-Stop button DOES NOT turn off the air compressor, pre-heat system, or other ancillary equipment.** If these systems need to be turned off, use their respective E-Stops or disconnect its electricity supply.
- In the event that the E-Stop is pressed while the system controller is not responding, urea injection will still stop and the purge will begin. However, without the controller's command, the purge will not stop. In this case, the air may be turned off after about 10 minutes of purging by closing the air isolation valve or by disconnecting the compressor's electrical supply.
- Ensure that the procedure outlined in Section 7.2 is followed any time the E-Stop is pressed

7.2 General E-Stop Procedure

NOTICE

Equipment damage due to unresolved issue.

- Operator must follow the E-Stop procedure in order to avoid damage to ecoCUBE® and/or ancillary equipment.
- Root cause behind pressing the E-Stop must be determined prior to restart.

The following procedure must be followed once the E-Stop is pressed:

1. Investigate the reason for E-Stop actuation
2. Troubleshoot and remediate the issue (it is recommended that the operator contacts SP at this stage)
3. Once the issue is remediated, the E-Stop can be released, resuming normal operation
4. Make a record of the incident

5. Inform SP of the incident

Chapter 8

Troubleshooting

This chapter provides an outline of the various alarms and faults that are automatically raised by the ecoCUBE® and ancillary equipment in the event of an issue and describes how to troubleshoot them.

The operator must contact SP prior to conducting any troubleshooting, and troubleshooting must only be conducted by SP-trained operating staff under the guidance of SP personnel. The following section provides guidelines for troubleshooting the system. For further support or question, please contact SP.

CAUTION

Unauthorized or improper troubleshooting work may lead to health hazards or equipment damage.

- **Always** contact SP prior to conducting any troubleshooting.
- **Always** contact SP if any messages or alarms appear on the HMI that are unclear to the operator.

8.1 ecoCUBE®

WARNING

Burns due to hot reactor surface.

- Ensure that the engine has been turned OFF alteast 48 hours prior to troubleshooting components on the reactor.
- If unsure about the ecoCUBE® reactor's surface temperature, wear heat resistant gloves before touching it.

8.1.1 ecoCUBE® Alarms & Faults

The ecoCUBE® emission control system includes automated fault and alarm detection. A fault condition causes the system to shut down while an alarm condition does not. Existing alarms and faults will be displayed across the bottom of the HMI Home-Screen. Additionally, a history of alarms and faults can be seen on the HMI Alarms & Faults page. Alarms and faults will clear automatically, and the system will return to its designated operating mode after the alarm or fault condition is fixed.

See Section 8.1.1.1 for the alarms and faults associated with ecoCUBE® SCR system.

8.1.1.1 SCR Alarms & Faults

Table 8.1 and Table 8.2 lists the faults and alarms associated with the SCR system, respectively. When appropriate, a link to the relevant troubleshooting instructions are provided within the tables. A fault raised from the SCR system will halt urea injection and trigger shutdown mode (Section 7.1.2.5). These faults do not have any bearing on the operation of the passive systems (oxidation catalyst, DPF, or silencing).

Table 8.1: SCR Faults

Fault Message	Description†	Troubleshoot
Engine Load Fault	Engine load signal is outside normal operating range; sensor or wiring is faulty.	8.1.2.4

Continued...

Table 8.1: SCR Faults

Fault Message	Description†	Troubleshoot
SCR Temperature Above Max.	Exhaust temperature is above maximum temperature setpoint.	
Low Air Pressure Fault	Air pressure dropped below the pressure sensor threshold while system was in run mode.	8.1.2.2
Critically Low Urea Level	Urea tank level dropped below the critical urea level setpoint; operator must refill urea.	
Urea Flow Fault	Urea flow was below minimum setpoint, signifying no urea flow.	8.1.2.1
E-Stop Activated	The E-Stop switch is activated.	

† For specific setpoint information, see Section 3.4.2.

Table 8.2: SCR Alarms

Alarm Message	Description†	Troubleshoot
Urea Level Sensor Failure	ML060 urea level signal is outside of normal operating range; sensor or wiring is faulty.	8.1.2.4
Pressure Sensor Failure	PR010 pressure signal is outside of normal operating range; sensor or wiring is faulty.	8.1.2.3
Pressure Sensor Failure	PR020 pressure signal is outside of normal operating range; sensor or wiring is faulty.	8.1.2.3
Temperature Sensor Failure	TC010 temperature signal is outside normal operating range; sensor or wiring is faulty.	8.1.2.3
Temperature Sensor Failure	TC020 temperature signal is outside normal operating range; sensor or wiring is faulty.	8.1.2.3
Temperature Sensor Failure	TC030 temperature signal is outside normal operating range; sensor or wiring is faulty.	8.1.2.3
Downstream NOx Sensor Failure	NX010 NOx sensor communication is not working.	8.1.2.3
Upstream NOx Sensor Failure	NX020 NOx sensor communication is not working.	8.1.2.3
SCR High Pressure	Pressure drop across the SCR is above the maximum operating setpoint.	

Continued...

Table 8.2: SCR Alarms

Alarm Message	Description†	Troubleshoot
Air Compressor Max Runtime Exceeded	Air compressor maintenance interval exceeded; Service air compressor as per its maintenance manual.	
Low Urea Level	Urea tank level dropped below the low urea level setpoint; operator must refill urea.	
In Manual Bypass	NeuralNOx™ controller software parameter is in manual bypass.	
Low NOx Reduction	Outlet NOx sensor reading is not reasonable based on mass flow, inlet NOx, and urea flow.	8.1.2.1
Failed to Reach Min. Temperature in Time	Temperature readings are not reasonable based on engine run time and load.	
Temperature Profile Discrepancy	Temperature profile from inlet to outlet is not reasonable. Removing a temperature sensor will result in the profile being in error.	
NX010 O_2 Incorrect with Engine Running	Incorrect O_2 levels measured at downstream NOx sensor when engine is running. Removing the NX010 sensor will result in this error.	
NX020 O_2 Incorrect with Engine Running	Incorrect O_2 levels measured at upstream NOx sensor when engine is running. Removing the NX020 sensor will result in this error.	
NX010 > NX020	Downstream NOx is higher than upstream NOx.	
EL040 > Min., but no ER040	Engine load signal > min. load required for injection, but no engine run signal.	8.1.2.4

† For specific setpoint information, see Section 3.4.2.

8.1.2 ecoCUBE® Troubleshooting

8.1.2.1 Low/No NOx Reduction

These troubleshooting steps move sequentially from the urea tank to the injection lance and provide a systematic method for identifying and remediating NOx reduction problems caused by insufficient urea flow into the ecoCUBE®.

Note that urea is a 32.5 % aqueous solution. If exposed to air, the water content will evaporate, leaving behind white crystallized urea which can plug components. Most urea plugging can be cleaned by dissolving with water.

▶ Urea Tank	
Cause	**Solution**
Urea tank is empty	• Refill urea tank
Urea tank outlet filter is plugged	• Clean filter
Urea tank foot valve is plugged / stuck closed	• Clean foot valve
Urea supply line valves are closed	• Open urea valves

▶ Urea Transfer System (if installed)	
Cause	**Solution**
Power On indicator is not illuminated	• Energize the panel
E-Stop is engaged	• Remediate reason for pressing E-Stop (Section 7.2) and disengage E-Stop
Off/Auto/Manual Selector Switch to Off	• Turn the Off/Auto/Manual Selector Switch to Auto
Fault indicator is illuminated	• See urea transfer system troubleshooting guide.

► Urea Dosing Pump	
Cause	**Solution**
No power to CP100 panel	• Energize the panel
CP100 Panel E-Stop is engaged	• Remediate reason for pressing E-Stop (Section 7.2) and disengage E-Stop
No power to the pump	• Check pump fuse (F6); replace if necessary • Check for 24 VDC at pump (across TS3:24F6 and TS3:0V) • Check wiring
Pump is not primed	• Open manual priming valve and run pump until primed • Ensure there is no more than 8 feet of suction head
Pump is seized	• De-energize CP100 panel and isolate air compressor • Remove pump head; inspect and clean gears • Check urea concentration level; dilute if necessary
Pump decoupled	• De-energize CP100 panel and isolate air compressor • Find and clear blockage in the urea line downstream of the pump • To re-couple turn off power to the pump, then turn back on

▶ Urea Over Pressure Protection Switch	
Cause	**Solution**
Blockage downstream of pump	• De-energize CP100 panel and isolate air compressor • Find and clear blockage in the urea line downstream of the pump

▶ Flow Sensor	
Cause	**Solution**
No power to the flow sensor	• Check flow sensor fuse (F3); replace if necessary • Check for 24 VDC at flow sensor (across TS3:24F3 and TS3:0V) • Check wiring
Flow sensor installed incorrectly	• Check flow sensor is installed in the correct orientation (flow arrow in direction of flow)
Flow sensor is seized	• De-energize CP100 panel and isolate air compressor • Remove flow sensor • Inspect and clean turbine wheel

▶ Check Valve	
Cause	**Solution**
Check valve installed incorrectly	• Ensure check valve in urea line is installed in correct orientation
Check valve is plugged / stuck closed	• De-energize CP100 panel and isolate air compressor • Remove check valve • Inspect and clean check valve

▶ 3-Way Valve	
Cause	**Solution**
No power to the 3-way valve	• Check 3-way valve fuse (F3); replace if necessary • Check for 24 VDC at 3-way valve (across TS3:24F3 and TS3:0V) • Check wiring
3-way valve not actuating	• Cycle power to 3-way valve (set VU110_s_manbypass to 2) and listen for audible clicking
3-way valve is plugged / stuck closed	• De-energize CP100 panel and isolate air compressor • Remove 3-way valve • Inspect and clean 3-way valve

▶ Injection Lance	
Cause	**Solution**
Injection lance is plugged	• De-energize CP100 panel and isolate air compressor • Ensure engine is OFF and ecoCUBE® is safe to touch • Remove injection lance from ecoCUBE® • Remove nozzle from injection lance • Inspect and clean injection lance and nozzle
Urea line blockage	• De-energize CP100 panel and isolate air compressor • Inspect and clean urea lines

8.1.2.2 Low/No Compressed Air

For standard compressors with a receiver tank, the Air Pressure Switch is set to 60 PSI. For tankless 'WOB-L' compressors, the Air Pressure Switch is set to 25 PSI. Tankless 'WOB-L' compressors only generate pressure when the engine is ON and the SCR is operating.

▶ Air Compressor	
Cause	**Solution**
Air compressor is OFF	• Energize the compressor
Air compressor not generating pressure	• Service air compressor
Air supply line isolation valves are closed	• Open air isolation valves

▶ Air Filter	
Cause	**Solution**
Air filter not passing air	• De-energize CP100 panel and isolate air compressor • Inspect and clean filter

▶ Inlet Air Regulator	
Cause	**Solution**
Inlet air regulator not passing	• Ensure inlet air regulator is set to 80 PSI • De-energize CP100 panel and isolate air compressor • Inspect and clean regulator

▶ Air Valve	
Cause	**Solution**
No power to the air valve	• Check air valve fuse (F3); replace if necessary • Check for 24 VDC at air valve (across TS3:24F3 and TS3:0V) • Check wiring
Air valve not actuating	• Cycle power to air valve (set VA110_s_manbypass to 2) and listen for audible clicking
Air valve is plugged / stuck	• De-energize CP100 panel and isolate air compressor • Inspect and clean air valve

▶ Air Pressure Switch	
Cause	**Solution**
No power to the air pressure switch	• Check air pressure switch fuse (F3); replace if necessary • Check for 24 VDC at air pressure switch (across TS3:24F3 and TS3:0V) • Check wiring
Air pressure switch is plugged / stuck	• De-energize CP100 panel and isolate air compressor • Inspect and clean air pressure switch

▶ Air Pressure Switch	
Cause	**Solution**
Outlet air regulator not passing air	• Ensure outlet air regulator is set to 40 PSI • De-energize CP100 panel and isolate air compressor • Inspect and clean regulator

▶ Injection Lance	
Cause	**Solution**
Injection lance is plugged	• De-energize CP100 panel and isolate air compressor • Ensure engine is OFF and ecoCUBE® is safe to touch • Remove injection lance from ecoCUBE® • Remove nozzle from injection lance • Inspect and clean injection lance and nozzle
Air line blockage	• De-energize CP100 panel and isolate air compressor • Inspect and clean air lines

8.1.2.3 CAN Bus Sensor Issue

Sensors installed on the ecoCUBE® use the CAN Bus communication protocol. A single sensor may stop communicating or the entire CAN Bus network may be faulty and all the sensors will stop communicating.

► NOx, Temperature, Pressure, and Mass Flow Sensors

Cause	Solution
Loss of power	• Check CAN Bus breaker (F5); reset if necessary • Check for 24 VDC at ecoCUBE® JB101 Junction Box (across TS4:1 (24V) and TS4:2 (0V), and also individual sensor terminals) • Check wiring
Loss of communication	• Reboot the NeuralNOx™ controller; open and close Fuse F2 • Check for 60 Ω at ecoCUBE® JB101 Junction Box (across TS4:3 (CAN Low) and TS4:4 (CAN High), and also individual sensor terminals) • Check wiring

ecoCUBE® CAN Bus Wire Colour Definition

Connection	Standard	Pressure (PR) Sensors
24 VDC	Red	White
0 VDC	Black	Blue
CAN Low	White	Grey
CAN High	Blue	Black

8.1.2.4 Analog Sensor Issue

► Urea Tank Level Sensor & Engine Load Sensor	
Cause	**Solution**
Loss of power	• Check sensor breaker (F4); reset if necessary • Check wiring
Loss of communication	• Reboot the NeuralNOx™ controller; open and close Fuse F2 • Check for 390 Ω resistor at analog input terminal on NeuralNOx™ controller • Check for signal from output terminal of sensor

8.1.3 Secure Controller Data (SCD)

The Secure Controller Data (SCD) utility allows non-authenticated users to extract encrypted data from the system controller. This feature proves useful in troubleshooting the system on sites that are not directly accessible to SP via an internet connection.

The data transfer can be done using a USB stick plugged into the USB port of the system controller (8.1.3.1) or through the web browser connected to the controller (8.1.3.2). The data can then be transmitted to SP via https://safetypower.net/drop.

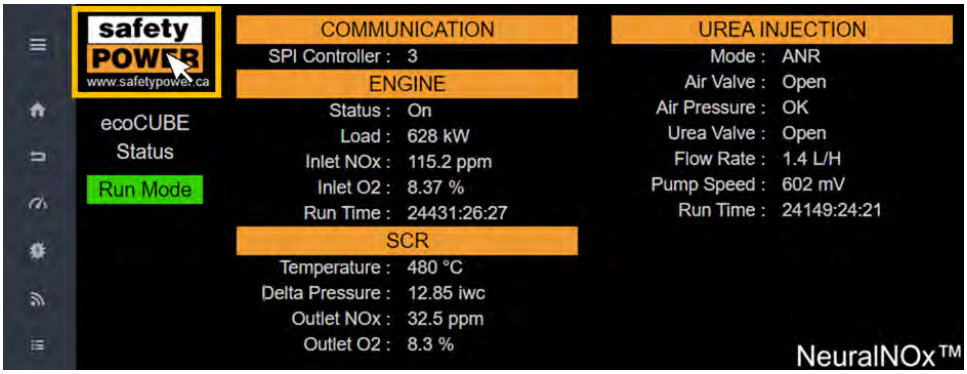


Figure 8.1: Click the Safety Power logo outlined by the yellow box on the HMI screen to open the SCD/SCX window

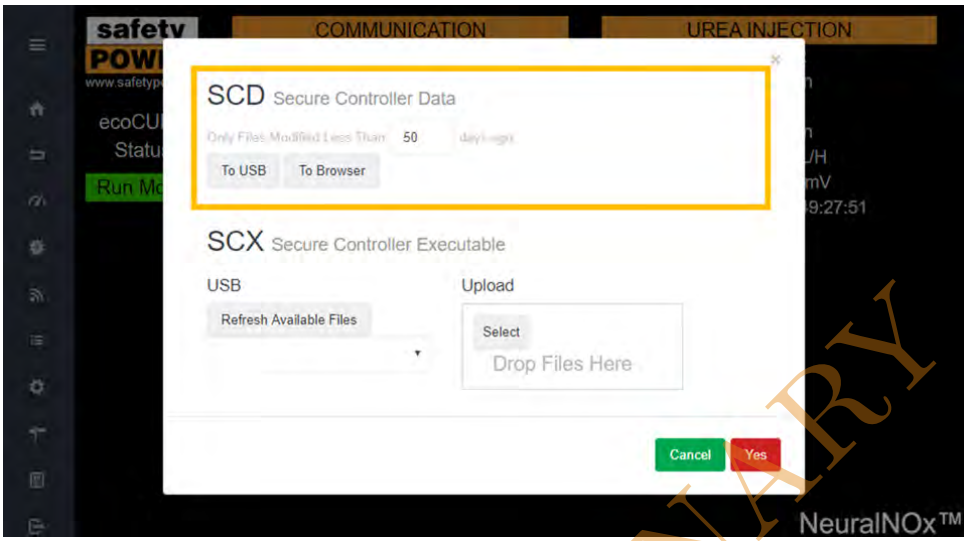


Figure 8.2: Use the outlined portion of the window to extract data files from the controller

8.1.3.1 SCD - USB

1. Plug a USB stick into the controller
2. Press the Safety Power logo on the HMI screen (Figure 8.1)
3. On the pop-up window enter the amount of data (in number of days) to be extracted; the default value is 50 days (Figure 8.2)
4. Press the **To USB** button to initiate the data transfer (Figure 8.2)
5. Remove USB stick once the data transfer is completed. The file will be placed in a folder named **spi**. If this folder does not exist it will be created. The name of the file will be the system_id followed by the date of extraction and have an .scd extension.
6. Upload the extracted data file to https://safetypower.net/drop by dragging and dropping the file into the webpage.

8.1.3.2 SCD - Browser

1. Connect to the controller's HMI using a web browser
2. Click the Safety Power logo on the HMI screen (Figure 8.1)
3. On the pop-up window enter the amount of data (in number of days) to be extracted; the default value is 50 days (Figure 8.2)

4. Press the **To Browser** button to initiate the data download to the web browser's downloads folder (Figure 8.2)
5. The name of the file will be the system_id followed by the date of extraction and have an .scd extension.
6. Upload the extracted data file to https://safetypower.net/drop by dragging and dropping the file into the webpage.

8.1.4 Secure Controller Executable (SCX)

The Secure Controller Executable (SCX) utility allows non-authenticated users to execute encrypted updated on the system controller. This feature proves useful in updating the system on sites that are not directly accessible to SP via an internet connection.

The SCX update can be done using a USB stick plugged into the USB port of the system controller (8.1.4.1) or through the web browser connected to the controller (8.1.4.2).

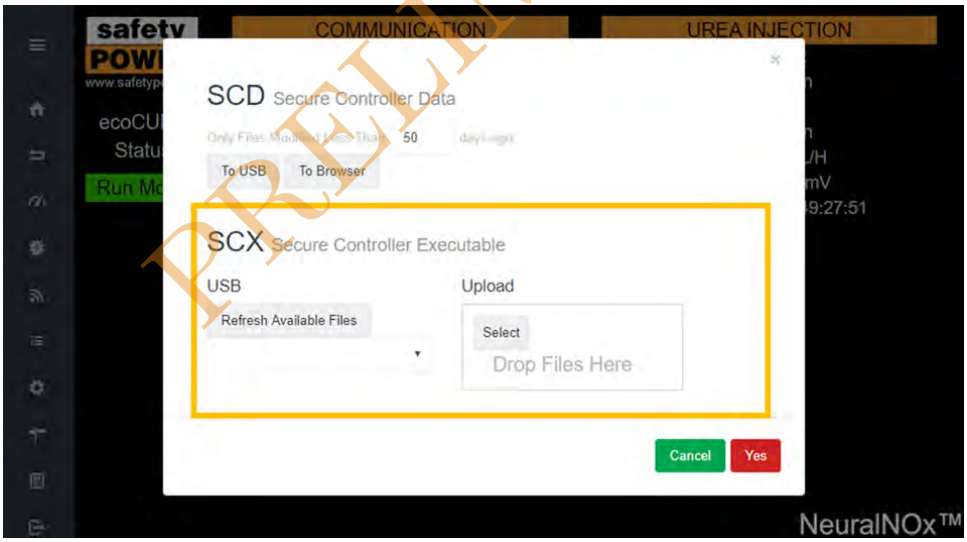


Figure 8.3: Use the outlined portion of the window to upload and execute updates to the controller

8.1.4.1 SCX - USB

1. Transfer the encrypted .scx file provided by SP onto a USB stick
2. Plug the USB stick into the controller
3. Press the Safety Power logo on the HMI screen (Figure 8.1)

4. On the pop-up window, press the **Refresh Available Files** button to generate a list of available .scx files on the USB stick (Figure 8.3)
5. Choose the desired .scx update file and press **Yes** at the bottom of the window
6. The update will then be automatically executed
7. Once the update is done, the USB stick can be unplugged

8.1.4.2 SCX - Browser

1. Transfer the encrypted .scx file provided by SP onto a computer with a web browser
2. Connect to the controller's HMI using the web browser
3. Click the Safety Power logo on the HMI screen (Figure 8.1)
4. On the pop-up window, upload the desired .scx update file into the **Upload** box under the SCX section and press **Yes** at the bottom of the window (Figure 8.3)
5. The update will then be automatically executed
6. Once the update is done, the connection to the controller can be terminated

Chapter 9

Maintenance

CAUTION

Unauthorized or improper maintenance work may lead to health hazards or equipment damage.

- For any maintenance activity not listed in this section, contact SP.
- Contact SP prior to any catalyst replacement or other major maintenance activity.

Periodic maintenance inspections are to be performed in order to:

- Improve system availability
- Identify and eliminate pending problems
- Perform preventative maintenance

9.1 Maintenance Visits

Factory maintenance or service calls can be arranged by contacting SP.

9.2 Replacing Components

If an operator discovers a faulty component and needs to replace it, they must contact SP. Depending on the complexity of the repair, SP may choose to:

1. Send the operator a replacement part with detailed replacement instructions. The operator must then install the part following the instructions.
2. Send SP personnel to conduct the repair.

The status of the warranty will inform the commercial aspects of component replacement.

9.3 Preventative Maintenance

SP recommends periodic maintenance of the entire system by the operator in accordance with the maintenance checklist(s) provided. The operator should keep an inspection/maintenance logbook. This will provide a useful record of maintenance activities and identify any operational problems. Specific instructions regarding each maintenance item is available from SP, if required by the operator.

9.4 ecoCUBE®

9.4.1 ecoCUBE® with SCR

Table 9.1: Recommended Maintenance Schedule - ecoCUBE® with SCR

Task/Item	Daily	Annually	Other
Check for alarms and faults on CP100 control panel	✓		
Check if reducing agent (urea) tank level is OK	✓		
Clean off any debris or combustible substances off the ecoCUBE®	✓		
Inspect system parts for urea leaks; remedy as necessary		✓	
Inspect system parts for air leaks; remedy as necessary		✓	
Visually inspect system parts for exhaust leaks (soot deposits); remedy as necessary			Monthly
Inspect heat tracing to ensure proper operation; remedy as necessary		✓	
Air compressor can turn on and air pressure is available		✓	

Continued...

Table 9.1: Recommended Maintenance Schedule - ecoCUBE® with SCR

Task/Item	Daily	Annually	Other
Check if atomizing air pressure at dosing panel >= 40 PSIg		✓	
DP across catalyst is within design limits (generally < 10 inH_2O)		✓	
Catalyst temperature (TC010) is > 300 °C		✓	
Check NOx outlet values as required by customer		✓	
Check system connections for tightness		✓	
Check if 3-way valve is OK; replace if necessary †		✓	
Check that the air separator drain is not latched open (hissing noise if it is); replace drain if necessary		✓	
Compare CP100 engine load vs. engine control panel engine load		✓	
Check torque on ecoCUBE® anchors to ensure they meet spec. on 99004026 DC-01 ecoCUBE® Design Criteria		✓	
Drain condensate using the drain port and close the port†			Quarterly
Verify urea concentration is within ISO 22241-1 requirements using a refractometer (Section 9.4.1.1)			1000 hrs
Inspect urea filter in dosing systems; clean if required†			Monthly
Inspect injection nozzle tip for wear (remove and visually inspect)‡			1000 hrs
Check gears on dosing pump†			1000 hrs
Inspect compressor intake air filter; clean/replace if required†		✓	1000 hrs
Tankless compressor system†		✓	1000 hrs
Receiver-based compressor system (follow OEM recommendations)†			✓
NOx analyzer (Testo) (follow OEM recommendations)†			✓

† Shut OFF ecoCUBE® before attempting to conduct these tasks.

‡ Shut down engine and ecoCUBE® and ensure that at least 48 hours has passed since the engine has been turned off, before attempting to conduct these tasks.

Special considerations for urea-based SCR systems:

- Urea/water solutions used in the SCR process are typically supplied in 32.5 % and 40 % urea concentrations. Urea crystallization can occur at temperatures below 14 °F for 32.5 % solutions and at temperatures below 33 °F for 40 % solutions.
- Urea is injected through a fine nozzle tip to achieve the desired droplet size for optimal NOx reduction performance. New piping should be thoroughly purged and cleaned to avoid plugging of nozzles and filters.

- Dosing nozzles are purged whenever the system shuts down to remove any urea solution. If the purge cycle does not take place (e.g. if compressed air is not available), the urea solution in the injection lance can be "boiled off" leaving behind urea salts. These salts can plug the injection lance.
- Urea solutions have a tendency to leak. Leaks can be identified by the appearance of white crystals at the location of the leak. These can be cleaned up with wet towels and water.

9.4.1.1 Urea Concentration Check

In order to check the concentration of urea, one must first acquire a small sample of urea (few drops are sufficient) and then use a urea refractometer to determine the concentration:

1. Drip a few drops of urea into the test port of the urea refractometer (Figure 9.1)
2. Close the port cover
3. Press the **GO** button to begin the test
4. The urea concentration in %wt is shown on the display
    - Urea concentration between 31.8 % and 33.2 % is within the ISO 22241-1 specifications; in reality, the NeuralNOx™ controller is robust enough to handle variations between 30 % and 35 %
    - If urea concentration is above acceptable bounds, the urea in the tank may be diluted using deionized water until the concentration is within the acceptable bounds
    - If urea concentration is below acceptable levels, it may be necessary to replenish/refill the urea in the tank

Figure 9.1: Urea refractometer

9.4.1.2 Catalyst Replacement

DANGER

Health hazards due to unexpected engine emissions.

- Prior to opening any doors, operator must follow proper lock-out/tag-out procedure to ensure that the engine and ecoCUBE® are disabled throughout the replacement procedure.
- Always wear respiratory mask with HEPA filter when replacing catalyst (soot present on catalyst may be disturbed during replacement procedure).

WARNING

Injury due to falling objects.

- Cordon off work area installing **DANGER** signs to prevent persons from entering the work area and/or the space underneath the work area.
- All maintenance personnel to use appropriate PPE.



WARNING

Burns due to hot reactor surface.

- Ensure that the engine has been turned OFF alteast 48 hours prior to troubleshooting components on the reactor.
- If unsure about the ecoCUBE® reactor's surface temperature, wear heat resistant gloves before touching it.

CAUTION

Injury due to improper lifting of heavy catalyst elements.

- Maintenance operators to follow all local and federal laws, requirements, and best practices associated with lifting components weighing over 50 lbs (23 kg).
- Use multiple people to lift and position catalyst elements, if necessary.

Catalyst replacement at end-of-life can be arranged by contacting SP; this work is **not intended** to be conducted by the operator or operating staff. For reference, the general procedure is as follows:

1. Wait **at least 48 hours** after the engine has stopped running before attempting catalyst removal.

- This generally provides enough time for the ecoCUBE® to cool to ambient temperature in sufficiently ventilated areas.
- Cooling time may be longer if area is not well ventilated.

2. Ensure adequate lighting is available around the work area prior to commencing work.
   - Includes portable lighting to provide illumination to the interior of the ecoCUBE®.
3. Ensure proper lock-out/tag-out procedure has been followed to ensure that the engine and ecoCUBE® are disabled throughout the replacement procedure.
4. Cordon off work area installing **DANGER** signs to prevent persons from entering the work area and/or the space underneath the work area.
5. Personnel to use appropriate PPE: head protection, foot protection, eye protection, heat-resistant gloves, respiratory protection, and if applicable, safety harness/fall-arrest equipment
6. Personnel to gain access to area around SCR door using previously agreed-upon means of access (e.g., scissor lift, ladder and fall-protection gear, catwalk, etc.).
   - All applicable local and federal regulations governing working-at-heights to be followed.
7. Remove the SCR door.
   - Position or secure the door such that it will not fall onto any persons that may be underneath the work area.
8. Remove the spent SCR catalyst.
   - Position or secure the catalyst such that it will not fall onto any persons that may be underneath the work area.
9. Install new SCR catalyst.
10. Remove any tools and light sources temporarily installed inside the ecoCUBE®
11. Install gasket and SCR door.
12. Temporarily release the lock-out/tag-out and turn on engine.
13. Check for blow-by around the edges of the SCR door using a Testo emission measurement device.
    - If blow-by is observed (emission measurement around the gaskets is higher than ambient), the gasket seal is not good and the gasket needs to be reinstalled. Restart procedure from Step 1.
    - If blow-by is not observed, the gasket seal is good. Replacement work is complete; engine lock-out/tag-out may be removed and cordoned off work area may be released.
14. Spent SCR catalyst is to be disposed appropriately (Section 10.2.2).

9.4.2 Spare Parts

The ecoCUBE® is designed to provide high performance while maximizing uptime when faced with component failure. There are many control redundancies built-in for a variety of sensor failures. The control system is able to automatically adapt its control mode in the event of detected failures, in addition to raising an alarm (Section 8.1.1). However, these secondary control modes may not provide the required emission reduction performance and it is critical that the failure is remediated for optimal performance (Section 8.1.2).

The spare parts list presented herein (Table 9.2) is intended to provide quick repair capability for particularly critical or susceptible parts, in order to maintain high levels of performance and safety. **Please notify SP immediately in the event of any component failure.** SP will provide specific instructions to replace components, when necessary.

Table 9.2: Recommended Spare Parts List

Component	Recommended Storage Quantity
Injector Lance	1
Injection Pump	1
Urea Flow Meter	1
NOx Sensor	1
3-Way Valve	1
Glass Fuse (250 VAC/10A)†	1
Glass Fuse (250 VAC/4A)†	1
Glass Fuse (250 VAC/3.15A)†	1
Glass Fuse (250 VAC/2A)†	1
Glass Fuse (250 VAC/1A)†	1
Glass Fuse (250 VAC/100mA)†	1

† 1 spare of each fuse is provided within each CP100 control panel.

Chapter 10

Decommissioning & Disposal

10.1 Decommissioning

CAUTION

Danger due to electric schock resulting from negligence.

- Operator must follow proper lock-out/tag-out procedure to ensure that all relevant equipment is disabled throughout the decommissioning procedure.
- All electrical supplies must be disconnected before decommissioning work may begin.

This section outlines general guidelines to be observed when decommissioning the ecoCUBE® or any ancillary equipment. This manual can only provide a minimum set of guidelines to be followed by the decommissioning staff; site variation may stipulate additional steps or precautions. If necessary, contact SP for site-specific recommendations.

10.1.1 ecoCUBE® & CP100 Control Panel

WARNING

Burns due to hot reactor surface.

- Ensure that the engine has been turned OFF alteast 48 hours prior to decommissioning.
- If unsure about the ecoCUBE® reactor's surface temperature, wear heat resistant gloves before touching it.

1. Ensure that the engine and the ecoCUBE® have been turned OFF for at least **48 hours**
   - In sufficiently ventilated areas, this is enough time to cool the ecoCUBE® and associated ducting to safe working temperatures
   - Cooling time may be longer if the area is not well ventilated
2. Follow proper lock-out/tag-out procedure to ensure that the engine, ecoCUBE®, and/or any ancillary equipment are powered down throughout the decommissioning procedure
3. Locate and disconnect/pull **Fuse 1 (F1)** in the CP100 control panel
4. Make sure to dissipate all forms of energy within the equipment; i.e., electrical, hydraulic, and/or pneumatic
5. Remove all wiring connecting:
   - Sensors to the junction box on the ecoCUBE®
   - Junction box to the CP100 control panel
   - CP100 control panel to the engine control panel
   - CP100 control panel to the building automation system (BAS)
6. Unscrew and detach all sensors on the ecoCUBE®; sensors may be returned to SP for recycling
7. Safely remove urea lines as follows:
   a. Locate and close all isolation vales on the urea line(s)
   b. Loosen the compression fittings on the urea line(s)

c. Detach the urea line(s)

8. Safely remove air lines as follows:
   a. Locate and close all isolation vales on the air line(s)
   b. Loosen the compression fittings on the air line(s)
   c. Detach the air line(s)
9. Unmount the CP100 control panel; it maybe returned to SP for recycling
10. Unbolt and detach the exhaust stack or connecting piping from the outlet of the ecoCUBE®
    - Ensure that entire system is at atmospheric pressure before unbolting components; see step 4
11. Unbolt the inlet flange of the ecoCUBE® from upstream piping
    - Ensure that entire system is at atmospheric pressure before unbolting components; see step 4
12. The ecoCUBE® may now be lifted and transported (Chapter 4) to a more convenient location, if necessary
    - Due to the effects of thermal cycling over the life of the ecoCUBE®, the structural integrity of the lifting lugs need to be verified prior to its use during decommissioning & disposal. Please contact SP for more information.
13. Remove the catalyst (Section 9.4.1.2) from the ecoCUBE®

10.1.2 Air Compressor

1. Disconnect all electrical supply to the air compressor
2. Follow proper lock-out/tag-out procedure to ensure that system remains powered down throughout the decommissioning procedure, if applicable
3. Relieve any pressure remaining in the receiver, if applicable
4. Detach the compressor from the air lines
5. Disconnect all wiring associated with the air compressor

10.2 Disposal

In order to minimize the environmental and health impacts associated with the disposal of materials used, the ecoCUBE®, or ancillary equipment, SP recommends the following procedures.

10.2.1 Urea Disposal

The disposal of urea requires contacting a vendor which specializes in the handling of hazardous chemicals. The general procedure is as follows:

1. Call the vendor for a representative to come to the site where the waste urea is located. Ensure that you call the vendor in advance, whenever possible, to prevent any delays in the disposal process.
2. The representative will arrive on site and collect samples and inspect the container of the urea. Ensure any documentation involved in urea handling is provided for the representative.
3. Representative will bring samples to their testing facility in order to determine disposal methods and cost of disposal. Any relevant permits will be collected in order to validate that the waste management follows the appropriate regional regulations.
4. The vendor will follow up with a quote and detailed procedure of disposal upon request.

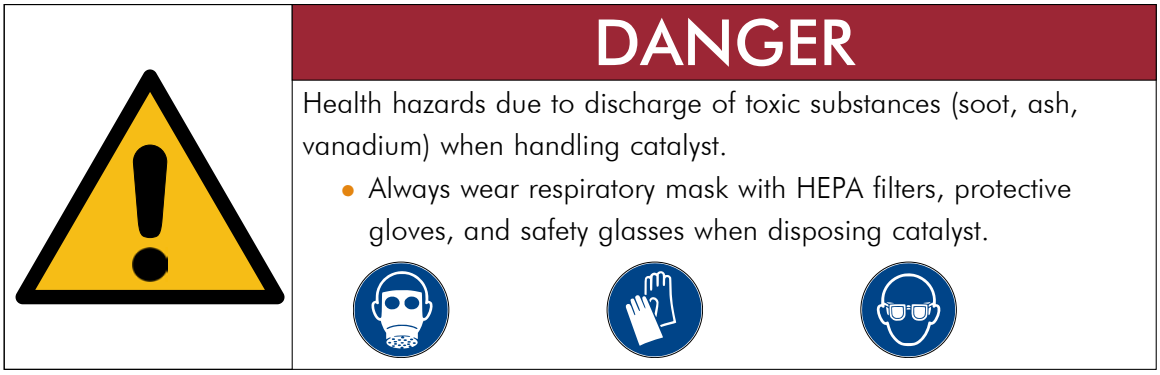
10.2.1.1 Recommended Vendors

In North America, SP recommends GFL Environmental for urea disposal services. GFL has locations in Canada and most of the United States. They can be contacted at:

- Website: http://gflenv.com/
- Phone: 1(866) 417 - 2797

For recommendations on urea disposal vendors in your region, please contact SP.

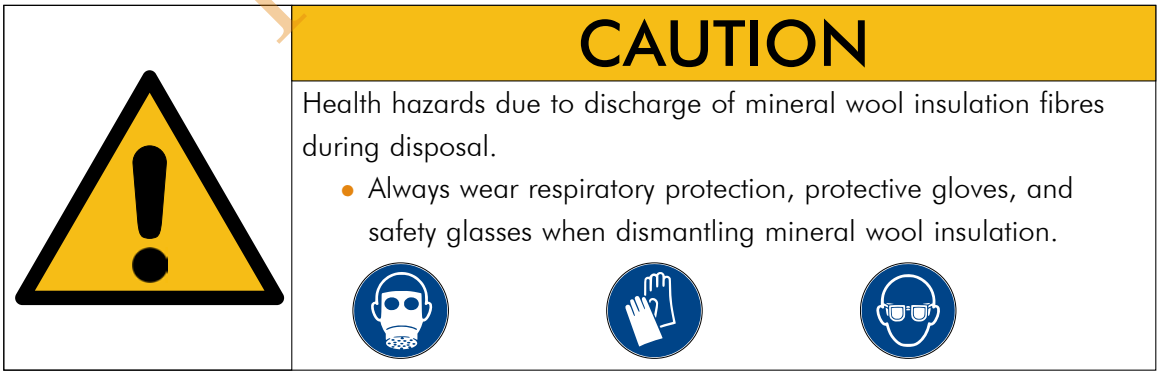
10.2.2 Catalyst Disposal



The disposal of catalyst is subject to all local and federal laws, requirements, and best practices. Complete understanding and interpretation of these rules and regulations is best suited for the local entities responsible. Contact local waste management authorities for pertinent information. The following general guidelines may aid in the disposal process:

- A Toxicity Characteristic Leaching Procedure (TCLP) as defined by the EPA may be used to determine if the waste is to be classified as hazardous. To SP's knowledge, the TCLP test results of SCR catalysts have generally indicated waste contaminant concentrations below the maximum allowable concentration thresholds, and as such spent catalyst in these instances has been classified as non-hazardous industrial waste, subject to any state, provincial, or local regulation dictating otherwise. If classified as non-hazardous, the waste may be be disposed at a landfill.
- Catalyst is not considered dangerous from a transportation perspective. It may be shipped as ''less than load'' (LTL), applying standard industry best practices regarding securing loads during transport.
- Oxidation catalysts may be sent for metal reclamation in order to extract value from the precious metals present (primarily, palladium and platinum), prior to disposal.
- The metal catalyst housing may be salvaged as scrap metal prior to disposal of the catalyst at a landfill.

10.2.3 Disposal of ecoCUBE® Reactor



The disposal of industrial equipment is subject to all local and federal laws, requirements, and best practices. Complete understanding and interpretation of these rules and regulations is best suited for the local entities responsible. Contact local waste management authorities for pertinent information. The following general guidelines may aid in the disposal process:

- The ecoCUBE® reactor is fabricated from high quality stainless steel surrounded by mineral wool insulation and an aluminum cladding.
- It is recommended that the insulation is separated from the cladding and reactor; use of respiratory protection, protective gloves, and safety glasses is recommended in order to avoid harm from the discharge of the insulation fibres.
- Insulation is generally classified as non-hazardous material and may be disposed at landfills. It may be beneficial to seal the insulation in a container or bags as it may release mineral wool fibres or dust during transport and final disposal.
- The stainless steel and aluminum may be sent for scrap metal recycling.

10.2.4 Disposal of Ancillary Equipment

The disposal of industrial equipment is subject to all local and federal laws, requirements, and best practices. Complete understanding and interpretation of these rules and regulations is best suited for the local entities responsible. Contact local waste management authorities for pertinent information.

Chapter 11

Attachments

11.1 Material Safety Data Sheets

11.1.1 Urea (Sample Only)

ANCO CHEMICALS INC.
85 MALMO COURT, MAPLE, ONTARIO L6A 1R4
(905) 832-2276 .FAX (905) 832-3701
www.ancochemicals.com

MATERIAL SAFETY DATA SHEET page 1 of 4

1. Product and Comapny Identification: AnClear32 Diesel Exhaust Fluid

Effective Date: Jan. 25, 2016

24 Hour Emergency Numbers
CANUTEC'S # 613-996-6666(call collect)
OR *666 cellular

Anco Chemicals Inc.
85, Malmo Court
Maple, ON, L6A 1R4
Tel. 905-832-2276

Chemical Name: Stabilized Urea mixture
Product Use: To reduce nitrogen oxide in diesel engines
Product Covered: 32.5% Urea Solutions CAS# 57-13-6
Published: Anco Chemicals Inc., Quality Department,
Tel : 1-905-832-2276 x 233 by Sat Anand

2. Hazardous Identification

Emergency Overview: Clear, colourless liquid with ammonia odour
Classification: WHMIS classification: It is not a controlled product in Canada and is not a hazardous product under OSHA regulations.
Short term health effects:
Eyes: May cause slight irritation on a longer contact.
Skin: May cause mild irritation if in contact for long period of time.
Inhale: It is not harmful to work with but if spilled on your body may cause sore throat, cough and may be shortness of breath.
Ingest: May cause throat and stomach irritation. It may cause headache, dizziness, nausea, vomiting and edema.

3. Composition/Information on Ingredients

Ingredients:	%	CAS. No.
Urea	32.5	57-13-6
Water	67.5	007732-18-5

4. First Aid Measures:

Inhaled: Move victim to fresh air. If not breathing give artificial respiration.
Keep patient warm and at rest and obtain medical attention if symptoms persists.
In Contact with the Skin: Flush skin with running water for at least 15 minutes.
Start flushing while removing contaminated clothing. If irritation persists, repeat flushing and obtain medical attention.

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AMERICAN PETROLEUM INSTITUTE CERTIFIED DIESEL EXHAUST FLUID

ANCO CHEMICALS INC.
85 MALMO COURT, MAPLE, ONTARIO L6A 1R4
(905) 832-2276 .FAX (905) 832-3701
www.ancochemicals.com

In Contact with the Eyes: Flush eyes with running water for a minimum of 15 minutes and seek medical attention.
Ingested: If victim is alert and not convulsing, rinse out mouth and give 1 to 2 glasses of water to dilute material. Do not induce vomiting. Never give anything by mouth if victim is unconscious.
Emergency Medical Care: Treat as per the victim symptoms as explained above.

5. Fire & Explosion Data:

Flamability: Not flammable but the container may rupture if exposed to excessive heat.
Fire Extinguishing Media: Use CO2, Dry Chemical, Water Spray to extinguish the surrounding fire.
Fire Fighting Procedures: Use water to keep fire-exposed containers cool. Use water fog to reduce concentration if necessary. Full protective equipment including a self-contained breathing apparatus, should be worn in a fire involving the material and surrounding.
Hazardous combustion products: May include CO2, oxides of nitrogen, ammonia and other irritating fumes

6. Accidental Release Measures

Personal precautions: Keep unwanted personals away from the area of spill. Use proper protective equipments.
Environmental precautions: Don't let the spill enter the sewers and waterways.
Special procedures: Small spill can be cleaned with non-reactive absorbent and placed in suitable, covered containers.
Large spill should be prevented to flow to the drains and sewers. Contact emergency service responders for help. Let the appropriate authority know about the spill.

7. Handling and Storage

Handling Procedures and Equipment: Handle this product in well vented area. Avoid contact with eyes, skin or clothing by using appropriate protective equipments. If in contact, wash with soap and water. Keep containers tight closed when not in use. **Storage Requirements**: Store in a cool, dry, well ventilated area away from incompatibles. Store away from strong oxidizing agents (e.g. hydrogen peroxide, nitric acid. Sodium Hypochlorite) and strong acids.

8. Exposure Controls/Personal Protection

Engineering Contacts: Local exhaust ventilation is required especially in confined areas. Follow the confined space regulations.
Respiratory Protection: Generally not required if handling in a ventilated atmosphere. Respirators may be required under certain conditions.
Skin Protection: Rubber gloves and protective clothing are recommended.

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ANCO CHEMICALS INC.
85 MALMO COURT, MAPLE, ONTARIO L6A 1R4
(905) 832-2276 .FAX (905) 832-3701
www.ancochemicals.com

MSDS: AnClear32 Diesel Exhaust Fluid effective date Jan. 25, 2016 page 3/4

Eye Protection: Use gas-tight chemical safety goggles when there is potential for eye contact.
Preventive Measures:
Wash hands before eating, drinking, smoking or using toilet facilities. Avoid contact with skin, eyes and clothing. Avoid breathing vapours.

9. Physical and Chemical Properties
Physical Properties

Appearance & Odour:	Colourless liquid with a slight ammonia smell.
Boiling Point:	104C
Melting/Freezing Point:	-12C
PH	9.5 – 10.0
Density:	9.1 lbs/USG
Specific Gravity	1.094 @ 25C
Evaporation Rate:	Not applicable.
Solubility:	100% Soluble in Water
Volatile by Volume:	No Data.

10. Stability and Reactivity

Stability: Stable under ordinary conditions of use and storage
Conditions to Avoid: Excessive Heat, sparks and open flame.
Materials to Avoid: Oxidizers, Acids
Hazardous Decomposition or Combustion Products: May include and are not limited to Oxides of Carbon and Nitrogen, ammonia.

11. **Toxilogical Information**

Toxicological and Health Data:
Toxicological Data: LC50 : N/A
LD50 : 11,500-13,000 mg/kg mouse, 14,300-15,000 mg/kg rat
Carcinogenicity Data: The ingredients of this product are not listed as carcinogens by NTP, (National Toxicology Program), not regulated as carcinogens by OSHA, (Occupational Safety & Health Administration), by IARC, (International Agency for research on Cancer or ACGIH (American Conference of Governmental Industrial Hygienists).
Acute exposure: May cause irritation to eyes and skin

12. **Ecological Information**

Ecotoxicity: This product should not be allowed to enter sewers. Components of this product have been identified as having environmental concerns.
Aquatic toxicity: Not available

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Bioaccumulation / accumulation: Not available
Other adverse effects: Not available

13. **Disposal Consideration**

Waste Disposal Methods: Dispose this product in accordance with all applicable local, provincial, state and federal regulations.
Handling of waste: Ref. to section 7 above.

14. **Transport Information**

Clear Language/TDG (Transportation of Dangerous Goods): Not regulated as dangerous goods

U.S. DOT (Department of Transportation): Not regulated as dangerous goods

15. **Regulatory Information**

Canadian Regulations:
All constituents of this solution are included on the DSL
WHMIS Classification: It is not a controlled product in Canada and is not a hazardous product under OSHA regulations. MSDS contains all the information required by the Controlled Product Regulations.

US Federal Regulations:
All constituents of this solution are included in TSCA list. This product is not classified as hazardous under U.S.EPA regulations.
Food and Drug Administration: Not available

16. **Other Information**

Prepared by: Sat Anand, Anco Chemicals Inc., Quality Department,
Tel : 1-905-832-2276 x 233
Effective date: Jan. 25, 2016
HMIS rating: Health: 1, Flammability: 0, Reactivity: 0

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AMERICAN PETROLEUM INSTITUTE CERTIFIED DIESEL EXHAUST FLUID

11.2 Supplementary Information

11.2.1 99003059 ecoCUBE® Urea System Installation Instructions

99003059 ecoCUBE® Urea System Installation Instructions

Revision History

Rev#	Date	Editor	Description
1.0	27Aug2018	IS/AB	Initial Release
1.1	17Oct2018	IS	Added Compressor Installation Notes

Table of Contents

Introduction

This document is meant to serve as a guideline for the installation of Safety Power's selective catalytic reduction (SCR) urea system. It outlines the requirements for positioning of air compressors, urea storage tanks, transfer system, and dosing (CP100) panel.

These instructions are meant to supplement the shop drawing package provided – please carefully review all installation notes on the relevant shop drawings before installing the system.

Guidelines and System Requirements

Various tank and dosing arrangement options are possible to supply urea to the SCR reactor. Common elements of the urea system are a main tank, day tank (if required), transfer system (if required), and the dosing panel. Three common arrangements are as follows:

- Dosing panel draws urea from a single main tank
- Dosing panel draws urea from a day tank, which is periodically refilled by a urea transfer system connected to the main urea storage tank
- Urea is supplied to the dosing panel from a single main tank, with a transfer system

CP100 and tanks

For tanks (main tanks or day tanks) that supply urea directly to the dosing panel, the following apply:

- Tank to be installed as close as possible to CP100 panel
- Dosing pump maximum suction head is limited to 8'. Elevation from bottom of tank to inlet of CP100 must not exceed 8' head
- If above cannot be accommodated, transfer system is required
- Dosing pump maximum discharge head is limited to 75'. Line from outlet of the CP100 to injection lance must not exceed 75' head
- Urea supply piping shall not be run above the elevation of the CP100 urea inlet (Refer to Figure 2 below). If supply piping is above the elevation of the CP100 urea inlet, this allows for air pockets to form in the lines and for the system to lose prime
- Vertical runs of piping between tank and dosing panel must NOT be larger than ¼" to avoid losing prime

Figure 1 - Recommended tank/dosing panel arrangement

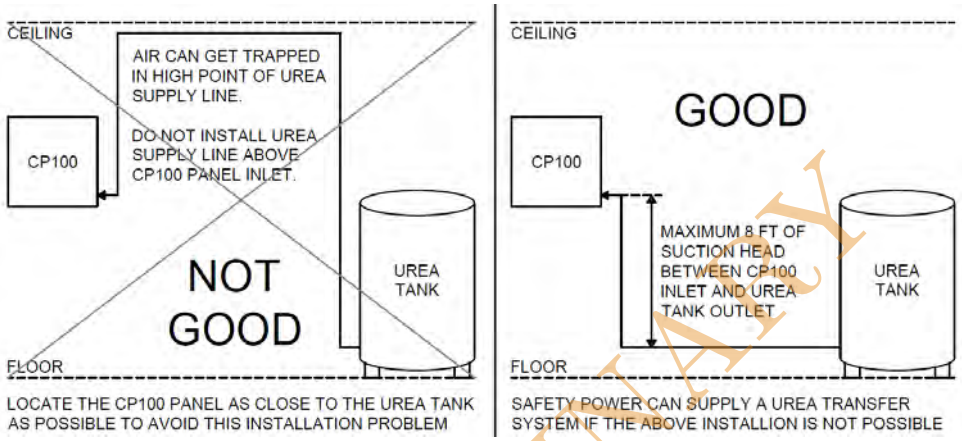

Figure 2 - Recommended piping from tank to dosing panel

Transfer Systems

When the main tank cannot be located in close proximity to the dosing panel, a transfer system is required. A transfer system pumps urea from a main storage tank to a day tank – refer to the figure below for a schematic showing a urea transfer system. They transfer system consists of a skid mounted duplex pump, pressure regulators, transmitters, and switches. The transfer system requires a urea transfer (UT) control panel to supply power and control the system.

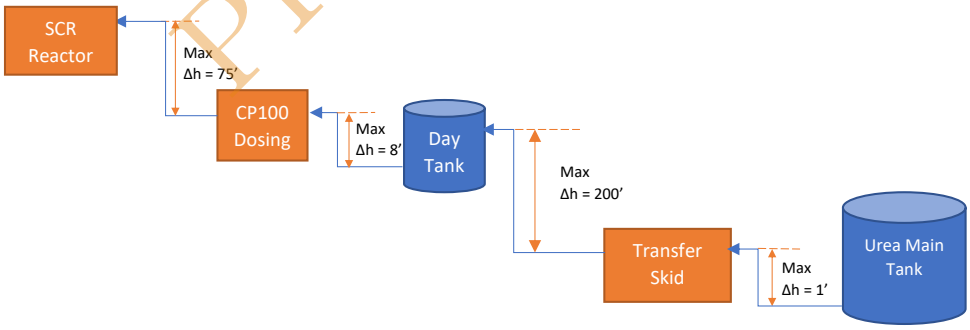

Figure 3 - Urea Flow Diagram with Transfer System (Note: elevations not to scale)

The following applies to installations with transfer systems:

- All guidelines above in “CP100 and Tanks” section apply to the day tank/CP100 system and must be followed to ensure successful installation
- The elevation of the transfer pump inlet must be no more than 1’ above the main tank supply line elevation, and the transfer pump system should be located no more than 10’ away from the tank
- The elevation of the day tank urea inlet must not be more than 200’ above the elevation of the transfer pump system outlet

Transfer Loops

Some installations have a transfer systems without a day tank. The transfer system provides the pressure required by the dosing pump when it is located far from the urea tank. This arrangement requires a pressure relief valve downstream of the urea supply line to the dosing panels, and is connected to the urea return lines to the tank. The pressure relief valve is to be located in an accessible area to allow for adjustment of the pressure at dosing panel inlet.

Urea Storage Tanks

Urea tanks can vary in shape, size, material of construction, single/double wall, urea supply orientation, etc. All tanks should follow the guidelines to ensure proper operation and prevent tank overpressure.

- All tanks shall have pressure vacuum vents to prevent evaporation and allow for venting during filling
- Installation contractor to verify that all fittings on the top of the tank shall be capped and completely sealed prior to filling the tank with urea
- HDPE tanks are not to have the pressure vacuum vent elevated more than 10” above the top of tank. If the vent is elevated, a static head condition can be created in case of tank overfill, which could cause tank overpressure. An HDPE tank cannot be used with an elevated urea fill station.
- If a vent or urea fill station is more than 10” above the top of the tank, a stainless steel tank is required
- A pressure vessel is required if the height of the urea fill station or vent is >23’ above the bottom of the tank. These tanks require a higher pressure rating and require review and stamp by a certified PEng.

Compressor Installation

Several different compressor designs are used to supply atomizing air to the SCR injection lance, namely tankless compressors and compressors with tank receivers. The following guidelines apply to tankless compressors:

- Ensure that the compressor is mounted upright on a flat surface (ie. Not on an enclosure wall)
- Ensure that coalescing filters downstream of compressors are located as close as possible to downstream equipment (ie. The CP100 panel). This is to ensure that all the moisture that has condensed due to temperature drop in the air line is captured by the filter. If there is a long pipe run downstream of the filter, additional moisture may condense in the air stream.

The following guidelines apply to reciprocating piston compressors with tank receivers:

- Allow minimum 18” behind the beltguard and around the unit
- Ambient temperature should be between 10°C and 40°C, and area should be well ventilated
- Ensure the floor under the unit is smooth, level, and capable of bearing the weight of the compressor
- Use vibration isolation pads at compressor feet and flex hose on the outlet of the compressor to minimize vibration
- Do not overtighten stainless steel fittings to brass fittings of compressor or air dryer components. Overtightening stainless steel fittings can lead to cracking of the softer brass fitting.

General guidelines

DOs

- Ensure a secure uninterruptible power supply to CP100 dosing panels. Any sudden loss of power to the panel will stop injection and prevent urea purge cycle from draining urea downstream of the panel
- All bottom outlet tanks are to have an Isolation valve, filter, and foot valve, and another isolation valve at the dosing panel inlet
- If urea supply line has to go above CP100 panel inlet, the urea dosing pump needs to be installed at tank outlet. Safety Power needs to be aware of this before fabricating the control panel
- All top outlet tanks are to have filter and foot valve on the suction line, and an isolation valve at the dosing panel inlet. Please see attachments for relevant specification sheets.
- Refer to tubing specifications below and shop drawing package for further details

DON’Ts

- Do not insulate any items that require service (filters, valves, check valves, etc.)
- Do not use wall thickness or diameter other than specified. Thicker walls reduce usable tube size and create additional pressure drop. Wider diameter causes system to lose prime in vertical runs of piping
- Shop insulated and heat traced Teflon urea tubing lines (Unitherm bundle) are acceptable in most applications in lieu of SS tubing (see attached cutsheets). However, do not use Teflon tubing between outlet of compressor and inlet of CP100. This can lead to issue as pictured below.
- Do not use swing check valves. Use foot valves at the base of any vertical tube runs upstream of dosing panels

Figure 4 - Teflon tubing failure at outlet of compressor

Tubing Specifications

- Tube sizes are to be as follows:
  - ¼" 304 SS for urea delivery lines leading to the dosing panel and all vertical lines upstream of the dosing panel
  - ½" 304 SS for urea headers running horizontally at the outlet of the urea tank. Any urea lines running vertically must be ¼"
  - ½" 304 SS for air lines from the compressor to dosing panel and dosing panel to injection lance
  - All wall thicknesses to be 0.035"

- Insulation specifications for SS lines
    - All SS urea lines where temperature may drop below freezing (indoor or outdoor) shall be heat traced and insulated. Heat tracing shall supply minimum of 25 W/m. Air lines do not require heat tracing.
    - For outdoor SS lines requiring insulation, use minimum ½" thick fiberglass pipe insulation, with PVC jacketing or equivalent material suitable for outdoor use. For indoor applications, Armacel Tubolit or equivalent polyethylene pipe insulation can be used.
- Teflon (Unitherm bundle) is acceptable **except as noted above.** Refer to attached cutsheets.
    - Use SS tube supports at all tube ends and compression fitting connections
    - Please see attachments for Unitherm bundle. Note maximum operating temperature for Unitherm bundle is 60°C.

Miscellaneous Items

- Installing urea level sensor
    - Trim the cord of the sensor such that the tip of the probe is just touching the bottom of the urea tank
    - Ensure that the cable is not coiled up inside the tank. Ensure that the wiring is not twisted inside the junction box, as this can cause the pressure tube to become pinched and give inaccurate readings
    - Ensure that all fittings on top of tank are tightened to prevent any potential urea leaks in the event of tank overfill

Figure 5- Potential pressure tube pinch point at level sensor junction box

Attachments

1. Unitherm Bundle, Urea Line Only
2. Unitherm Bundle, Urea Supply Line and Return Line
3. Unitherm Bundle, Air and Urea
4. Common Swagelok Fittings

Electric Traced SR Product Catalog

Item Number : 2256-24A49

This picture is for presentation purposes only, it does not represent actual product.

Description

DEKORON®/Unitherm™ Self-Regulating Electric Traced Tubing is a thermally insulated fluid transport line for use in applications requiring freeze protection or condensation prevention. The energy-efficient design provides a temperature maintenance of up to 250ºF (121ºC). Available in 120/240 VAC. Bundles in this Series are FM Approved & The Self-Regulating Heating Element is approved by CSA & ATEX.

Features:
- Compact Design
- Low heat loss
- Low-maintenance
- Employee protection
- Easy to install
- Light, durable, easy to handle
- Consistent thermal characteristics

Applications:
- Process Analyzers
- Stack Gas sampling
- Gas transport lines
- Liquid transport lines
- Analyzer and instrument lines
- Small diameter process lines
- Impulse lines – D/P cells

Construction

1. (1) 1/4" O.D. x .040" Wall PFA Fluoropolymer Process Tubes (Heated)
2. 8 Watts/Ft 120 VAC Low Temperature Self-Regulating Heater (Chromalox SRL 8-1CT)
3. Aluminum Mylar Thermal Barrier
4. Non-Wicking Inorganic Fibrous Glass Thermal Insulation
5. 105°C Black FR-LTPVC (Flame Retardant Low Temperature Polyvinyl Chloride) Jacket

MECHANICAL SPECIFICATIONS	Nominal OD		Min. Bending Radius		Working Pressure [1]		Max. Continuous Length		Weight	
	Inches	Millimeter	Inches	Centimeter	PSI	Barg	Foot	Meter	Lbs/FT	Kgs/Me
	1.41	35.8	9.87	25.1	40	3	1000	305	0.40	0.59

[1] Working Pressure based on the MTR of this item in relation to the tables ASME B31.1-2001 and ASME B31.3-2001.

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Telephone 239-995-8111 • Fax 239-995-8027
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Item: 2256-24A49
Revision: 20150115SP

ISO 9001:2008 CERTIFIED

Electric Traced SR Product Catalog

Item Number : 2256-24A49

DEKORON Unitherm™ Tubing Bundle Experts Since 1962

TEMPERATURE SPECIFICATIONS

Max Temp. Rating [1]: °F	Max Temp. Rating [1]: °C	Mininum Install. Temp [2]. °F	Mininum Install. Temp [2]. °C
150	66	-25	-31

Design Temp. Maintenance °F	Design Temp. Maintenance °C	Low Ambient Temp. °F	Low Ambient Temp. °C
111	44	-50	-45
120	49	-20	-28
125	52	0	-17
131	55	20	-6

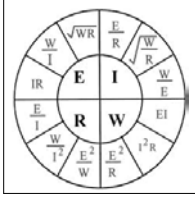
[1] Maximum Temperature Rating indicates the maximum temperature that the core of the bundle can withstand at the high ambient temperature of 80°F(26°C). Temperatures in excess of this rating may result in deterioration of the components. It does not represent maintenance temperature or rating of components distant from the core.

[2] Minimum Installation Temperature relates to the brittleness of this item's jacket material, during installation. Ambient operating temperature for this item per jacket material as follows:

	Low	High
PVC	-36°F/-38°C	221°F/105°C
DSJM	-50°F/-45°C	221°F/105°C
TPU	-45°F/-43°C	212°F/100°C
TPE	-50°F/-45°C	257°F/125°C
PE	-76°F/-60°C	158°F/70°C

ELECTRICAL SPECIFICATIONS

Voltage	Wattage Per Foot	Wattage Per Meter	Max Circuit Length Foot	Max Circuit Length Meter	Amps Per Foot	Amps Per Meter	Breaker Amps
120	8	26	200	61	0.000	0.000	30.00



General Info

L = Length
W= Watts
I = Amps
E = Volts

Power Adjustment Factors

(Actual E²/Heater E²)*Heater W = Actual W
e.g. (220V²/240V²)*18w/ft=15w/ft

Total Wattage

L*W= Total Wattage
e.g. 100ft*18w/ft=1800 total wattage

Current Draw

(L*W)/E=I
e.g. (100ft*18w/ft)/240V=7.5A

Recommended Accessories

Electrical Connection & Termination Kit | End-Boots | Cable Entry Seals | Unicut™ Bundle Jacket Cutter | Seal Patch Kits | Bundle Bender

Assigned accessories to item:

*1548-30110**1548-30310**BOOT-2**SEAL 1.60**1540-10000 / 1540-20000**1535-02120*

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Item: 2256-24A49
Revision: 20150115SP

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Electric Traced SR Product Catalog

Item Number : 2266-24B49

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Description

DEKORON®/Unitherm™ Self-Regulating Electric Traced Tubing is a thermally insulated fluid transport line for use in applications requiring freeze protection or condensation prevention. The energy-efficient design provides a temperature maintenance of up to 250ºF (121ºC). Available in 120/240 VAC. Bundles in this Series are FM Approved & The Self-Regulating Heating Element is approved by CSA & ATEX.

Features:
- Compact Design
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- Stack Gas sampling
- Gas transport lines
- Liquid transport lines
- Analyzer and instrument lines
- Small diameter process lines
- Impulse lines – D/P cells

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1. (2) 1/4" O.D. x .040" Wall PFA Fluoropolymer Tubes (Heated)
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4. Non-Wicking Inorganic Fibrous Glass Thermal Insulation
5. 105°C Black FR-LTPVC (Flame Retardant Low Temperature Polyvinyl Chloride) Jacket

MECHANICAL SPECIFICATIONS	Nominal OD		Min. Bending Radius		Working Pressure [1]		Max. Continuous Length		Weight	
	Inches	Millimeter	Inches	Centimeter	PSI	Barg	Foot	Meter	Lbs/FT	Kgs/Me
	1.5	38.1	10	25.4	100	7	1000	305	0.40	0.59

[1] Working Pressure based on the MTR of this item in relation to the tables ASME B31.1-2001 and ASME B31.3-2001.

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Electric Traced SR Product Catalog
Item Number : 2266-24B49

DEKORON Unitherm™ Tubing Bundle Experts Since 1962

TEMPERATURE SPECIFICATIONS	Max Temp. Rating [1]: °F	°C	Mininum Install. Temp [2]. °F	°C	Design Temp. Maintenance °F	°C	Low Ambient Temp. °F	°C
	150	66	-25	-32	95	35	-50	-46
					105	41	-20	-29
					112	44	0	-18
					119	48	20	-7

[1] Maximum Temperature Rating indicates the maximum temperature that the core of the bundle can withstand at the high ambient temperature of 80°F(26°C). Temperatures in excess of this rating may result in deterioration of the components. It does not represent maintenance temperature or rating of components distant from the core.

[2] Minimum Installation Temperature relates to the brittleness of this item's jacket material, during installation.

	Low	High
PVC	-36°F/-38°C	221°F/105°C
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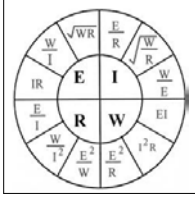
PE	-76°F/-60°C	158°F/70°C

ELECTRICAL SPECIFICATIONS	Voltage	Wattage Per Foot	Wattage Per Meter	Max Circuit Length Foot	Max Circuit Length Meter	Amps Per Foot	Amps Per Meter	Breaker Amps
	120	8	26	200	61	0.067	0.219	30.00



General Info

L = Length
W= Watts
I = Amps
E = Volts

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(Actual E^2/Heater E^2)*Heater W = Actual W
e.g. ($220V^2$/$240V^2$)*18w/ft=15w/ft

Total Wattage
L*W= Total Wattage
e.g. 100ft*18w/ft=1800 total wattage

Current Draw
(L*W)/E=I
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Item: 2266-24B49
Revision: 20170111SP

Electric Traced SR Product Catalog

Item Number : 2266-44B49-141012

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MECHANICAL SPECIFICATIONS	Nominal OD		Min. Bending Radius		Working Pressure [1]		Max. Continuous Length		Weight	
	Inches	Millimeter	Inches	Centimeter	PSI	Barg	Foot	Meter	Lbs/FT	Kgs/Me
	1.76	44.7	12.5	31.8	75	5	500	152	0.60	0.89

[1] Working Pressure based on the MTR of this item in relation to the tables ASME B31.1-2001 and ASME B31.3-2001.

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Max Temp. Rating [1]: °F	Max Temp. Rating [1]: °C	Mininum Install. Temp [2]. °F	Mininum Install. Temp [2]. °C
150	66	-25	-31

Design Temp. Maintenance °F	Design Temp. Maintenance °C	Low Ambient Temp. °F	Low Ambient Temp. °C
71	22	-50	-45
84	29	-20	-28
93	34	0	-17
102	39	20	-6

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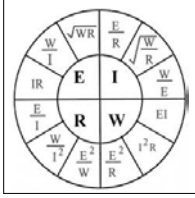

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e.g. (220V²/240V²)*18w/ft=15w/ft

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Current Draw

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Item: 2266-44B49-141012
Revision: 20150728SP

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Owners and Operators Manual

Selective Catalytic Reduction (SCR) System

Holt Texas LTD.

Holt CAT Dual Lance (C175) SCR Systems

VPN 1040249

Catalytic Combustion Corporation
311 Riggs St
Bloomer, WI 54724
P: 715-568-2882
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Document No.: 51982 Rev B

Published December 2022

Owners Manual Selective Catalytic Reduction (SCR) System

Holt CAT Dual Lance (C175) SCR System VPN 1040249

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Operations Manual

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• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

ISO 9001 Certified
Verisys Registrars®

Integrity | Service | Excellence

Catalytic Combustion Corporation introduced cutting edge technology in 1950 with the development of the first ever US patented catalyst to destroy VOCs (Volatile Organic Compounds). Since that time, the company has expanded into the design and supply of catalysts and emission control system for a wide variety of industries.

Catalytic Combustion Corporation
• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

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Catalytic Combustion Corporation
• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

1. Forward

This Operations Manual is intended for CAT C175-16 DM8455

Please read and thoroughly understand this manual, the safety warnings and the complete system before attempting to service or maintain the system. Please observe all specifications, guidelines, and notes in the manual.

The graphics and photos may be representative. The parts on your package may not match the photos or drawings in this manual.

Please contact Stewart & Stevenson Manufacturing Technologies LLC or Catalytic Combustion Corporation with questions.

CONTACT INFORMATION

Catalytic Combustion Corporation
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2. System Overview

This manual is intended to provide an overview of the Catalytic Combustion Corporation (CCC) Selective Catalytic Reduction system.

2.1. Definitions

The following definitions may be used throughout this manual.

AUS 32	Aqueous Urea Solution of 32.5%. Synonym for DEF
CCC	Catalytic Combustion Corporation
CFM	Cubic Feet per Minute
DOC	Diesel Oxidation Catalyst
DOTC	Diesel Oxidation Trapping Catalyst
DDU	DEF Dosing Unit
DEF	Diesel Exhaust Fluid, 32.5% solution meeting ISO22241 (also known as Urea)
ECU	Electronic Control Unit
INJ	DEF Injector
NH3	Ammonia
NO	Nitrogen Oxide
NO2	Nitrogen Dioxide
NOx	Oxides of Nitrogen
PID	Proportional Integral Derivative
P&ID	Process and Instrumentation Diagram
PM	Particulate Matter
PSI	Pounds per square inch
SCR	Selective Catalytic Reduction
SOD	System Operations Document
ULSD	Ultra-Low Sulfur Diesel containing <15ppm Sulfur
US EPA	United States Environmental Protection Agency

3. NOx Reduction system

The emission reduction system reduces NO_x emissions generated by the engine during combustion. The NOx reduction system is comprised of the following components:

1. SCR Reactor containing:
    a. DEF Injection Duct
    b. DEF Mixing duct
    c. SCR Catalyst
2. DEF Dosing Components including:
    a. DEF Supply Pump (2)
    b. DEF Dosing Unit (2)
    c. DEF Injection Lance (2)
    d. Compressed Air Pressure Regulator
3. Dosing System Control Panel with Touchscreen Display (control panel door mounted)
4. Temperature Sensors (2)
5. Differential Pressure Transducer (1)
6. NOx Concentration Sensor and Control Unit
7. NH3 Concentration Sensor and Control Unit

The exhaust flows from the engine through an exhaust pipe and into the inlet plenum, passing through the OC. The exhaust then moves through the DEF Injection and Mixing section. The DEF is injected into the exhaust stream and passes over/through CCC proprietary exhaust mixers before being routed through the SCR catalysts. The SCR catalyst plus the ammonia (NH_3) generated from the DEF controls the NO_x emissions.

3.1. Engine Exhaust Parameters

Flow:	9,975 CFM wet
NOx emissions:	6.05g/bhp-hr
Maximum Temperature:	921°F
Normal Operating Temperature:	890°F

3.2. Lube Oil Requirements

Engine Lube oil must meet or exceed API CJ-4 classification or better for the SCR system. All the lube oil and viscosity specifications in the engine operations and maintenance manual must also be followed.

3.3. Diesel Exhaust Fluid (DEF or AUS 32)

Diesel Exhaust Fluid (DEF) is a clear, non-toxic chemical. It is safe to handle in normal conditions and is not harmful to the environment. Urea is diluted in deionized, distilled water to create a 32.5% solution of DEF. DEF is widely used in 2010 and newer on-road trucks and non-road equipment to control NO_x in the same way it is being used by the CCC emission control system. Please check with your local fuel and/or chemical provider for further information.

All DEF used with this engine package MUST meet ISO22241 standards for quality.

	Failure to use DEF that meets the appropriate ISO standard may void the warranty, cause damage to injection components, poison the SCR catalyst and/or render the engine non-compliant with US EPA regulations.

DEF has a shelf life depending on the storage temperature. Please observe manufacturer storage instructions. Generally, DEF should be stored at less than 32°C (90°F) and higher than -5°C (23°F). Solidified DEF has an approximate volume 7% larger than liquid, therefore frozen DEF may cause the storage container to burst if expansion is not taken into account. Table 1 details DEF shelf life as a function of temperature per ISO22241.

Table 1: DEF Shelf Life as a Function of Temperature Per ISO22241[1]

CONSTANT AMBIENT STORAGE TEMPERATURE		MINIMUM SHELF LIFE (months)
(° C)	° F	
≤ (10)	≤ 50	36
≤ (25[a])	≤ 77	18
≤ (30)	≤ 86	12
≤ (35)	≤ 95	6
> (35)	> 95	_[b]
NOTE: The main factors taken into account to define the shelf life in this table are the ambient storage temperature and the initial alkalinity of the DEF. The difference in evaporation between vented and non-vented storage in an additional factor.		
[a] To prevent decomposition of DEF, prolonged transportation or storage above 25°C (77°F) should be avoided. [b] Significant loss of shelf life. Each batch should be tested prior to use.		

DEF must be stored in a plastic (Polyethylene, Polypropylene, PFA, PFE, PVDF, or PTFE) or stainless steel (304, 304L, 316, 316L only) tank.

Carbon steels, zinc coated carbon steels, mild iron, non-ferrous (copper and copper alloys, zinc, lead), aluminum and aluminum alloys, magnesium and magnesium alloys, and plastic or metals coated with nickel are not recommended for DEF storage.

3.4. DEF/AUS 32 Storage Tank

	Particular care must be observed in maintaining the cleanliness of the DEF tank. While the SCR system is protected from the introduction of large particulate matter (>40 microns), contamination in the tank may be dissolved by DEF (caustic) and will be passed into the SCR system which may lead to non-compliance, accelerated maintenance, component and/or system failure.

[1] International Standard ISO 22241-3, Part 3: Handling, transportation and storage (First Edition, 2008-02-15)

	Do not inhale fumes directly from the DEF Storage Tank. Ammonia gas may be present inside the tank. Venting of the storage tanks must be in accordance with governing regulations. CCC is not responsible for tank venting.

3.5. Diesel Fuel

Ultra-Low Sulfur Diesel fuel containing <15ppm Sulfur must be used with this engine. Filling with other fuel will damage the emission aftertreatment system and may void the warranty. Do not mix any additives in the fuel without written permission from Catalytic Combustion Corporation. Mixing lube oil in the fuel is prohibited.

Biodiesel blends are approved up to a B20 (20% bio content) providing the base diesel fuel <500ppm S. Higher bio concentrations can be approved on a case-by-case basis by Catalytic Combustion Corporation.

3.6. Component Identification

The following components are part of the emission aftertreatment system.

3.6.1. **Reactor**

The reactor is constructed of stainless steel and houses the injection/mixing ducts and SCR catalysts. Access to the catalysts is through bolted hatches located on the side & top of the reactor. The hatches are gasketed to prevent exhaust leaks.

The DEF/AUS32 injector is bolted on the side of the reactor and is sealed via high temperature gasket.

	Do not operate the engine with the injector removed from the reactor unless a block off plate is installed. Failure to block off the injector mounting location will lead to a massive exhaust leak.
	Do not operate the engine with the injector removed from the reactor unless the aftertreatment system has been disabled. Failure to do so may lead to excessive component wear, component failure and/or dosing from the removed injector.

The reactor is mounted at four points. During operation the reactor will grow significantly due to thermal expansion. The estimated expansion is detailed on drawing 706026. The reactor must be mounted in a manner that allows for the estimated thermal expansion.

The reactor is wrapped in an insulating blanket. It is intended to trap as much heat in the system as possible as well as provide a safe buffer between the hot exhaust system and local area.

	The insulating wrap is intended to prevent burns; however, the surface can be hot to the touch hours after engine shutdown. Assume the exhaust system is hot and use extreme care when working around the exhaust system. Wear appropriate PPE as prescribed by your organization.

3.6.2. **DEF/AUS 32 Injector**

The DEF injector carries the reactant and compressed air to the nozzle tip where they are mixed and the DEF is atomized. Figure below shows the DEF injector and Zone C7/D7, DWG 706026, Sheet 1 shows the mounting position in the reactor.

1. Mounting Flange Gasket
2. Mounting Flange
3. Mounting bolts
4. Gasket, Injector to DDU
5. O-Ring, Injector to DDU
6. Injection Nozzle tip

Figure 1: DEF Injector

The DEF injector is manufactured using a semi-rigid stainless steel tube located within a stainless steel braided hose. The minimum bend radius is 8 inches. Attempting a tighter bend radius may cause the inner hose to kink closed preventing the flow of DEF to the injector tip.

WARNING	Do not attempt to bend the semi rigid hose tighter than an 8-inch bend radius. Failure to comply may lead to the inner hose kinking closed preventing the flow of DEF to the injector. This may lead to denial of a warranty claim, void the warranty, render the system non-compliant and create additional maintenance.

Please review the Maintenance Manual for information on removing, reinstalling and/or servicing the injector.

Please review the Parts Manual for part numbers associated with different components of the injector.

3.6.3. **DEF Dosing Cabinet**

The DEF Dosing Cabinet is located on the Reactor (Figure below).

The DEF Dosing Cabinet contains the DEF Dosing unit and the Compressed Air Regulator/Drier with air pressure switch.

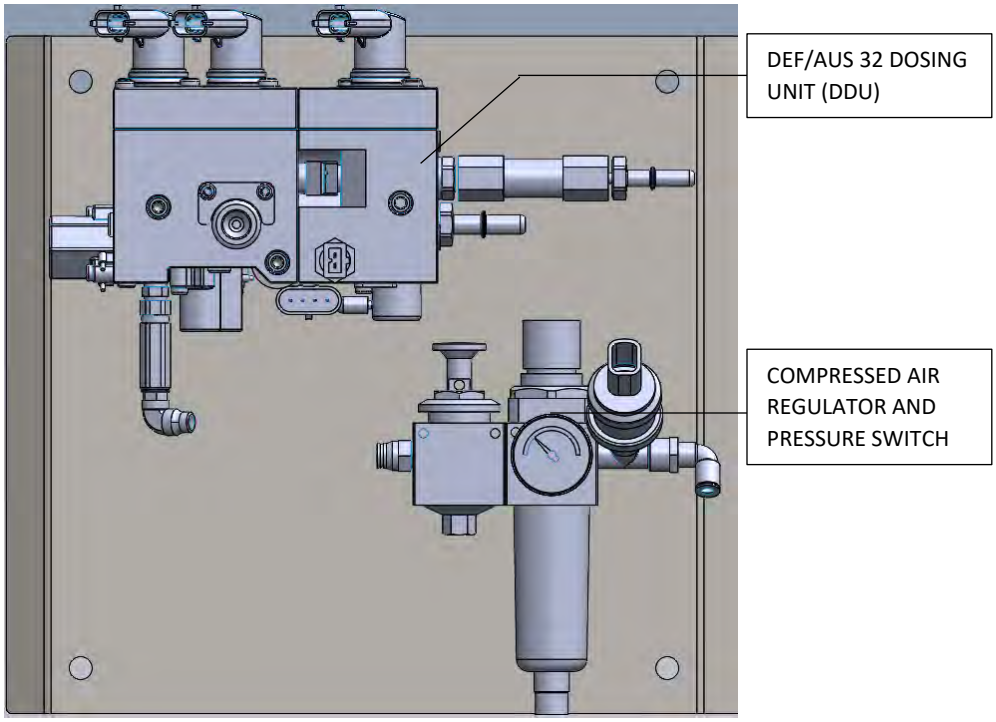

Figure 2: DEF Dosing Cabinet

The DEF Dosing Unit is a DEF metering device controlled by the DEF Dosing System Control Panel. DEF is circulated through a fixed pressure regulator. A DEF valve controls metering. Accuracy is ensured through temperature and pressure sensing up and downstream of the DEF injector. A separate pressure sensor monitors air flow through the DEF injector. Air flow and post-injection flush are controlled by two solenoid valves. The Dosing unit is equipped with a DEF filter to prevent particulates from entering the dosing unit. All liquid connections are via SAE J2044 fitting. Figure below details the DEF Dosing Unit.

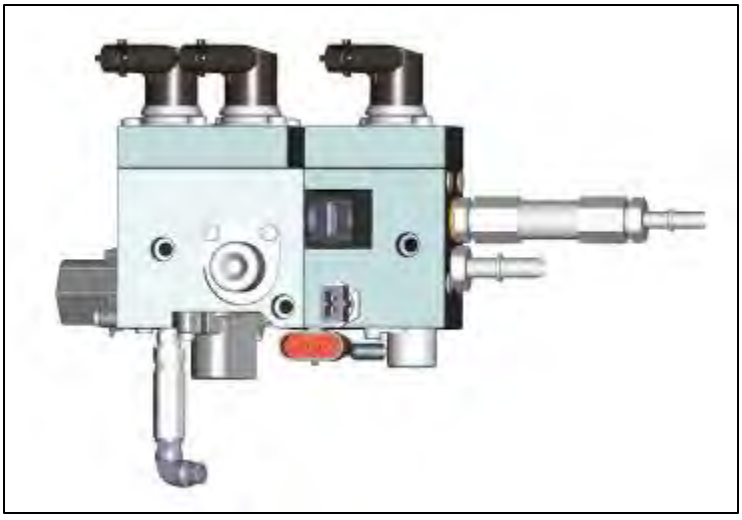

Figure 3: DEF Dosing Unit

WARNING	Please review the Maintenance Manual for information on removing, reinstalling and/or servicing the DEF Dosing Unit.

The DEF Supply Pump delivers DEF from the storage tank to the DEF Dosing Unit. DEF not consumed by the injection process is returned to the storage tank. The pump is speed and direction controlled by the DEF Dosing System Control Panel. All liquid connections are via SAE J2044 fittings. Figure below shows the DEF Supply Pump.

Figure 4: DEF Supply Pump

WARNING	Please review the Maintenance Manual for information on removing, reinstalling and/or servicing the DEF Pump.

The Compressed Air Regulator/Drier consists of a shut-off switch, an electronic pressure switch, and a condensate trap. The unit regulates the air supply to the DEF Dosing Unit as well as drops out water vapor that may be present in the air supply. Figure below details the Compressed Air Regulator/Drier.

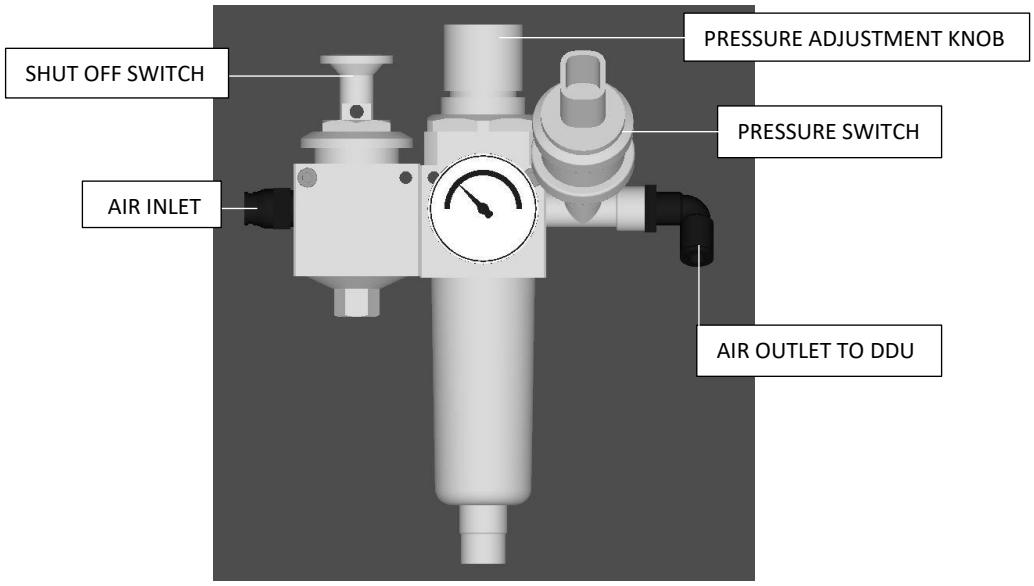

Figure 5: Compressed Air Regulator/Drier

Compressed air should be regulated to between 4 and 5bar on the gauge.

To adjust the pressure:

1. Lift pressure adjustment knob up
2. Rotate knob clockwise to increase pressure or counter clockwise to decrease pressure
3. Adjust pressure so that the gauge shows 5bar while the system is dosing DEF into the exhaust stream
4. Press knob down to lock adjustment

WARNING	The air pressure is preset when the aftertreatment system is built. Air pressure should not be changed unless directed to do so by Catalytic Combustion Corporation Technical Personnel. Failure to comply may lead to non-compliance, accelerated maintenance, component and/or system failure.

3.6.4. DEF Dosing Control Cabinet

The DEF Dosing Control Cabinet contains electronic components necessary to control the various processes. In most cases, the control cabinet will not need to be opened or serviced. Only trained certified technicians are permitted to service any parts inside the control cabinet.

WARNING	Do not service any components in the DEF Dosing Control Cabinet unless directed by Catalytic Combustion Corporation Technical Personnel Only.

3.6.5. DEF Dosing System Touch Screen Interface (HMI)

The emission aftertreatment system includes a touchscreen interface on the door of the Control Panel. This interface communicates important information regarding the state of the emission aftertreatment system.

The touchscreen will go to “sleep” after 10 minutes of inactivity. It can be awakened by touching the screen anywhere.

In most cases, the operator(s) will see the home screen (Figure below) when the screen is awake.

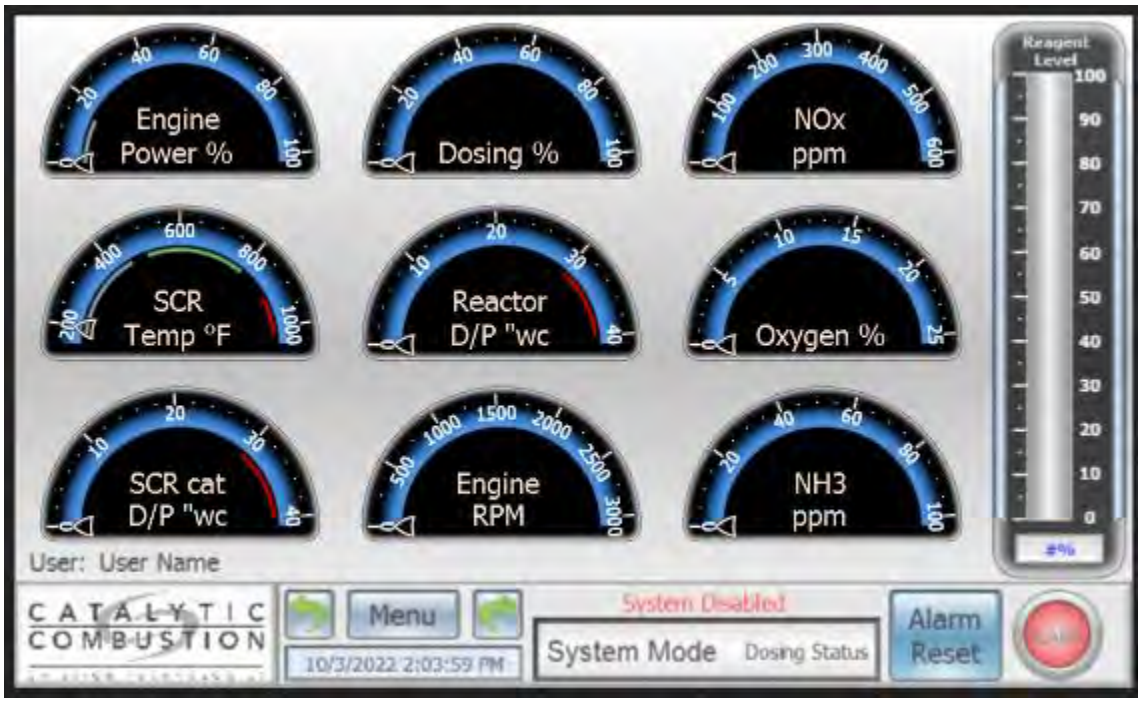

Figure 6: Home Screen of the HMI

The Home screen communicates:

1. Engine Power (%)
2. Dosing Rate (%)
3. NOx Concentration (ppm)
4. SCR Inlet Temperature (°F)
5. Differential Pressure across the SCR catalyst (in WC)
6. Oxygen Concentration in exhaust stream (%)
7. Engine Speed (RPM)
8. NH3 Concentration (if equipped – optional item)
9. DEF Day Tank Level Gauge (if equipped – optional item)
10. Alarm State

The system has multiple levels of password protection. Operators are able to view the Menu screen, the Sensor screen and the Alarms Screen (Figures below). Authorized users are able to access all other functions.

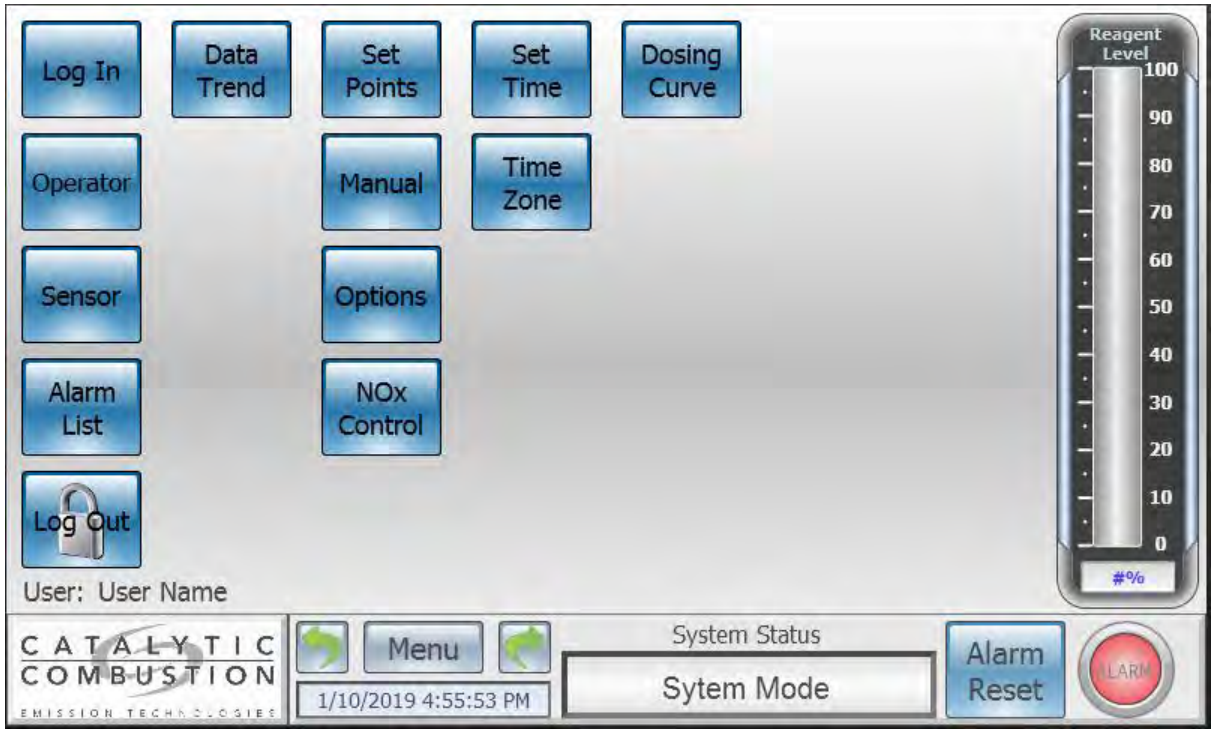

Figure 7: Menu Screen

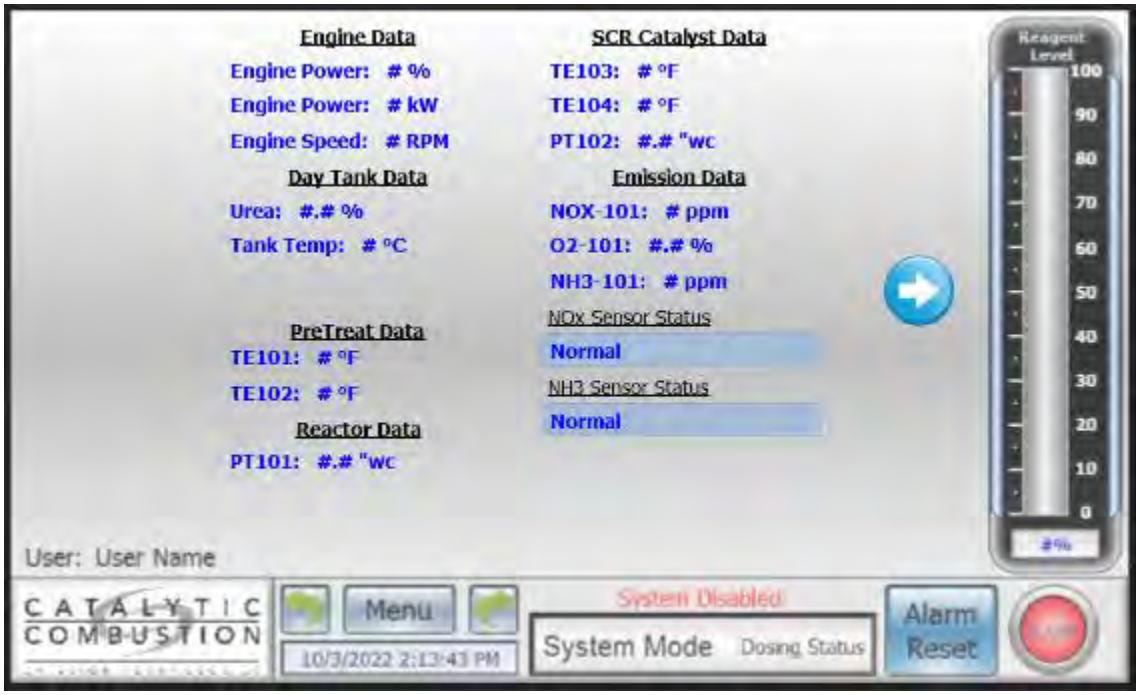

Figure 8: Sensor Screen 1

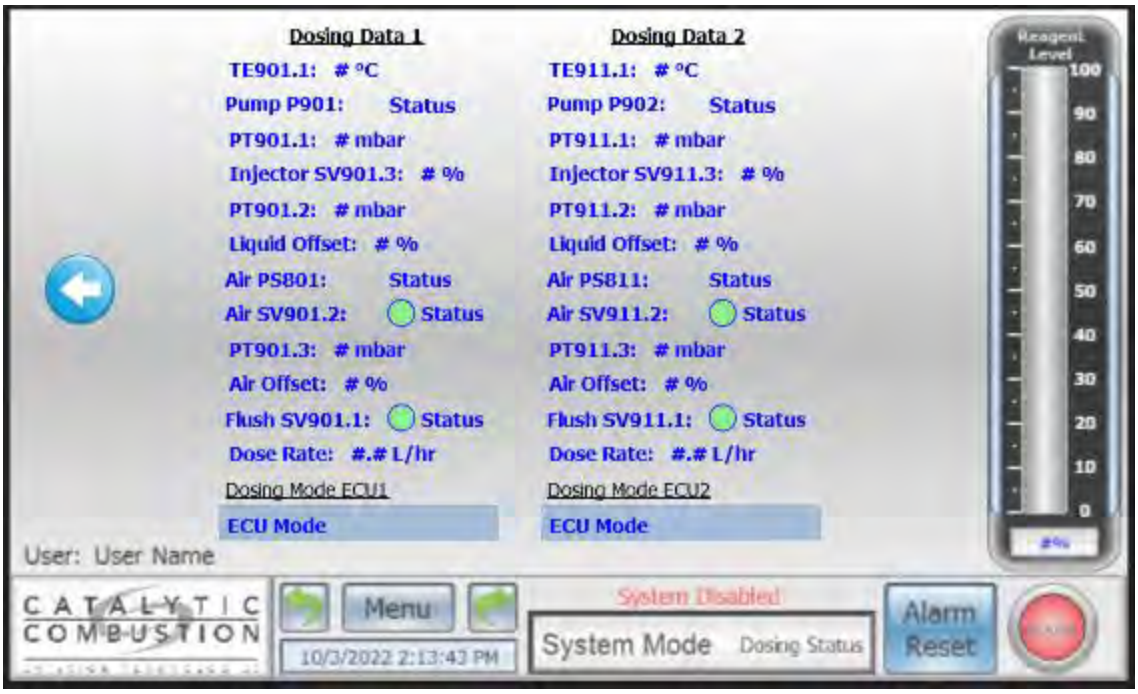

Figure 9: Sensor Screen 2

3.6.6. **Alarm State**

Alarms are communicated via the round “lamp” on the bottom right of the Home screen.

A Yellow lamp communicates a Pre-Alarm or Global Alarm.

A Red lamp communicates a Critical Alarm.

An operator can acknowledge the alarm by pressing the Alarm button which will navigate to the Alarm History Screen. Alarms can be viewed by date and time. Alarms can also be acknowledged in this screen. Alarms cannot be erased.

An acknowledged alarm will reassert if the conditions which caused the alarm are not satisfied.

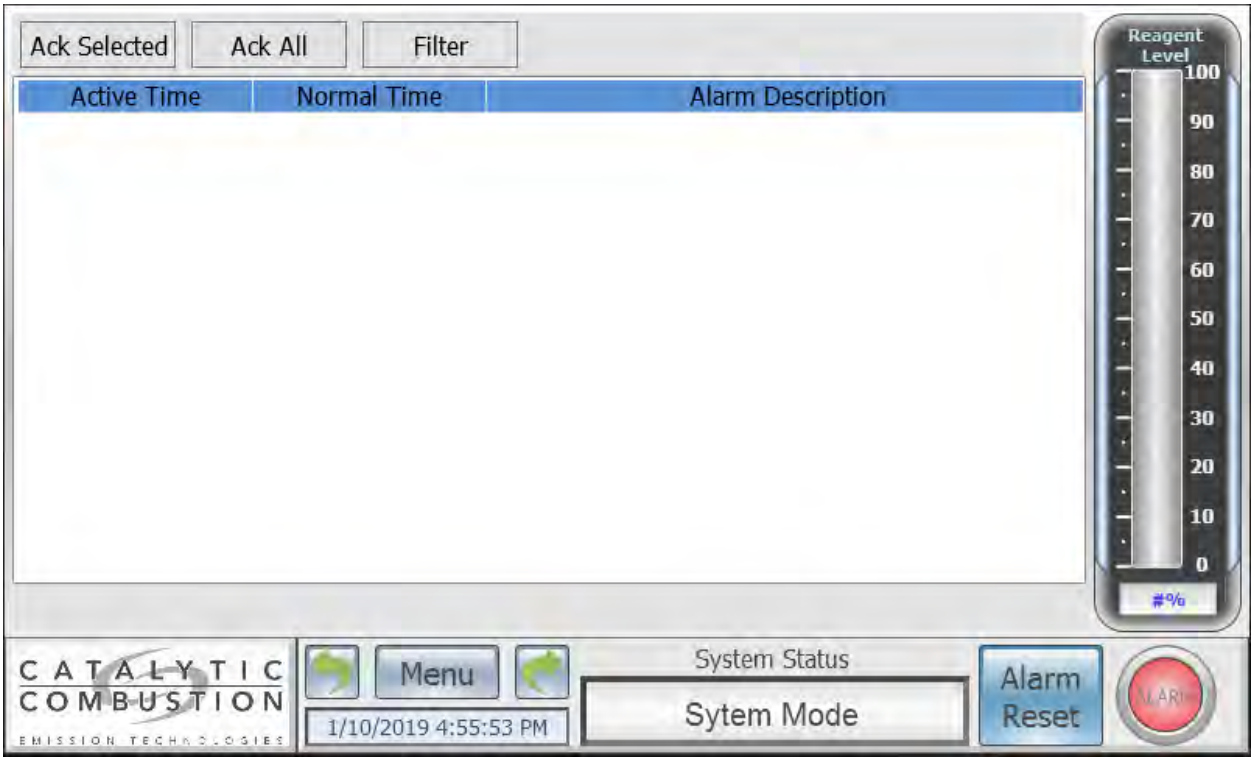

Figure 10: Alarm Screen

3.6.7. **NOx Concentration Sensor**

The NOx concentration sensor is located at the base of the exhaust stack. The sensor is connected to the NOx sensor ECU via a wiring harness. The ECU is mounted on the side of the reactor, refer to Zone D2, DWG 706026, Sheet 1. The sensor and the ECU are serviceable individually. The sensor is a maintenance part and must be replaced after 9,000 hours of operation (or upon request of the emission control system control panel). The ECU must be replaced if it fails.

3.6.8. **Differential Pressure Transducers and Temperature Sensors**

Differential pressure transducers are located inside the Junction Panel. External connection is via ¼" female NPT.

The differential pressure transducers measure the amount of differential pressure being generated by the SCR catalysts. The sensors communicate the pressure to the DEF Dosing System Control unit which will alert the operator via the HMI in the event the differential pressure builds inside the system.

PT102 reads pressure across the SCR catalysts, PT102H is the high-pressure side (pre SCR) and PT102L is the low-pressure side (post SCR).

The system uses 2 – Type K thermocouples to sense the exhaust temperature.

TE103 reads the temperature before the SCR catalyst. TE103 is the temperature permissive for the system.

TE104 reads the temperature after the SCR catalyst.

The systems use a cascading temperature permissive. For example, if TE103 fails, the permissive is automatically transferred to TE104. If both fail, the system will not operate.

Zone E1/E2, DWG 706026, Sheet 1 shows the locations for the pressure taps and thermocouples associated with the SCR.

3.6.9. Electrical

The emission aftertreatment system requires a 208 VAC 3 phase and 120 VAC single phase power supplied by others.

The DEF Supply Pump and DEF Dosing Unit are powered directly from the DEF Dosing System Control Cabinet and each component has a specific wiring harness with a unique weather tight connector.

Please review the wiring schematic for specific wire routing and interconnection.

4. Operation and Handling of the Emission Aftertreatment System

4.1. Daily Operations Checklist

The following items should be checked daily:

1. DEF Tank Level: The HMI located in the door of the control panel provides a DEF Tank Level gauge for your convenience. Please ensure the DEF storage tank is kept above 15% remaining to ensure the tank does not run dry.
2. The HMI should be monitored periodically to ensure the system is not in an alarm state. An alarm state is communicated by the display via a Yellow or Red Alarm Lamp on the bottom right of the HMI screen (Figure below).

Figure 11: Alarm Communication

4.2. Normal Operating Mode

4.2.1. System Start-up

The system will operate automatically. No operator interaction is required except for the periodic monitoring of the Dosing System Display.

The DEF Dosing System activates after each of the following parameters are met:

1. Engine is operating
2. Engine load signal is present
3. Compressed air is available
4. DEF Tank level is OK
5. TE103 is >225°C (440°F)
6. The system is not in an alarm state

Once each of the previous parameters are met, the system will activate and prepare to dose DEF into the exhaust stream. DEF dosing will commence after the following parameters are met:

1. DEF pump primes and builds proper pressure to the DEF Dosing Unit
2. DEF dosing unit has appropriate air pressure
3. TE103 is >225°C (440°F)
4. The system is not in an alarm state

The operator can monitor Operational Parameters via the Sensor screens.

4.2.2. System Shut Down

The DEF Dosing System will shut down automatically if one of the following parameters is active:

1. Engine is off
2. Loss of load signal
3. Loss of compressed air or inadequate air pressure
4. TE103 <225°C (440°F)
5. DEF Day Tank level is too low
6. DEF pressure is too low
7. System enters an alarm state because of a malfunction reported by the DEF Dosing Unit or the DEF Pump

The system follows a specific procedure when it shuts down to prevent DEF from remaining in any of the components and potentially crystalizing. Power must be

maintained to the DEF Dosing System for five minutes after the engine has shut down to ensure the system can completely purge before going to sleep. The procedure is as follows:

1. Injection stops
2. The pump evacuates the dosing unit and lines. DEF is returned to the DEF tank.
3. Compressed air is flowed through the various components at different rates to ensure the lines are cleared.

	The power must be maintained to the DEF Dosing System for five minutes after the engine has shut down to ensure the system can completely purge before going to sleep. Failure to do so will lead to plugging of the DEF Dosing System and poor performance and/or non-compliance.

5. Decommissioning/Dismantling/Recycling

The emissions aftertreatment system must remain in good operating order for the life of the engine. Failure to do so may lead to non-compliance with US EPA regulations.

Dismantling of the emissions aftertreatment system should be carried out by a qualified company and technician to ensure all legal and environmental processes are followed. All components should be recycled wherever possible. Ensure there is no electrical power to the system before dismantling the electrical components.

5.1. Disposing/Recycling Metals

The reactor is made of stainless steel and is completely recyclable.

5.2. Disposing/Recycling Catalysts

The DOTC/DOC or SCR catalysts can be returned to Catalytic Combustion for recycling. Costs for transport, packing, handling are the end user's responsibility.

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Maintenance Manual

Holt Texas LTD.

Holt CAT Dual Lance (C175) SCR Systems

VPN 1040249

Published December 2022

• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

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EMISSION TECHNOLOGIES

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Integrity | Service | Excellence

Catalytic Combustion Corporation introduced cutting edge technology in 1950 with the development of the first ever US patented catalyst to destroy VOCs (Volatile Organic Compounds). Since that time, the company has expanded into the design and supply of catalysts and emission control system for a wide variety of industries. The Selective Catalytic Reduction System installed on this engine represents the most advanced and least maintenance intensive system enabling compliance with US EPA regulations.

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1. Forward

Please read and thoroughly understand this manual, the safety warnings and the complete system before attempting to service or maintain the system. Please observe all specifications, guidelines, and notes in the manual.

The graphics and photos may be representative. The parts on your package may not match the photos or drawings in this manual.

Please contact Catalytic Combustion Corporation with questions.

CONTACT INFORMATION

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2. Maintenance Schedule

This is a general maintenance schedule for SCR systems. Some equipment in this schedule may not be equipped for a specific SCR system.

			Interval		Interval (Hours)					
Component	**Subcomponent**	**Task**	**Weekly**	**12 Month**	**3,000 Engine Hours**	**6,000 Engine Hours**	**9,000 Engine Hours**	**12,000 Engine Hours**	**15,000 Engine Hours**	**18,000 Engine Hours**
Control Panel	Operators HMI	Review	X	X						
	Control Cabinet	Inspect		X						
	Cooler/Compressed Air Filter	Inspect		X						
		Replace			X	X	X	X	X	X
DEF Level	Level Gauge (HMI)	Inspect	X	X						
	Sending Unit/Pickup	Inspect		X						
	Sending Unit Filter	Replace					X			X
	Supply/Return Hose	Inspect		X						
DEF Dosing Unit	N/A	Inspect		X						
	N/A	Replace					X			X
	Primary DEF Filter	Replace			X	X		X	X	
	Compressed Air Filter	Inspect		X						
		Replace			X	X	X	X	X	X
DEF Pump	N/A	Inspect		X						
	N/A	Replace					X			X
Injection Nozzle	N/A	Inspect		X						
	N/A	Replace		X		X		X		X
NOx Sensor	Sensor Element	Inspect		X						
	Sensor Element	Replace				X		X		X
NH3 Sensor	Sensor Element	Inspect		X						
	Sensor Element	Replace				X		X		X
Thermocouple	N/A	Replace								X
Differential Pressure Sensor	N/A	Replace								X
Reactor	SCR Catalyst	Replace								X
	OC Catalyst (if equipped)	Replace								X
	DPF Modules (if equipped)	Inspect/Clean					X			X
	DOTC Catalyst(if equipped)	Clean					X			
		Replace								X
	Exhaust Pipe and Joints	Inspect		X						
	DEF Piping/Hose	Inspect		X						
	Wiring	Inspect		X						
	Insulation	Inspect		X						
	Compressed Air Supply	Inspect		X						

Figure 1: SCR General Maintenance Schedule

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3. Weekly Maintenance

This section details what maintenance needs to be carried out weekly.

1. Inspect HMI for Day DEF Tank Level. Ensure level is >15%.
2. Ensure the System is not in an alarm condition. An alarm condition is communicated by a Red Flag on the bottom of the HMI.
3. Visually inspect components for obvious signs of leakage or damage

4. Every Twelve (12) Months

This section details what maintenance needs to be carried out every 12 months of service. In addition to weekly checks, perform the following:

1. Inspect Control Cabinet by opening the door and visually inspecting inside for obvious signs of wear, damage or oil intrusion (if equipped with a compressed air panel cooler).

	For systems equipped with a Compressed Air Panel Cooler, oil intrusion inside the Control Cabinet is a sign that the compressed air supply has excessive oil in the stream and does not meet ISO8573 Class 2.4.4 for compressed air cleanliness. Failure to remedy the situation is grounds for warranty denial in the event of a claim.

	Ensure the power supply to the Control Cabinet is disconnected before attempting any service inside the Control Cabinet.

2. If equipped with a compressed air panel cooler, inspect the coalescing filter/dryer for condensate and/or damage.

	The coalescing filter/dryer may be under pressure up to working pressure of the vessel. Ensure the pressure is relieved before attempting to service the coalescing filter/dryer.

3. Inspect the DEF Level Sending Unit, fill valve and hose connections on the pick-up for visual signs of damage or leaks.
4. Inspect the DEF Dosing Unit located in the panel mounted on the reactor for visual signs of damage or leaks around the hoses, fittings and body of the unit.
5. Inspect the DEF Supply Pump located between the DEF Day Storage Tank and the Control Cabinet for visual signs of damage or leaks around hoses, fittings and body of the unit.

	DEF leaks are characterized by a white powder around fittings or by a snowflake pattern on a flat surface. After the leak is repaired, the area can be cleaned with fresh water.

6. Inspect exhaust pipes for signs of exhaust leaks.
7. Inspect exhaust insulation for signs of damage.

8. Inspect hardware for tightness.
9. Inspect NOx and NH3 Concentration sensor harnesses to ensure it is not chafing or rubbing against fasteners.
10. Inspect DEF Injection Lance hose to ensure it is not chafing or rubbing against fasteners.

5. Every 3,000 Hours of Operation

1. Replace the coalescing air filter element in the coalescing filter/dryer before the Control Panel Compressed Air Cooler (if equipped).
    a. Ensure the air pressure is bled off the system and that the engine is off
    b. Turn the condensate bowl ¼ turn counter clockwise
    c. Remove the existing filter
    d. Replace with new filter
    e. Reinstall the condensate bowl
    f. Repressurize the system and inspect for leaks

	For systems equipped with a Compressed Air Panel Cooler, excessive oil in the filter is a sign that the compressed air supply has excessive oil in the stream and does not meet ISO8573 Class 2.4.4 for compressed air cleanliness.

	Ensure air pressure is bled off the system before attempting to service the coalescing air filter element.

2. Replace the DEF Filter on the DEF Dosing Unit
    a. Ensure the engine is off and cool to the touch.
    b. Ensure the power supply to the control cabinet is off
    c. Open the Dosing Cabinet door. The dosing cabinet is located on the reactor (refer to Operations Manual, Figure 1)
    d. Locate the DEF Dosing Unit. The DEF Dosing Unit is shown in Figure below.

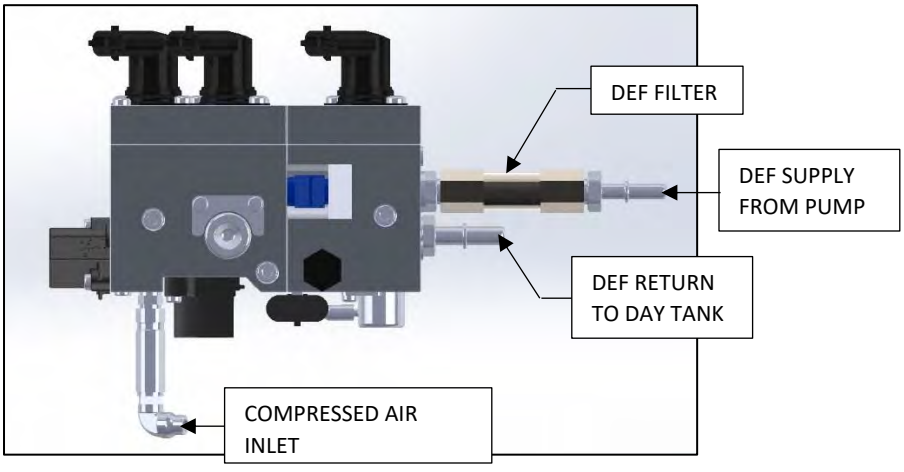

Figure 2: Def Dosing Unit

    e. Remove the DEF Supply Hose from the end of the DEF Filter

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i. Press the SAE J2044 fitting onto the DEF filter
ii. Lift up on the Locking Tab to unlock the fitting
iii. Press down on the Thumb Tab and pull the fitting off the fitting on the DEF filter (Figure below)

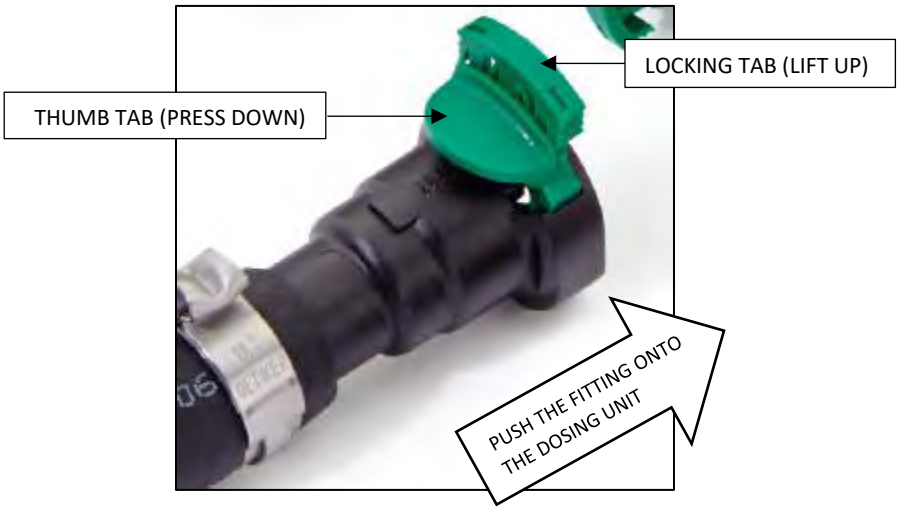

Figure 3: Removal of the DEF Fittings from the DEF Dosing Unit

f. Remove the DEF Filter by turning it counter clockwise with a wrench.

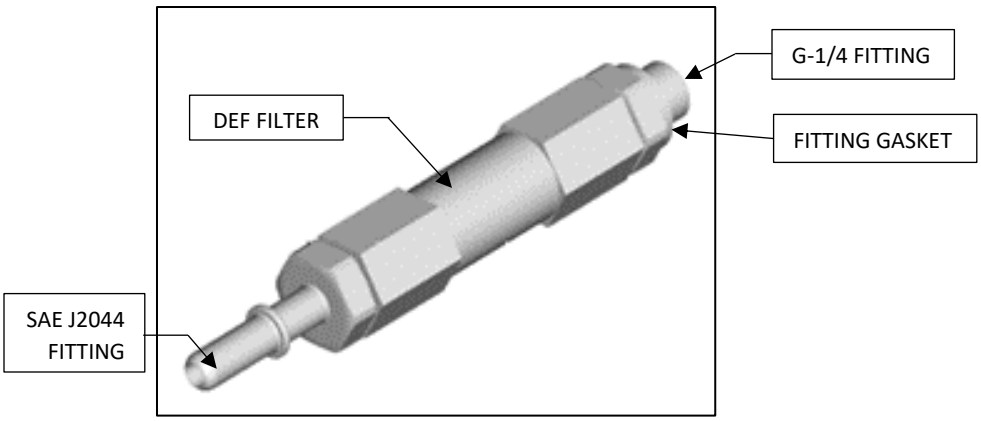

Figure 4: Replacement DEF Filter with Gasket and Fittings

g. Install new filter by threading it into the opening on the DEF Dosing Unit clockwise. The replacement DEF filter is provided complete (Figure 4) with a G-1/4 fitting on the filter outlet, a replacement gasket to seal the fitting against the DEF Dosing Unit and a SAE J2044 fitting on the inlet. It is ready to install and does not require any additional sealant, thread locker or Teflon tape. Tighten finger tight until the filter is seated against the Dosing Unit and then tighten to 15-17 lb-ft (20-23Nm).
    i. Note, the filter element inside the housing can also be replaced by separating the housing. CCC p/n: 1032986

	1. Do not add any additional sealant, thread locker or Teflon tape to the G-1/4 fitting. 2. Tighten the new fitting to 15-17 lb-ft (20-23Nm).

h. Reconnect the DEF supply hose to the DEF filter.
   i. Ensure the Locking Tab is in the UP position
   ii. Press the fitting onto the inlet of the DEF filter
   iii. Push down on the lock ring to lock it on the fitting
   iv. Test that the fitting is seated and locked by attempting to pull the fitting off the DEF filter

3. Replace the Coalescing Air Filter/Dryer filter element in the Air Pressure Regulator in the Dosing Panel (Figure below)

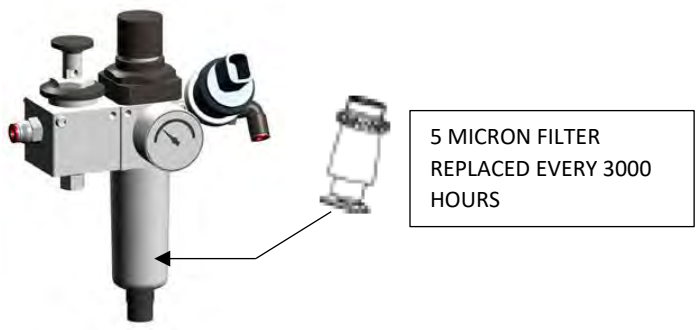

Figure 5: Air Pressure Regulator Coalescing Filter/Dryer

a. Ensure the air pressure is bled off the system and that the engine is off
b. Turn the condensate bowl ¼ turn counter clockwise
c. Remove the existing filter
d. Replace with new filter
e. Reinstall the condensate bowl
f. Repressurize the system and inspect for leaks

	Ensure air pressure is bled off the system before attempting to service the coalescing air filter element.

6. Every 6,000 Hours of Operations

1. In addition to the procedures for the 3,000 hour maintenance, the following items must be serviced at 6,000 hours of operation.
2. Replace the injection nozzle
   a. Ensure the engine is off, the exhaust system is cool and the engine cannot be started while servicing the injection nozzle.
   b. Locate the DEF Dosing Unit in the Dosing Cabinet
   c. Unscrew the outer hood of the Injection lance (Figure 6)

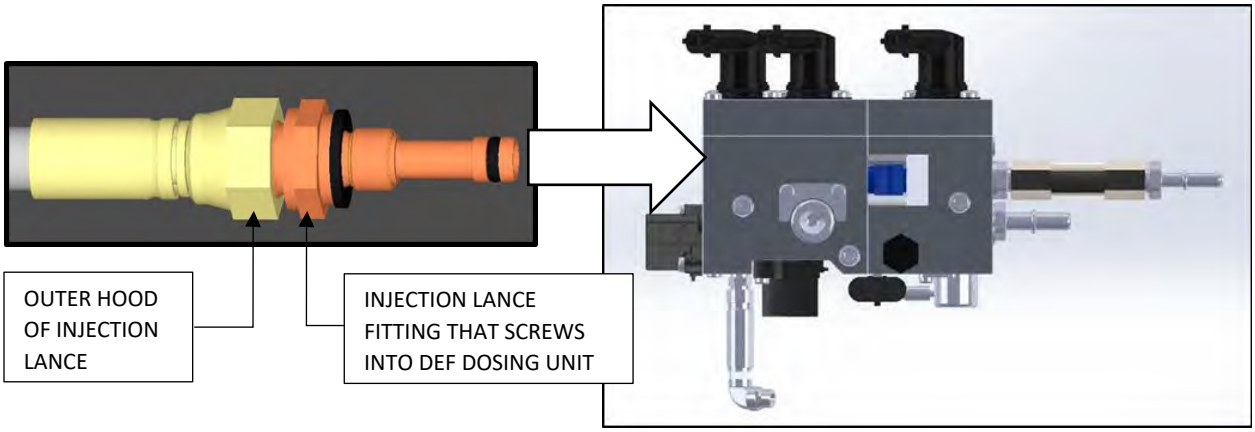

Figure 6: Injection Lance as it Screws into the DEF Dosing Unit

d. Unscrew the Injection Lance Fitting from the DEF Dosing Unit (Figure 6)
e. Pull the Injection Lance fitting from the DEF Dosing Unit and allow the hose to hang loose outside of the DEF Dosing Cabinet
f. Remove the 4 – bolts attaching the Injection Lance to the Reactor.
g. Remove Injection Lance from the Reactor.
h. Using the new gasket included with the new Injection Lance, reinstall the Injection Lance into the Reactor. The nozzle tip must be pointed with the direction of exhaust flow.

	IMPORTANT! The Injection Lance Nozzle Tip must be pointed with the exhaust flow direction!

i. Ensure the Gasket is installed on the end of the Injection Lance Fitting and lightly lubricate the O-Ring on the tip of the Injection Lance Fitting with a general purpose lubricant such as WD-40 (Figure 7).

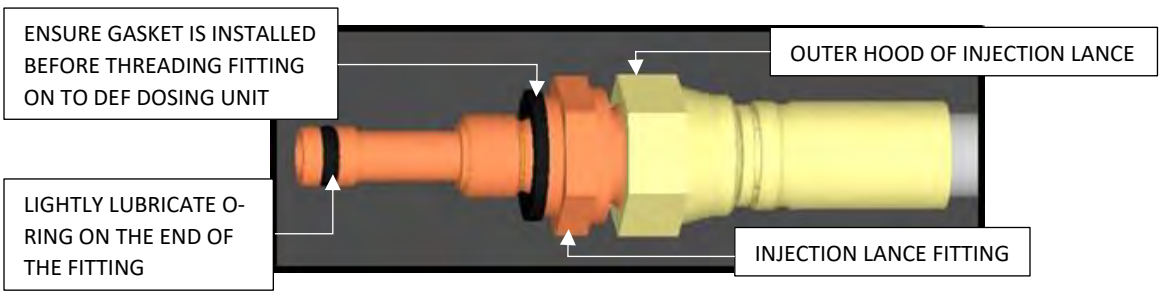

Figure 7: Injection Lance Fitting with O-Ring and Gasket

j. Find the center of DEF Dosing Unit with the end of the Injection Lance Fitting and press into place. Thread the fitting into the DEF Dosing Unit. Tighten to 10 lb-ft.
k. Thread Outer Fitting onto Injection Lance Fitting and tighten to 10 lb-ft.

	Ensure both the Injection Lance Fitting and the Outer Hood of the Injection Lance are tightened properly. Failure to tighten properly may result in air leaks, DEF leaks, system non-performance, regulatory non-compliance and increased maintenance.

3. Replace the NOx/NH3 Concentration Sensor

a. Ensure the engine is off and the exhaust system is cool to the touch before attempting to replace the NOx/NH3 Concentration Sensor.
b. Locate the NOx/NH3 Concentration Sensor ECU located on the side of the reactor (see Operations Manual).
c. Unplug the NOx/NH3Concentration Sensor from the NOx/NH3 Concentration Sensor ECU extension cable. It is the rectangular plug, not the small round one (Figure below).

Figure 8: NOx/NH3 Concentration ECU and Sensor

d. Unscrew the NOx/NH3 Concentration Sensor from the reactor. The NOx/NH3 Concentration Sensor is located on the front of the reactor below the outlet pipe (see Operations Manual).
e. Apply Anti-Seize compound to the threads of the replacement NOx/NH3 Concentration Sensor and thread into the sensor location. Torque to 15lb-ft.

	IMPORTANT! Apply Anti-Seize compound to the threads of the NOx/NH3 Concentration Sensor. Failure to do so may prevent the sensor from being removed in the future and cause damage to the reactor.
	Do not get Anti-Seize compound on the sensing element. It may cause premature failure of the sensor. If Anti-Seize gets on the sensor, clean by applying a non-residue solvent to a rag and wipe the sensor element clean.

f. Route the wiring harness back to the NOx/NH3 Concentration Sensor ECU and plug into the ECU. Secure wiring harness to ensure it does not touch hot or rotating components.

7. Every 9,000 Hour Maintenance

1. In addition to carrying out the procedures in the 3,000 hour maintenance section, the following parts must be serviced. The DEF Filter does not need to be replaced. The DEF Dosing Unit is provided with a new DEF filter installed.
2. Replace the DEF Dosing Unit
    a. Ensure the engine is off and cool to the touch before replacing the DEF Dosing Unit.
    b. Remove the DEF Supply Hose from the end of the DEF Filter and the DEF Return fitting.
        i. Press the SAE J2044 fitting onto the fitting
        ii. Lift up on the Locking Tab to unlock the fitting

iii. Press down on the Thumb Tab and pull the fitting off the fitting on the DEF Dosing Unit (Figure below)

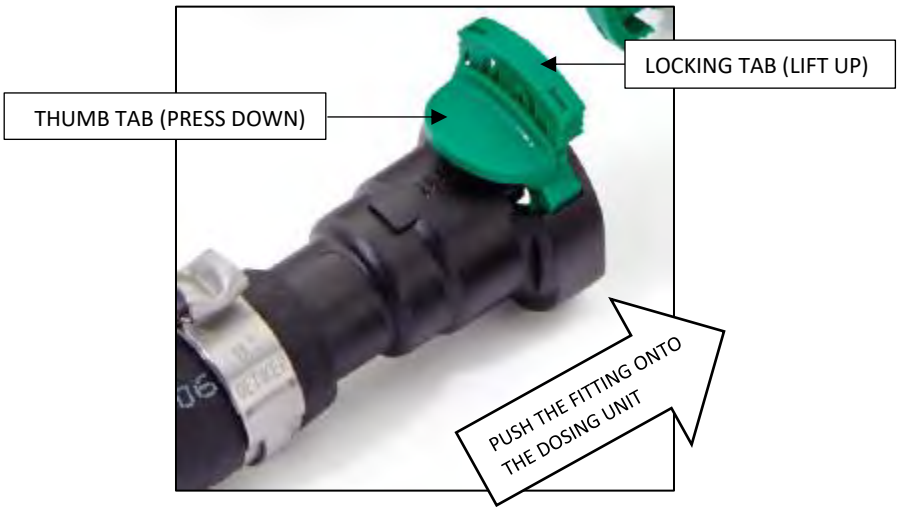

Figure 9: DEF Supply and Return Fitting

c. Unplug the DEF Dosing Unit Harness
d. Remove the ¼" air line
e. Remove Injection Lance from the DEF Dosing Unit.
f. Remove the 3 screws that hold the DEF Dosing Unit to the vibration isolators.
g. Install new DEF Dosing unit following the above steps
    i. Replace the O-ring at the tip of the injection lance and the Gasket at the base of injection lance fitting prior to reinstalling the injection lance into the DEF Dosing Unit.

⚠	You must replace the O-Ring at the tip of the Injection Lance and the Gasket at the base of the Injection Lance fitting prior to reinstalling the Injection Lance into the DEF Dosing Unit. Failure to do so may lead to leaking DEF, leaking compressed air, system under performance and regulatory non-compliance. Review Section 8.2.

3. Replace DEF Supply Pump
    a. Locate the DEF Supply pump (see Operations Manual, Figure 8).
    b. Remove the DEF Hoses from the Inlet and Outlet of the DEF Supply Pump.
    c. Unplug wiring harness from the DEF Supply Pump.
    d. Remove the 4 screws holding the DEF Supply Pump to the DEF Supply Pump Mounting Bracket.
    e. Reinstall following per the steps above.

8. Every 12,000 Hour Maintenance

The 12,000 Hour maintenance cycle is identical to the 6,000 hour maintenance procedure.

9. Every 15,000 Hour Maintenance

The 15,000 Hour maintenance cycle is identical to the 3,000 hour maintenance procedure.

10. Every 18,000 Hour Maintenance

1. The 18,000 hour maintenance cycle includes all items in the 9,000 hour maintenance as well as replacing the thermocouples, differential pressure transmitters, and SCR Catalyst.
2. Replace the Differential Pressure Transducer
    a. Locate the Junction Panel (see Operations Manual)
    b. Open the Junction Panel door.
    c. Remove the pressure hoses from the Push-To-Connect fittings by pressing down on the collar and pulling up on the hose.
    d. Remove the differential pressure transmitter wiring from the pressure transmitter. They should be labeled 24V and C8.
    e. Note the orientation of the sensor in the bracket to prevent mixing up the high and low pressure hoses when installing the new sensor.

	IMPORTANT! Note the orientation of the sensor prior to removing to prevent mixing up the high and low pressure hoses when installing the new sensor.

    f. Remove the Differential Pressure Transmitter from the bracket
    g. Remove the Push-To-Connect fittings from the sensor and install on the new sensor.

	Apply Teflon tape or anti-seize compound to the threads of the new pressure transducer to prevent thread galling over time.

    h. Install the new sensor into the bracket
    i. Install the high and low pressure hoses into the Push-To-Connect fittings (press the hose into the fitting)
        i. Rewire the 24V and C8 lines.
    j. Close the Control Panel door and latch closed
3. Replace the Thermocouples (TExxx)
    a. Locate the yellow thermocouple connector (Figure 10) near the Control Cabinet and pull to unplug – TExxx.

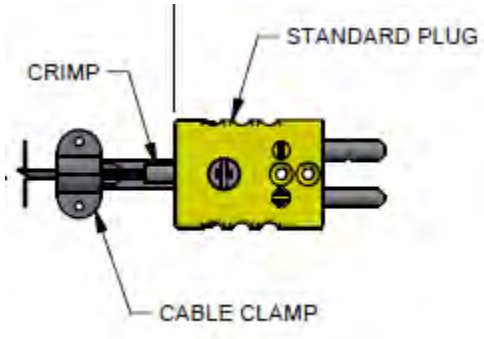

Figure 10: Thermocouple Connector

    b. Unscrew the thermocouple from the Reactor

c. Apply anti-seize to the threads of the new thermocouple
d. Thread new thermocouple into the reactor

	Apply anti-seize compound to the threads of the new thermocouple to prevent thread galling over time.

e. Route harness back to connector on control panel and plug in.
f. Repeat for each thermocouple.

4. Replace the SCR Catalyst
   a. Ensure the engine is off, locked out and has not been running for at least 24 hours before attempting to replace the SCR catalyst. The SCR catalyst retains heat extremely well therefore has the potential to be hot for hours after the engine is shut off.

	Burn Warning! Ensure the engine is off, locked out and has not been running for at least 24 hours before attempting to replace the SCR catalyst. The SCR catalyst retains heat extremely well therefore has the potential to be hot for hours after the engine is shut off.

	Proper PPE must be worn during the SCR catalyst removal process. Please review your company policy regarding proper PPE. It is suggested that safety shoes, safety glasses, a dust mask and gloves (latex or work style) be worn when replacing the SCR Catalyst.

   b. Locate the SCR catalyst access door hatch, see DWG 706026, Sheet 1.
   c. Remove the Reactor insulation and exhaust stack to reveal access hatch.
   d. Remove the nut/bolts and remove the access hatch. (Note: Gasket is not reusable and should be replaced).

	It is recommended that a dust mask or respirator be worn during this step. The insulation is a fiberglass type and the access door gasket is vermiculite impregnated fiberglass. Fibers may be shaken loose when working this step.

   e. Loosen the hardware securing the SCR catalyst in place.

	Each SCR Catalyst weighs approximately 55lbs.

   f. Remove the SCR catalyst through access hatches.
   g. Re-Gasket SCR Catalyst Wall Face.
   h. Install replacement SCR Catalysts. Each catalyst is the same therefore it does not matter which slot the catalyst is installed.
   i. Torque first nut to 30 ft-lbs using a torque wrench or monitoring device.
   j. While holding first nut from rotating torque the second/jam nut to 45 ft-lbs
   k. Install new gasket onto access hatch seal faces.
   l. Re-install the side access hatches.

m. Tighten exterior hardware to 45lb-ft

11. Lay-up Maintenance

Should the SCR system not be installed or not operated for an extended period of time (>1 month), take the following actions to ensure proper start-up.

1. Install Foreign Material Exclusion (FME) covers to inlet and outlet piping to the reactor as necessary. Ensure any ports where instrumentation is not installed are closed.

2. The DEF pump is a gear driven, positive displacement type pump. Lubricate gear internals by applying PTFE lubricant through the inlet and outlet ports of the pump. This will ensure proper lubrication during the dry priming cycle upon start-up.

3. DEF has a shelf life that is dependent upon temperature which could be as little as six months when stored above 120 F. Consult the specific DEF provider to understand storage requirements based on time and temperature conditions.

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Parts Manual

Holt Texas LTD.

Holt CAT Dual Lance (C175) SCR Systems

VPN 1040249

Published December 2022

• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

PROJECT NAME:		Dual Lance			
PROJECT #:		1040158-CP-B7-238KG-3030-NA-NA-UZ-1	REV:	A	
DESCRIPTION:		Electrical Bill of Materials	DATE:	9/23/2022	
Qty	**Ref.**	**Description**	**Manufacturer**	**Manufacturer Part No.**	**CCC Part #**
Control Panel					
1	CB145	CB 15A 2P 1489 Series C-Curve AB	Allen-Bradley	1489-M2C150	1040149
1	CB150	CB 2A 1P 1492 Series C-Curve AB	Allen Bradley	1492-SPM1C020	1035679
1	CB155	CB 4A 1P 1492 Series C-Curve AB	Allen Bradley	1492-SPM1C040	1039560
1	CB159	CB 2A 1P 1492 Series C-Curve AB	Allen Bradley	1492-SPM1C020	1035679
1	CB163	CB 2A 1P 1492 Series C-Curve AB	Allen Bradley	1492-SPM1C020	1035679
1	CB207	CB 20A 1P 1492 Series C-Curve AB	Allen Bradley	1492-SPM1C200	1040155
1	CB223	CB 2A 1P 1492 Series C-Curve AB	Allen Bradley	1492-SPM1C020	1035679
1	CB235	CB 6A 1P 1492 Series D-Curve AB	Allen Bradley	1492-SPM1D060	1035681
1	CB237	CB 6A 1P 1492 Series D-Curve AB	Allen Bradley	1492-SPM1D060	1035681
1	CR215	Relay 24VDC DPDT LED 8Amp IDEC	IDEC	RJ2S-CL-D24	1028528
1	CR215	Relay Base DPDT 8AMP	IDEC	SJ2S-05BW	1028530
1	CR353	Relay 24VDC DPDT LED 8Amp IDEC	IDEC	RJ2S-CL-D24	1028528
1	CR353	Relay Base DPDT 8AMP	IDEC	SJ2S-05BW	1028530
1	MCR231	Relay 24VDC DPDT LED 8Amp IDEC	IDEC	RJ2S-CL-D24	1028528
1	MCR231	Relay Base DPDT 8AMP	IDEC	SJ2S-05BW	1028530
1	DS143	Disconnect Non Fused 32Amp 3 Pole 600vac	Socemec	22003003-UL	1027554
1	DS143	Disconnect Handle S00 Nema 4/4x	Socemec	147D1111	1027556
1	DS143	Disconnect Handle Shaft S0 320mm	Socemec	14070532	1027557
1	ECU401	ECU Bracket	STT Emetec AB	102184-01	1026051
1	ECU401	ECU Connector	Allied Electronics	70231196	1026052
1	ECU401	ECU 38kg/hr 6ft whip	STT Emetec AB	109760-01	1033151
1	ECU501	ECU Bracket	STT Emetec AB	102184-01	1026051

PROJECT NAME:		Dual Lance			
PROJECT #:		1040158-CP-B7-238KG-3030-NA-NA-UZ-1	**REV:**	A	
DESCRIPTION:		Electrical Bill of Materials	**DATE:**	9/23/2022	

Qty	Ref.	Description	Manufacturer	Manufacturer Part No.	CCC Part #
1	ECU501	ECU Connector	Allied Electronics	70231196	1026052
1	ECU501	ECU 38kg/hr 6ft whip	STT Emetec AB	109760-01	1033151
1		Enclosure 30x30x8 SCE NEMA 4 Gray	SAGINAW Control and Engineering	SCE-30EL3008LP	1033211
1		Sub-Panel, Mounting 30x30	SAGINAW Control and Engineering	SCE-30P30	1001827
1	HMI223	HMI Color 7in touch 24vdc	Beijer Electronics Inc.	630001805	1030286
1	HMI223	HMI Can Bus Module	Beijer Electronics Inc.	100-0193	1030287
1	HS231	Block Contact NCLB 10A AB	Allen Bradley	800F-MX01L	1000573
1	HS231	Legend Yellow Estop 40mm AB	Allen Bradley	800F-15YE112	1000587
1	HS231	Pushbutton Mushroom Head Red	Allen Bradley	800FP-MT44	1000607
1	HS231	Guard E-Stop Yellow 40mm AB	Allen Bradley	800F-A6PR5	1002260
1	PLC241	MODBUS TCP/UDP network adapter	Beijer Electronics Inc.	GN-9289	1031701
1	PLC252	Analog ThermoCouple Input Module - 4 points	Beijer Electronics Inc.	GT-3804	1031702
1	PS206	Power Supply 120V-24VDC 20A	Meanwell	SDR-480-24	1040156
1	U150	Receptacle Duplx GFCI 120VAC 15A Encl AB	Allen Bradley	1492-REC15G	1017322
1	UPS200	UPS, SDU850B	SolaHD	SDU850B	1039053

CATALYTIC COMBUSTION
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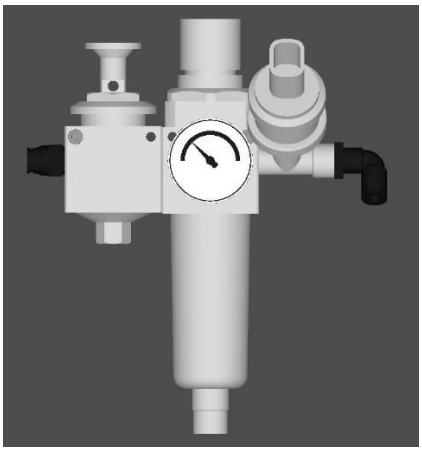
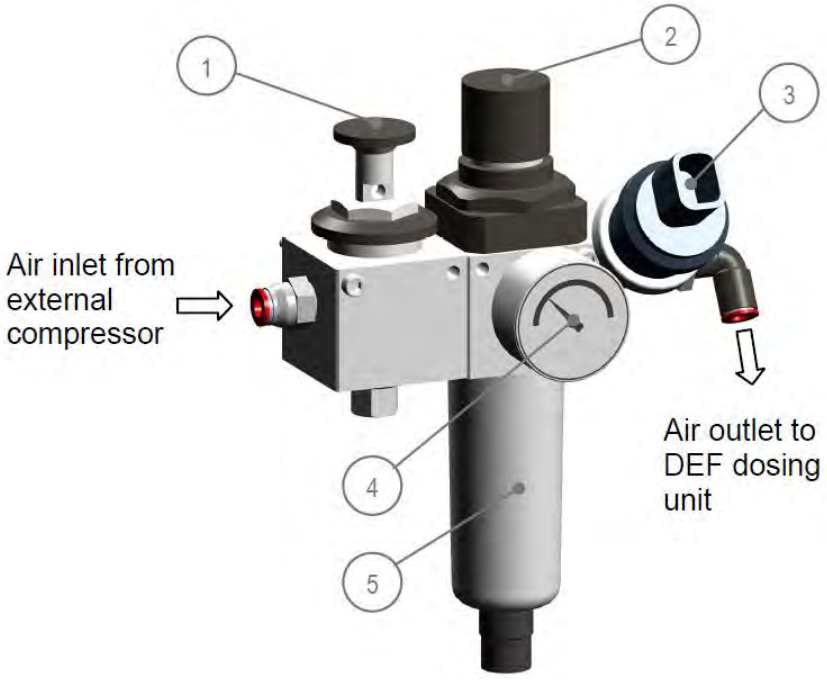
Datasheet

Compressed Air Regulator/Dryer



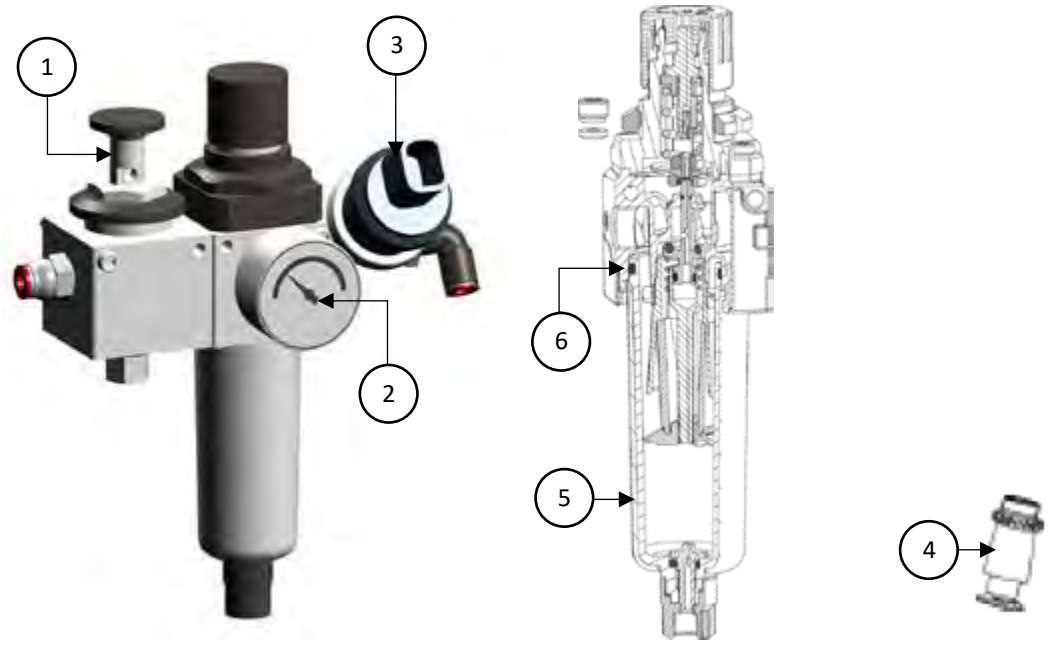
Published January 2019

Product Family		SCR Dosing System
Function		Compressed air regulator/dryer
Purpose		Regulate air pressure and dry air supply
Material		Brass, NBR, technopolymer
Mounting		Inside Dosing Cabinet with DEF dosing unit
Media		Compressed Air
Pressure	Inlet	Max 16bar
	Outlet	0.5 to 10bar
Filter	Pore Size	5µm
Drain		Automatic
Connection	Inlet	¼" OD Teflon or polyamide tube



Call Out	Description
1	Shut off valve
2	Pressure regulator
3	Pressure switch
4	Pressure gauge
5	Condensate trap

SPARE PARTS



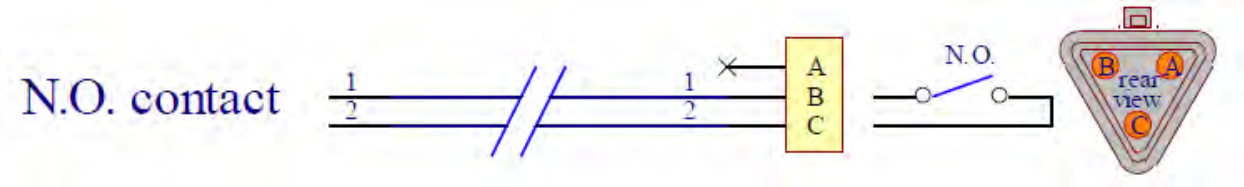
Item	Detail	P/N
1	Shut off valve	107357
2	Gauge	108859
3	Pressure switch	109578
4	Replacement Filter, 5µ	1028298
5	Bowl, complete with semi-auto drain	1028297
6	Standard Bowl O-Ring	1028299

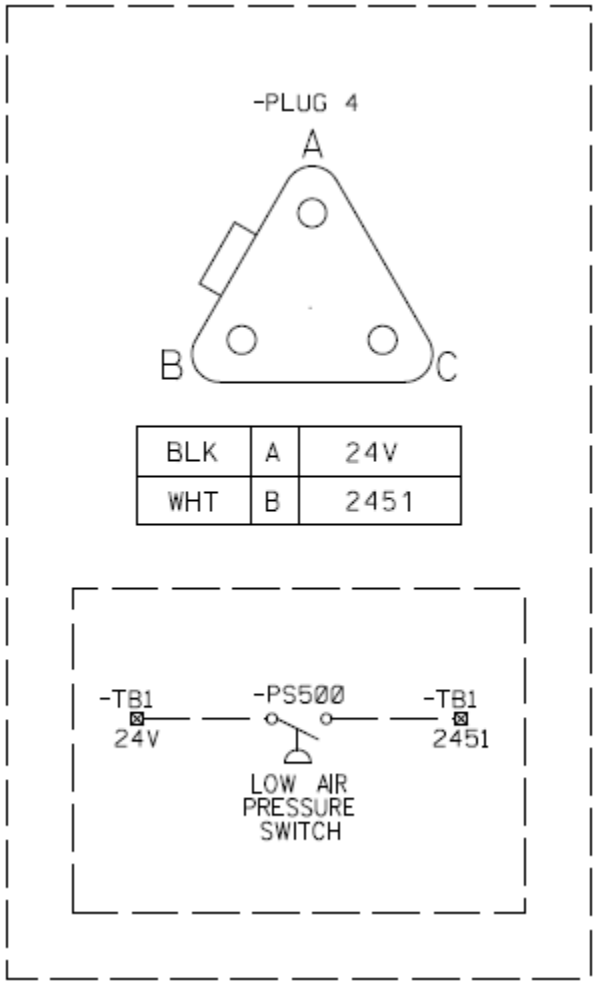
MECHANICAL INTERFACES

Description	Air Connection	Thread Pitch
Inlet	¼” OD Poly or Teflon, Push-to-Connect	¼” female NPT
Outlet	¼” OD Poly or Teflon, Push-to-Connect	N/A

ELECTRICAL INTERFACE

Pressure Switch





CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

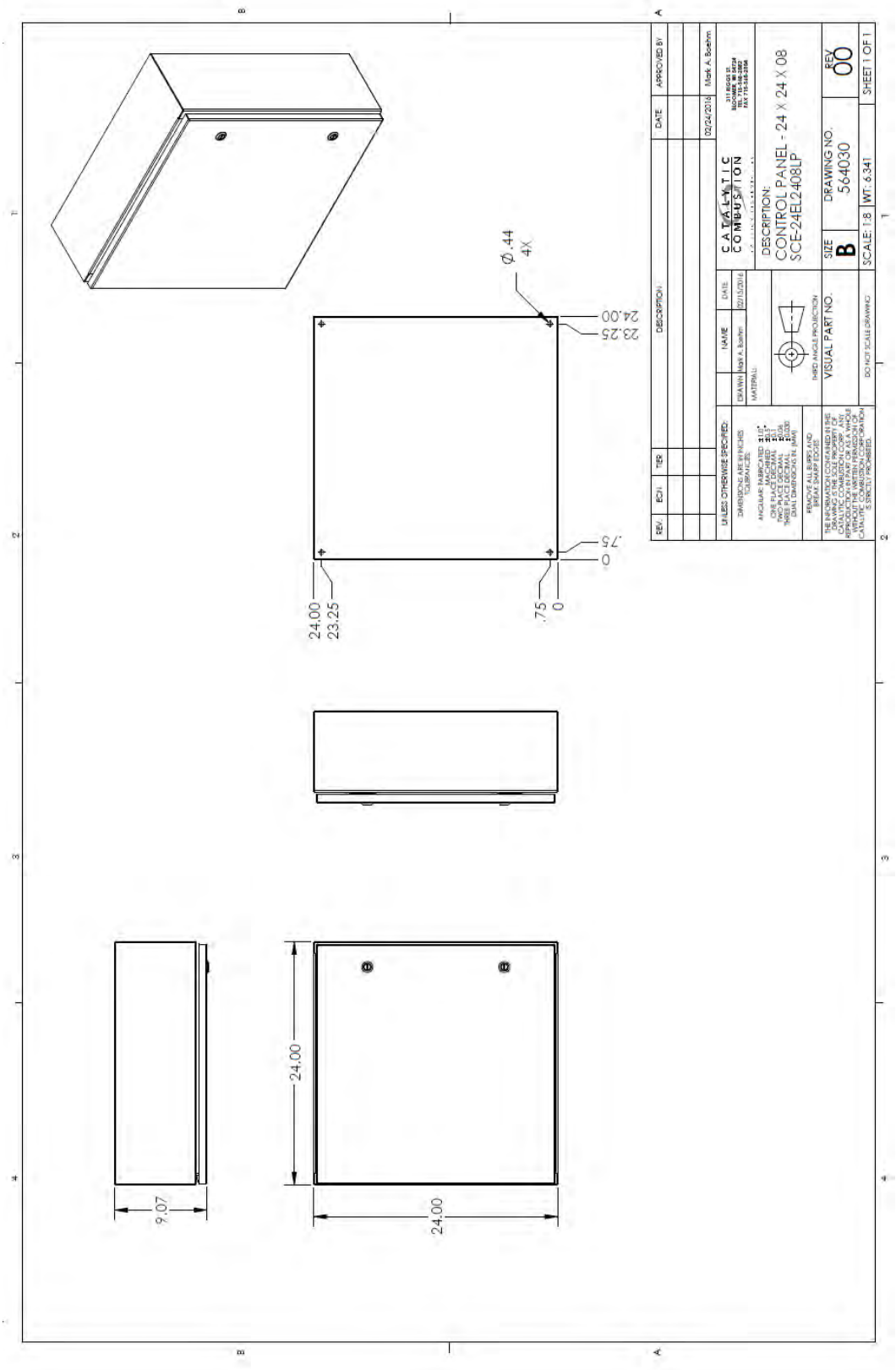
Selective Catalytic Reduction (SCR) System

Datasheet

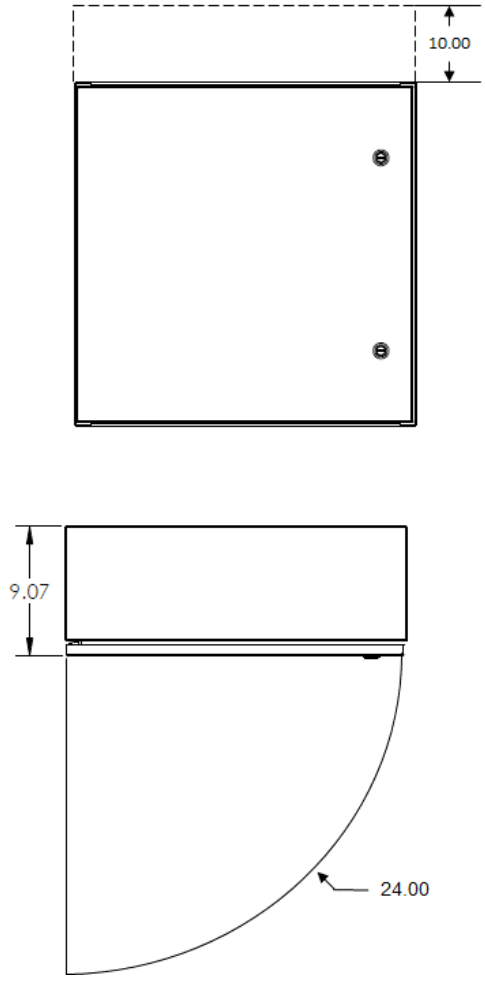
DEF Dosing System Control Panel with HMI

Published January 2019

Product Family		SCR Dosing System
Function		DEF Dosing Control Unit
Purpose		DEF Dosing System Control, 0.4l/h – 10l/h
Temperature	*Environment*	-20°C to +55°C (-4°f to +131°f)
	Storage	-25°C to +75°C (-13°f to +167°f)
Power	*Voltage*	24 VDC
	Nominal Current	11.25A (at 24 VDC)
Material	*Enclosure*	Stainless Steel
	Cable Glands	Nickle plated, steel
	Tube Fitting	Bulkhead, ¼" OD tube
Weight		32kg (70lbs)
Environmental Protection		IP65
Mounting	*Fixing*	Bolted, 4x 5/16 dia with isolation
	Location	Rear
Scope of Supply		Assembled component, no loose parts
Air Conditioning		None


Ø.44
4X
24.00
23.25
.75
0
24.00
23.25
.75
0
24.00
24.00
9.07
DESCRIPTION:
CONTROL PANEL - 24 X 24 X 08
SCE-24EL2408LP
DRAWING NO.
564030
SIZE
B
REV
00
SCALE: 1:8
WT: 6.341
SHEET 1 OF 1

REQUIRED MAINTENANCE SPACE

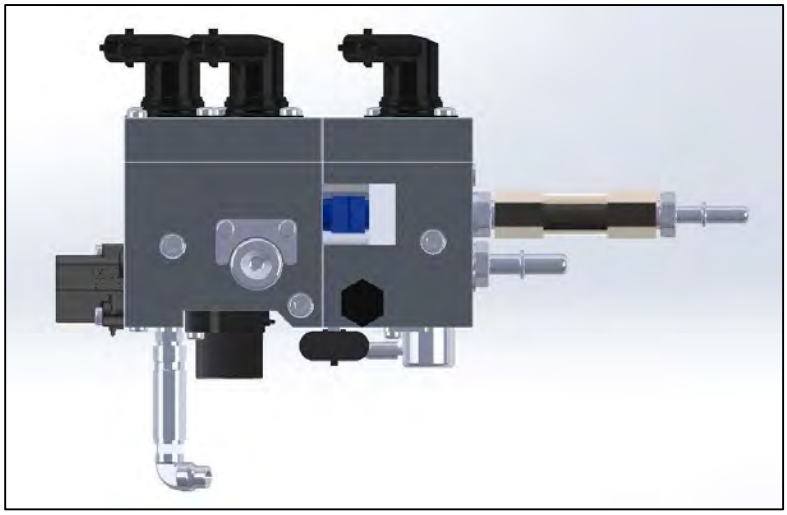


CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

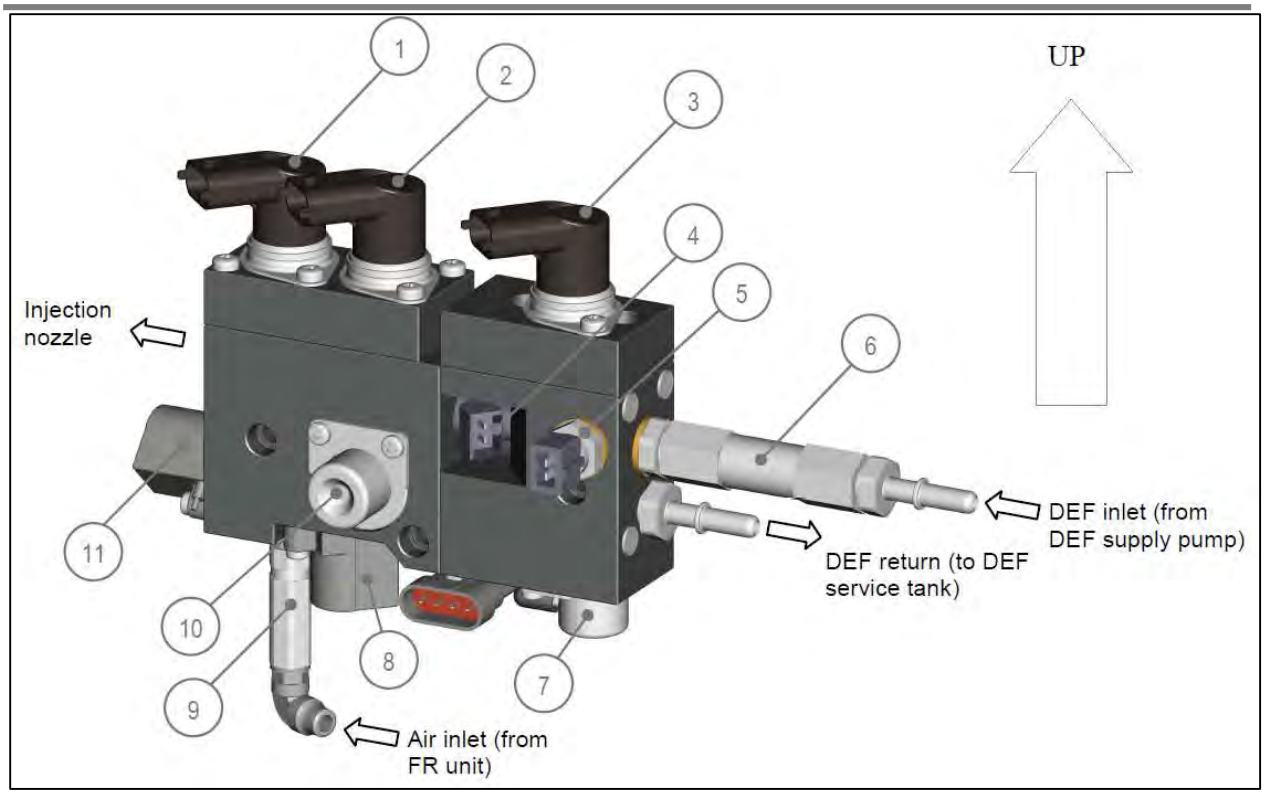
Datasheet

DEF Dosing Unit (DDU)



Published January 2019

Product Family		SCR Dosing System
Function		DEF Dosing Unit
Purpose		DEF Dosing control, 12kg/hr – 57kg/hr
Media	Reactant	Type: Diesel Exhaust Fluid (DEF), AUS 32.5
		Pressure: 5bar
		Quality: Per ISO22241 (32.5% Urea Conc.)
	Air	Consumption: 4cfm (nominal), 7cfm (peak)
		Pressure: 4.5bar (+/- 0.25bar)
		Quality: ISO8573-1:2010, Class 4.4.4
Materials	Housing	Anodized aluminum
Interfaces	Reactant	SAE J2044
	Air	Push-to-connect, ¼" Teflon or poly
	Electric	Deutsch
Supply	Power	20W (nominal), 25W (peak)
	Voltage	5 VDC, 12 VDC (FROM CONTROL CABINET)
Weight		1.7kg (4.0lbs)
Mounting	Interface	Via 3 vibration isolators
	Location	DEF Dosing Cabinet
Temperature	Environment	-40°C to +50°C (-40°f to +122°f)
	Storage	Same
	Media	Air: 0°C to +40°C (32°f to 104°f)
		Reactant: -5°C to +50°C (23°f to +122°f)
Environmental Protection		IP65
Scope of Supply		Assembled Part, no loose items

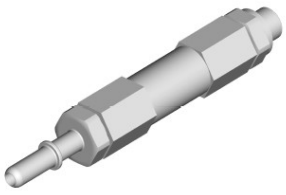


Position	Detail	Part Number
1	DEF Pressure Sensor	1028120
2	DEF Pressure Sensor	1028120
3	DEF Pressure Sensor	1028120
4	DEF Injector (NOT USER SERVICEABLE)	N/A
5	DEF Temperature Sensor	1028121
6	DEF Filter	1028126
7	DEF Pressure Regulator	1028123
8	Compressed Air Solenoid (Flush)	1028124
9	Compressed Air Check Valve	1028125
10	DEF Pressure damper	1028122
11	Compressed Air Solenoid (Atomization)	1028124

MAINTENANCE ITEM

DEF FILTER (ANNUAL): p/n 1028126

Complete with gasket and fittings.



MECHANICAL INTERFACES

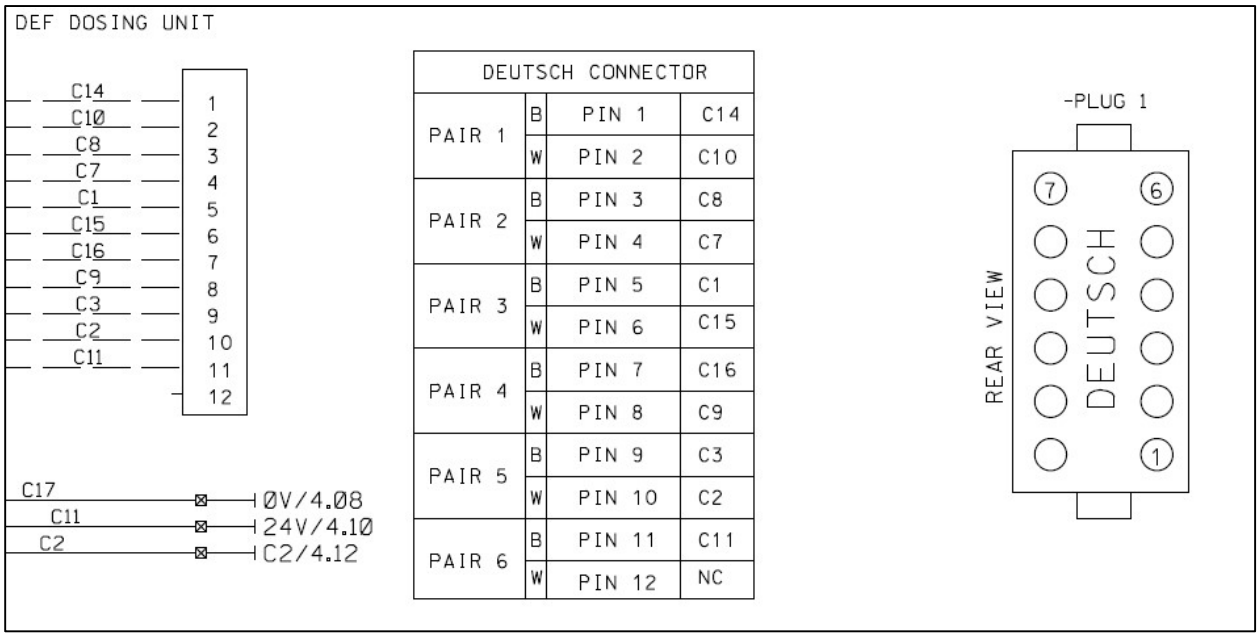
Detail	Liquid Sealing	Thread Pitch (DDU)
DEF Inlet from DEF Supply Pump	SAE J2044, 5/16” diameter	¼” NPT
DEF Return to Storage Tank	SAE J2044, 3/8” diameter	G-1/4
DEF/AIR to Injection Nozzle	***SPECIAL – Contact Catalytic Combustion with questions***	

Liquid sealing via Parker Safe Lock or Equivalent.

Description	Parker Safe Lock P/N	Photo
Straight End form: 5/16” Barb tail: 5/16”	**A614 A50 G06 02**	
Straight End Form: 3/8” Barb Tail: 3/8”	**A614 M53 08 02**	
90 Degree End form: 5/16” Barb tail: 5/16”	**A624 A50 D06 02**	
90 Degree End Form: 3/8” Barb tail: 3/8”	**A624 M53 08 02**	

HOSE AND CLAMPING EXAMPLE		
Description	**P/N**	**Photo**
Hose, 5/16” I.D., 7/16” O.D. PTFE with 304 SS Braid	**McMaster-Carr 52515K3**	
Hose, 3/8” I.D., 9/16” O.D.	**McMaster-Carr 52515K4**	

ELECTRICAL INTERFACE



DEUTSCH CONNECTOR			
PAIR 1	B	PIN 1	C14
	W	PIN 2	C10
PAIR 2	B	PIN 3	C8
	W	PIN 4	C7
PAIR 3	B	PIN 5	C1
	W	PIN 6	C15
PAIR 4	B	PIN 7	C16
	W	PIN 8	C9
PAIR 5	B	PIN 9	C3
	W	PIN 10	C2
PAIR 6	B	PIN 11	C11
	W	PIN 12	NC

CATALYTIC COMBUSTION

EMISSION TECHNOLOGIES

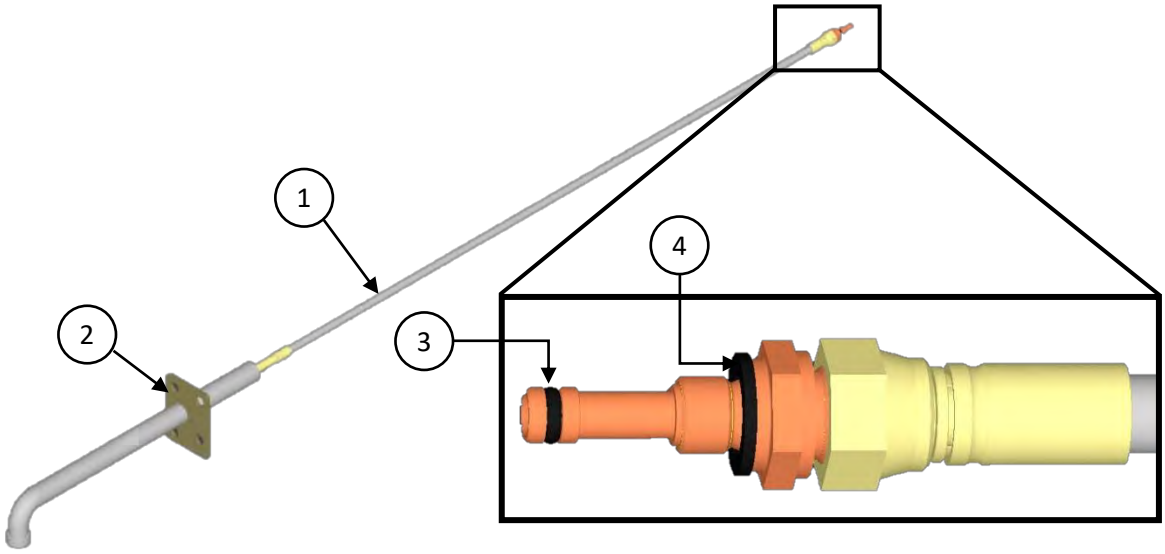
Selective Catalytic Reduction System

Datasheet

DEF Injection Lance

Document No.: INJ Rev. 0 Published January 2021

Product Family		SCR Dosing System, Stationary
Function		DEF Injector
Purpose		Inject DEF into exhaust stream
Media	Reactant	DEF (32.5% urea concentration) AUS 40 (40.0% urea concentration)
		Pressure, 5bar
		Quality per ISO22241 (DEF, 32.5% conc.) Quality per ISO18611 (AUS 40, 40% conc.
	Air	Consumption: 4cfm (nominal), 7cfm (flushing)
		Pressure: 4.5bar (+/- 0.25bar)
		Quality per ISO 8573-1:2010 Class 4:4:4
Materials	Body	Stainless steel, Teflon
	Part in contact with media	Stainless steel, Teflon
Connections	Reactant	Proprietary sealed design at DDU.
	Air	
Weight		3.4kg (7.5lbs)
Mounting		Flange mount, keyed for direction, gasketed
Temperature	Environment	-40°C to +260°C (-4°f to +500°f)
	Storage	-40°C to +75°C (-4°f to +167°f)
	Media	Reactant: -5°C to +50°C (23°f to +122°f)
		Air: -5°C to +75°C (23°f to +167°f)
Scope of Supply		Assembled component, no loose parts



Position	Detail	VPN
1	DEF Injector, Complete	1031080
2	Injector Flange Gasket	1026556
2	O-ring	1028149
3	Washer, gasket	1028150

MECHANICAL INTERFACES

Detail	Liquid Sealing	Thread Pitch
Connection to DDU	Via machined fit and O-ring	G-1/4

ELECTRICAL INTERFACE

None

CATALYTIC COMBUSTION

EMISSION TECHNOLOGIES

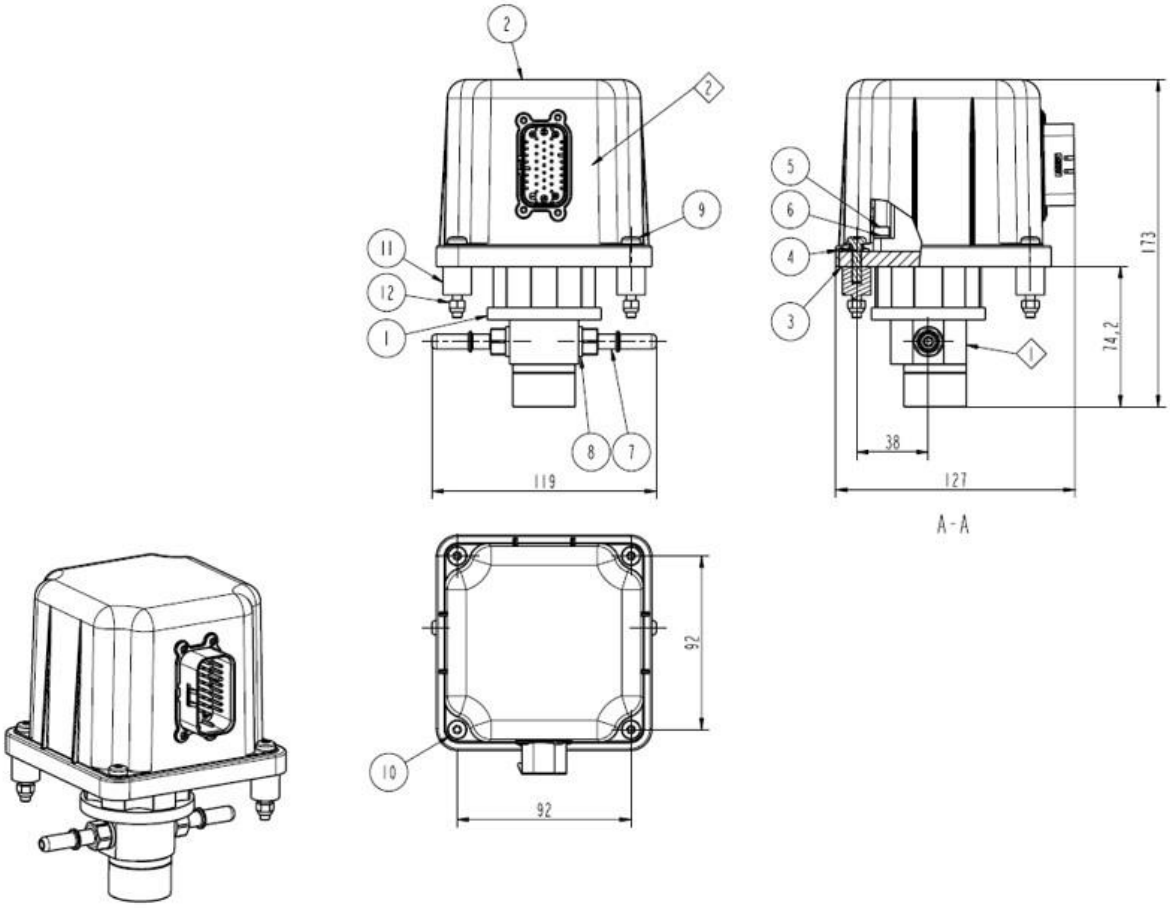
Selective Catalytic Reduction (SCR) System

Datasheet

DEF Supply Pump

Published: June 2018

Product Family		SCR Dosing System
Function		DEF Supply Pump
Purpose		DEF supply to DEF Dosing Unit
Media	Reactant	Diesel Exhaust Fluid (DEF)
	Quality	Per ISO22241 (32.5% urea solution) Per ISO18611 (40% urea solution)
Pressure	Pressure	5 bar (MAX)
	Suction Height	2m (6ft) (MAX)
Flow Rate	liters/hr (gal/hr)	75 (19.8) maximum
Temperature	Environment	-20°C to +50°C (-4°f to +122°f)
	Storage	-40°C to +75°C (-40°f to +167°f)
	Reactant	-5°C to +50°C (+23°f to +122°f)
Power	Watts	50W (nominal), 75W (peak)
	Supply	24VDC (supplied from DEF Dosing Control Unit)
Material	ECU	ABS, Aluminum, Copper
	Pump	Stainless steel
	Parts in contact with reactant	Stainless Steel
Weight		2.9kg (6.4lbs)
Degree of Protection		IP65
Mounting	Fixing	Via 4 vibration isolators
	Position	Vertical only, pump down
Scope of Supply		Assembled component, no loose parts

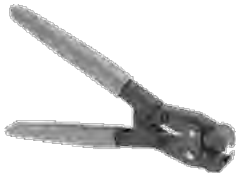


Position	Detail
1	DEF Pump (Marked with direction of flow)
2	DEF Pump, ECU
3	DEF Pump, Baseplate
4	Sealing Ring
5	Screw, MC6S 5x16 FZB
6	Washer spring, M5
7	Fitting, SAE J2044, 5/16”, G-1/8”
8	Washer, R1/8”, Tredo 12
9	Screw, MRT, 5x20, Torx, black
10	Screw, MRT, M5x10, Torx, Black
11	Vibration isolator
12	Nut, M5 with nylon lock ring

MECHANICAL INTERFACES

Detail	Liquid Sealing	Thread Pitch
DEF Inlet from DEF Storage Tank	SAE J2044, 5/16” diameter	G-1/8
DEF Outlet to DEF Dosing Unit (DDU)	SAE J2044, 5/16” diameter	G-1/8

Liquid sealing via Parker Safe Lock or Equivalent.

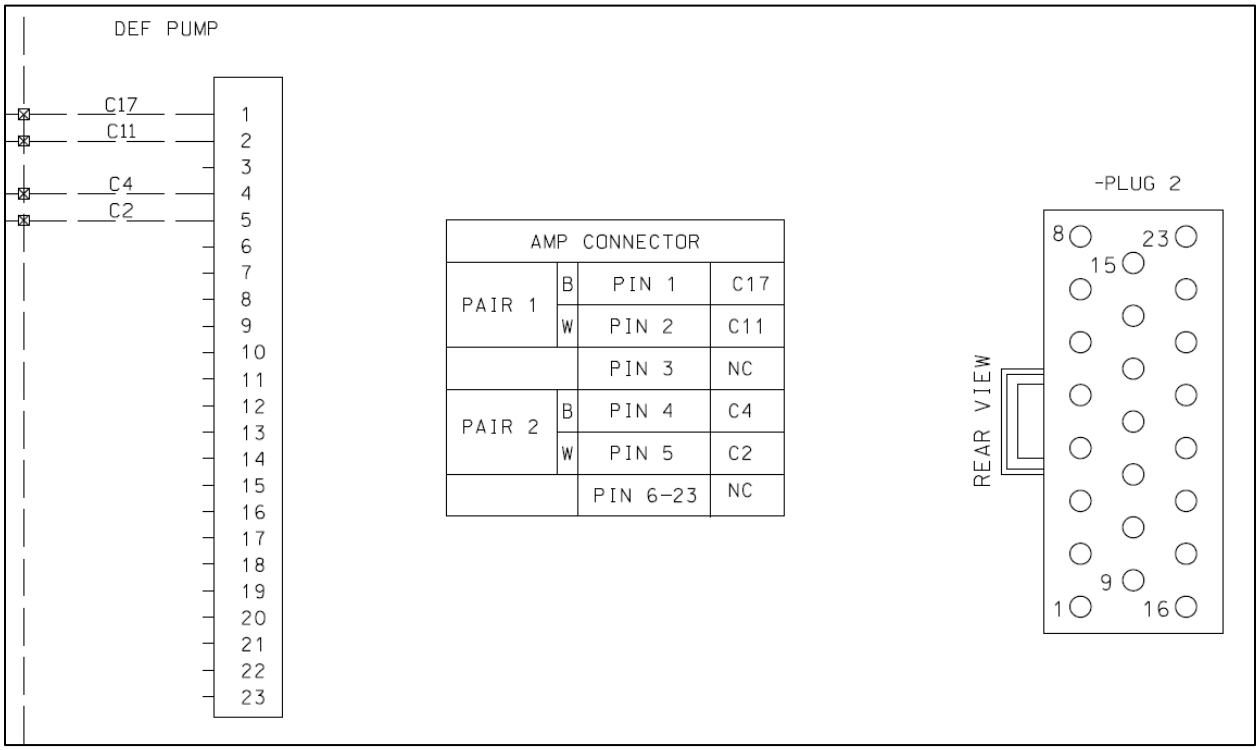
Description	Parker Safe Lock P/N	Photo
Straight End form: 5/16” Barb tail: 5/16”	**A614 A50 G06 02**	
90 Degree End form: 5/16” Barb tail: 5/16”	**A624 A50 D06 02**	
HOSE AND CLAMPING EXAMPLE		
Description	**P/N**	**Photo**
Hose, 5/16” I.D., 7/16” O.D. PTFE with 304 SS Braid	**McMaster-Carr 52515K3**	
Single pinch vibration resistant clamp (304SS), 13/32” to 31/64”	**McMaster-Carr 5435K14**	
Pinch Clamp Pliers	**McMaster-Carr 6541K69**	

MAINTENANCE ITEMS

None. Replace pump and/or ECU per Maintenance Schedule or upon demand. See Parts Manual.

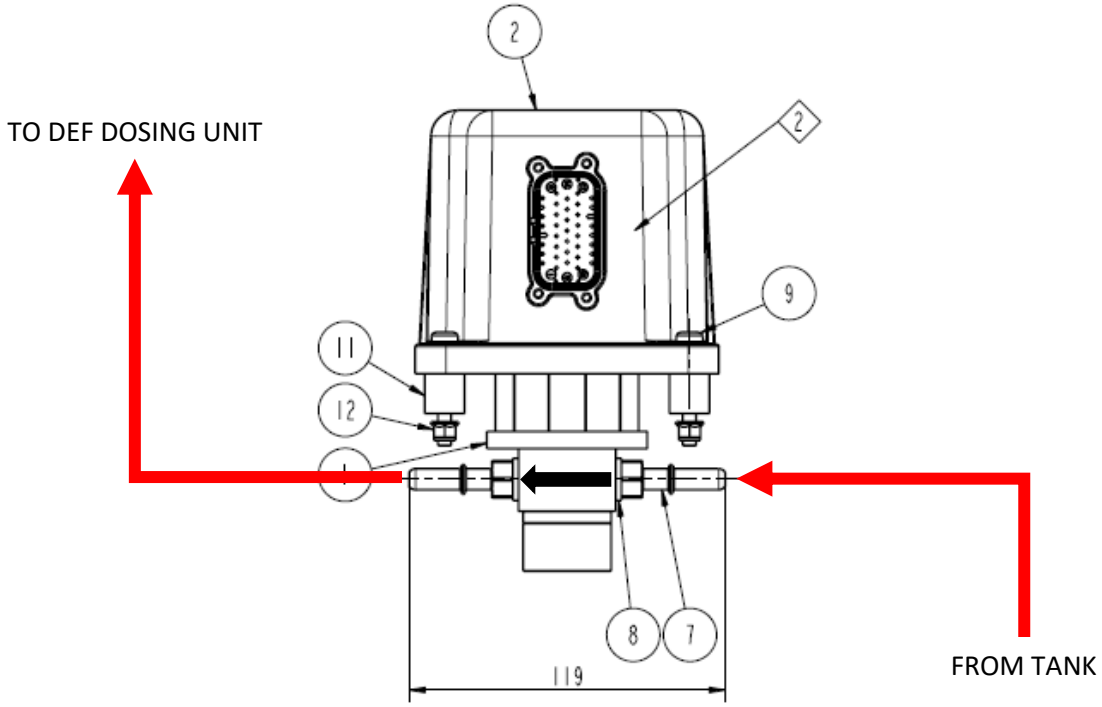
ELECTRICAL INTERFACE

Electrical interface is via an AMP style plug on the pump and terminal strip in the DEF Dosing Control Cabinet.



AMP CONNECTOR			
PAIR 1	B	PIN 1	C17
	W	PIN 2	C11
		PIN 3	NC
PAIR 2	B	PIN 4	C4
	W	PIN 5	C2
		PIN 6–23	NC

1. The pump is marked with a flow direction arrow. Please observe direction of flow through the pump.



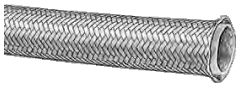
2. Liquid connections are made via fittings meeting the SAE J2044 standard. Male fittings are provided on the pump. Female fittings are NOT included with the system; however, they are widely available from Parker. They are available in a straight form or 90° form. Part numbers are shown below.

Description	***Parker Part Number***	
5/16” end form and hose barb, straight	A614A50G06 02	
5/16” end form and hose barb, 90°	A624A50D06 02	

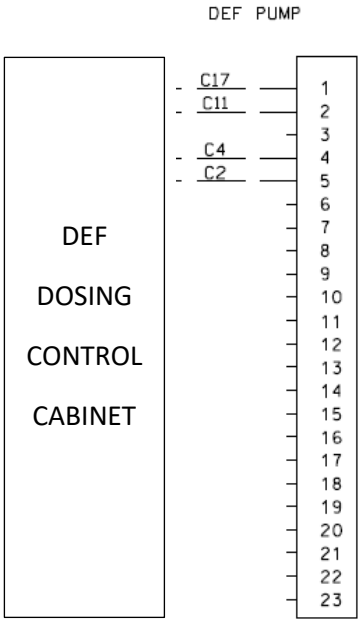
Catalytic Combustion recommends the use of tubing made with FEP Teflon for applications where the tube is protected from abrasion. PTFE or PFA Teflon hose protected by stainless steel braiding is suggested where the hose may be at risk of abrasion or routed near hot components.

5/16” I.D. hose is required.

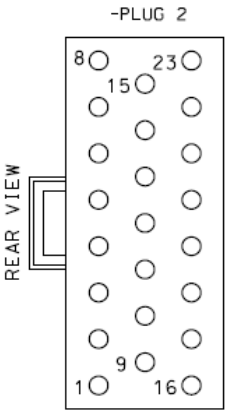
Single pinch or double pinch hose clamps are suggested instead of worm gear type clamps. Suggestions for hose and hose clamps are shown below.

Description	***McMaster-Carr Part Number***	
Teflon PTFE hose with 304 stainless steel braid, 5/16” ID, 7/16” OD	52515K3	
Single pinch, Tight-Seal Vibration resistant pinch clamp, 27/64” – 17/32”	52545K51	

3. Catalytic Combustion includes a wiring harness terminated with the correct AMP style connector on one end and striped bare wire on the other.
    a. The connector plugs into the pump
    b. The unterminated end is routed to the DEF Dosing Control Cabinet where the wires are inserted into the appropriate terminal strips



AMP CONNECTOR			
PAIR 1	B	PIN 1	C17
	W	PIN 2	C11
		PIN 3	NC
PAIR 2	B	PIN 4	C4
	W	PIN 5	C2
		PIN 6-23	NC



CATALYTIC COMBUSTION

EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Datasheet

Exhaust Pressure Transducer

Document No.: Differential Pressure

Published January 2019

Product Family	SCR Dosing System
Function	Exhaust Pressure Sensor
Purpose	Sense differential pressure across catalyst bed
Media	Wet exhaust gas
Accuracy	0.08% BSL linearity, hysteresis and repeatability combined
Operating Temperature	-45°C to 115°C (-20°F to 239°F)
Compensated Temperature Range	-29°C to +85°C (-20°F to 185°F)
Pressure Cycles	1 million, minimum
Long Term Stability	+/- 0.1%, full scale
Response Time	<1ms
Compliance	CE, EN61326-1: 2006 for industrial locations
Wetted Parts	316L stainless steel
Line/Static Pressure	35bar max applied to both sides simultaneously
Proof Pressure (Differential)	6.8bar
High side containment pressure	To 70bar
Pressure Ports	¼” male NPT
Electrical Termination	Cable
Output	4-20mA
Weight	350g

Position	Detail
1	PIT101 Low Pressure
2	PIT101 High Pressure

MECHANICAL INTERFACES

Detail	Liquid Sealing	Thread Pitch
Inlet and Outlet	N/A	¼" male NPT

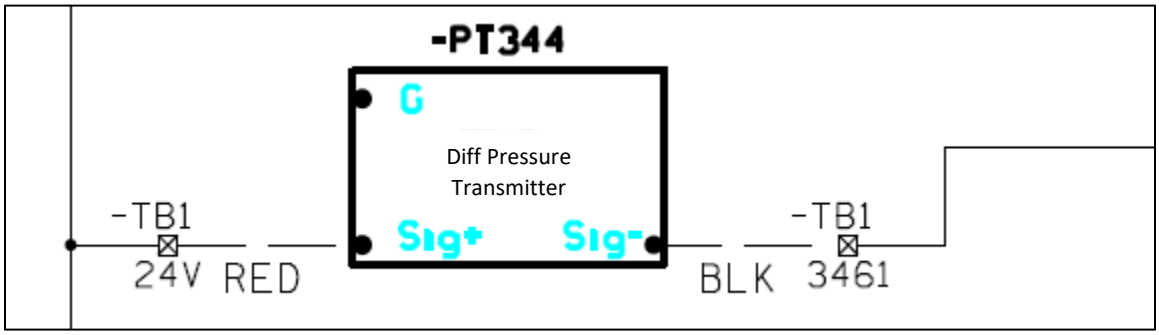
Supplied mounted to the Control Cabinet Door (internal) with two (2) ¼" push-to-connect tube fittings installed on sensor. Two (2) ¼" push-to-connect by ¼" NPT bulkhead fittings are installed in the Control Cabinet. JIC fittings enable connection of the exhaust hose to the bulkhead fitting.

¼" flexible poly tubing shipped loose inside the Control Cabinet to connect pressure transducer to bulkhead fitting. Customer responsible for plumbing tubing from PIT101 and PIT102 ports on reactor to bulkhead fittings. Stainless steel tubing (1/4" O.D.) suggested, however properly supported copper tubing is acceptable.

Flexible stainless tubing is acceptable.

ELECTRICAL INTERFACE

Delivered with 3ft pigtail and tinned wire. Pre-Installed in Control Cabinet by Catalytic Combustion. No external wiring required.

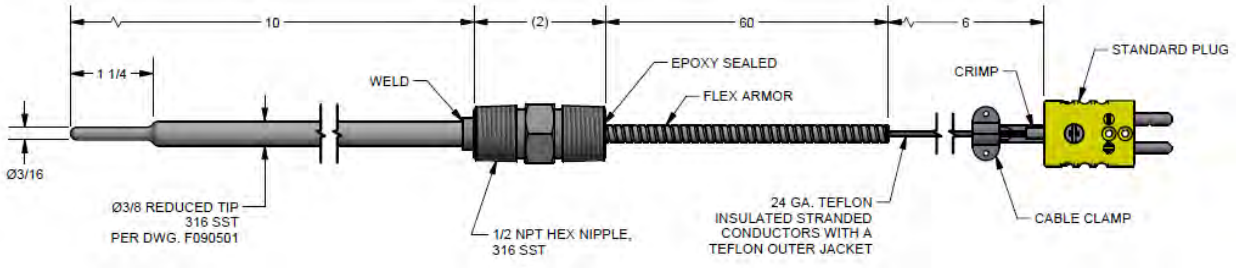


CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

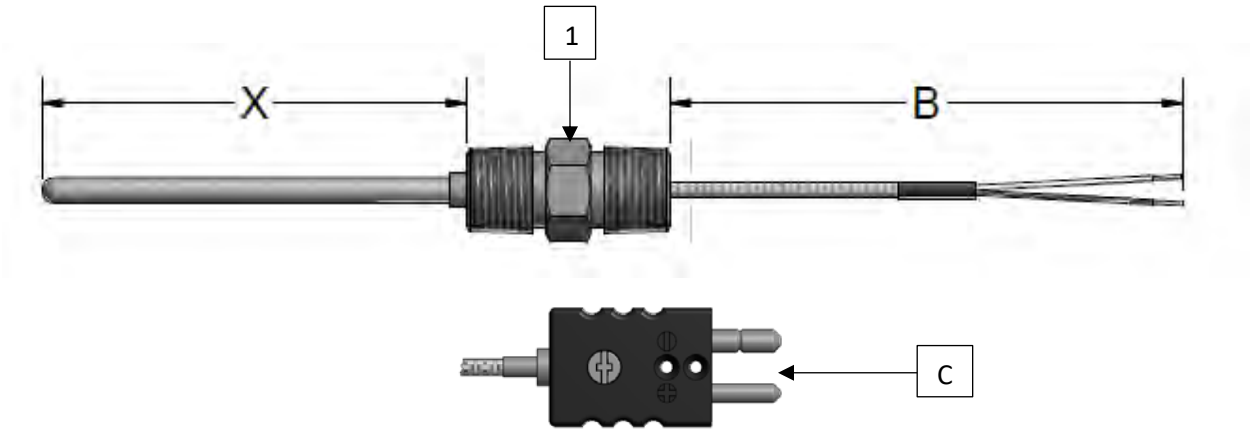
Datasheet

Exhaust Temperature Sensor



Published January 2019

Product Family		SCR Dosing System
Function		Exhaust Temperature Sensor
Purpose		Sense exhaust temperature
Media		Exhaust gas
Type		Type K thermocouple, ungrounded
Size	Probe	12” long, 3/8” diameter
	Interface	1/2” male NPT
	Termination	Male Type K Connector
	Length	60” OAL
Material	Sheath	316 SS
	Fill	MgO
	Insulation	Fluoropolymer, Flexible armor
	Conductor	Stranded

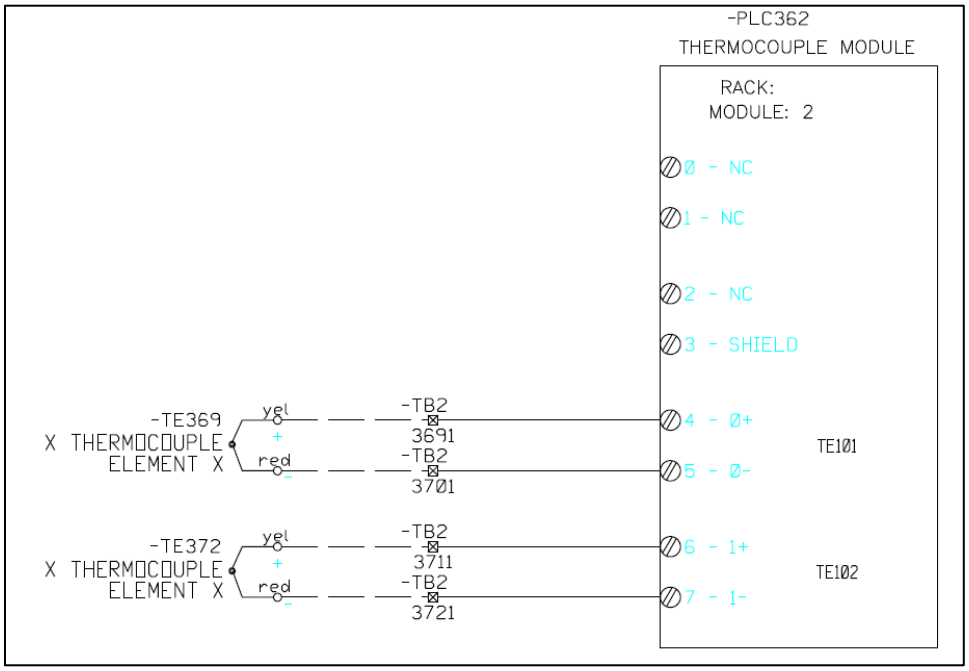


Position	Detail
X	12”, 3/8” diameter, reduced tip 3/16”
B	60 inches, armored
C	Type K Connector, male

MECHANICAL INTERFACES

Detail	Interface
1	½” Male NPT

ELECTRICAL INTERFACE



CATALYTIC COMBUSTION

EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Datasheet

NH3 Concentration Sensor and ECM

Published January 2019

Product Family		SCR Dosing System
Function		Sense exhaust outlet NH3 concentration
Purpose		Sense NH3 Concentration in exhaust gas
Media		Exhaust gas, diesel
Accuracy		+/- 5ppm (0-200ppm) +/-20ppm (200-1000ppm)
Response Time		< 1 second
Communication		CAN, high speed per ISO 11898
Environmental	Temperature (module)	-55°C to +125°C
	Temperature (sensor)	950°C continuous
	Sealing (module)	IP67
Dimensions	Module	145mm x 120mm x 40mm
	Sensor	1.5m (Interconnect cable)
		18mm x 1.5mm (mounting)
Power	Voltage	11 to 28 VDC (From Control Cabinet)
	Current	1.2A @ 12V (steady state) 4A @ 12V for 30s (start-up)

Position	Detail
1	NH3 Concentration Sensor
2	NH3 Concentration Sensor Electronic Control Module

MECHANICAL INTERFACES

Detail	Liquid Sealing	Thread Pitch
Sensor Mounting	N/A	18mm x 1.5mm

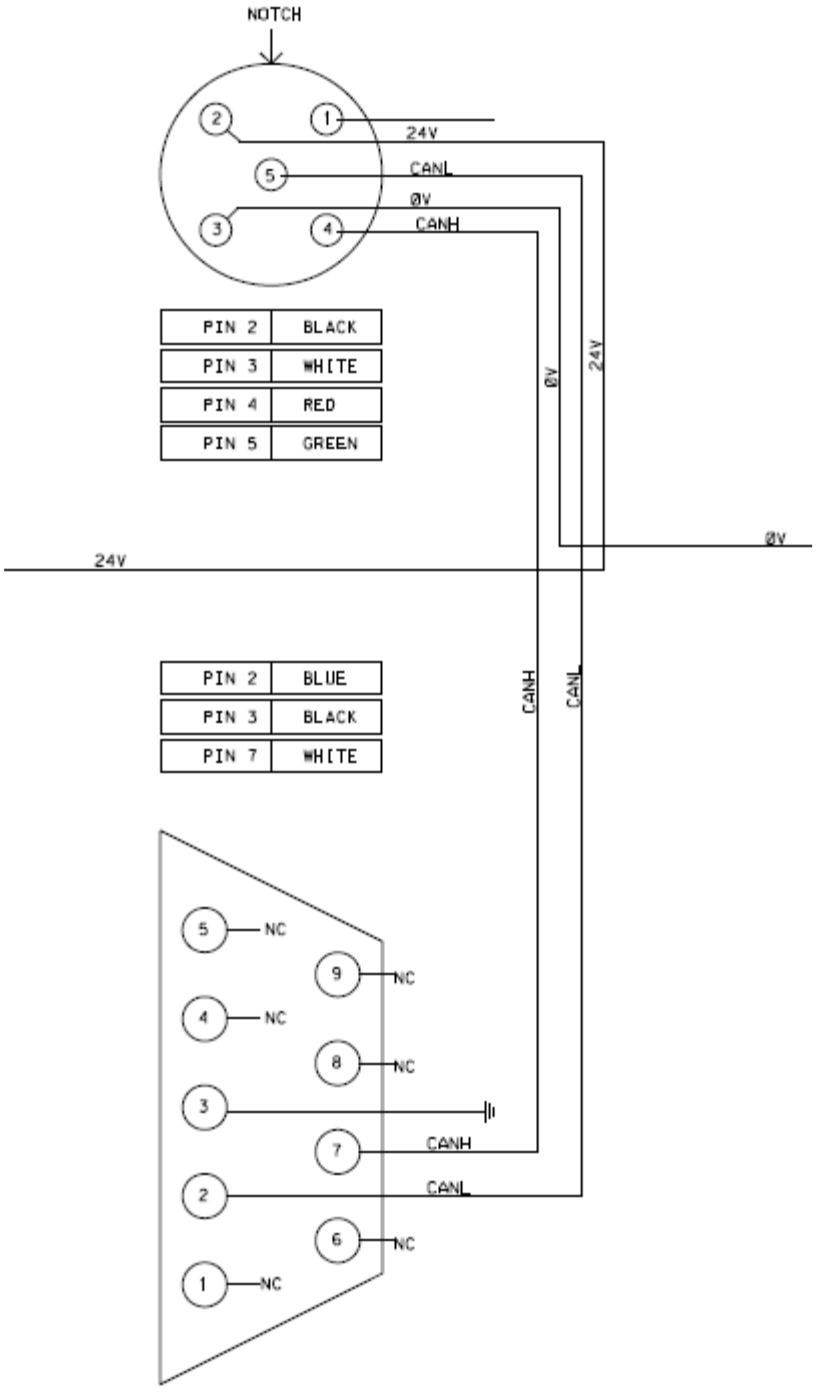
ELECTRICAL INTERFACE

Sensor delivered with 8inch pigtail to connect to wiring harness.

4.5-foot wiring harness connects Sensor to ECM.

Proprietary wiring harness connects NH3 Concentration ECM's to the Control Cabinet.

NH3 CONCENTRATION SENSOR ECM INTERCONNECT TO DOSING CONTROL CABINET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CANL
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4
CANH
PIN 2 BLACK
PIN 3 WHITE
PIN 4 RED
PIN 5 GREEN
0V
24V
24V
0V
CANH
CANL
PIN 2 BLUE
PIN 3 BLACK
PIN 7 WHITE
5 NC
9 NC
4 NC
8 NC
3
7 CANH
2 CANL
6 NC
1 NC

CATALYTIC COMBUSTION

EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Datasheet

NOx Concentration Sensor and ECM

Published January 2019

Product Family		SCR Dosing System
Function		Sense exhaust outlet NOx concentration
Purpose		Sense NOx Concentration in exhaust gas
Media		Exhaust gas, diesel
Accuracy		+/- 5ppm (0-200ppm) +/-20ppm (200-1000ppm)
Response Time		< 1 second
Communication		CAN, high speed per ISO 11898
Environmental	Temperature (module)	-55°C to +125°C
	Temperature (sensor)	950°C continuous
	Sealing (module)	IP67
Dimensions	Module	145mm x 120mm x 40mm
	Sensor	1.5m (Interconnect cable)
		18mm x 1.5mm (mounting)
Power	Voltage	11 to 28 VDC (From Control Cabinet)
	Current	1.2A @ 12V (steady state) 4A @ 12V for 30s (start-up)

Position	Detail
1	NOx Concentration Sensor
2	NOx Concentration Sensor Electronic Control Module

MECHANICAL INTERFACES

Detail	Liquid Sealing	Thread Pitch
Sensor Mounting	N/A	18mm x 1.5mm

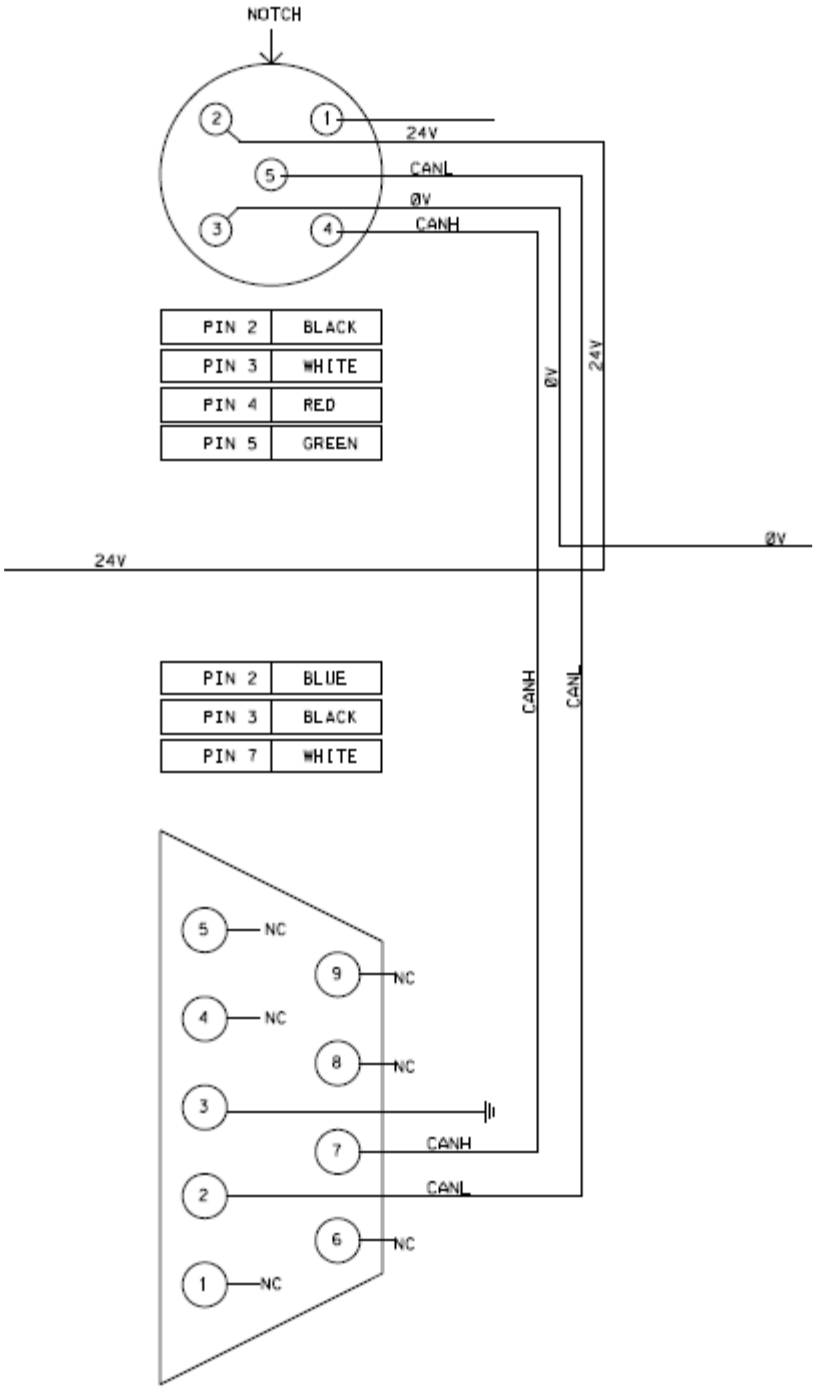
ELECTRICAL INTERFACE

Sensor delivered with 8inch pigtail to connect to wiring harness.

4.5-foot wiring harness connects Sensor to ECM.

Proprietary wiring harness connects NOx Concentration ECM's to the Control Cabinet.

NOx CONCENTRATION SENSOR ECM INTERCONNECT TO DOSING CONTROL CABINET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PIN 4 RED
PIN 5 GREEN
0V
24V
24V
0V
CANH
CANL
PIN 2 BLUE
PIN 3 BLACK
PIN 7 WHITE
5 NC
9 NC
4 NC
8 NC
3
7 CANH
2 CANL
6 NC
1 NC

Specification

General

The Powerex Enclosed Scroll Air Compressor unit is designed to provide clean, dry air for industrial applications where the quality of the compressed air is critical. The standard unit is rated for a maximum of 115 PSIG. A higher pressure version (max. 145 PSIG) is also available. The unit is UL/CSA certified[1].

Air Compressor System

The package shall include one oil-less scroll air compressor, a 13 gal. tank, and associated equipment. The only field connections required will be system exhaust, power connection at the control panel, and condensate tank drain connection. All interconnecting piping and wiring shall be included and operationally tested prior to shipment. Single phase 3HP units require installation of an additional external 30 gal. tank and single phase 5HP units require installation of an additional external 60 gal. tank. Anti-corrosion tank lining is available. Package includes sound reducing enclosure.

Sound Reducing Enclosure

The system is constructed with an internal frame and steel base system with an individual vibration isolation mounted compressor module. The sound reducing enclosure has side access panels to allow service of the electrical controls. The enclosure has side cooling air intakes and all exhaust air leaves the enclosure from the right side.

Oilless Scroll Compressor Pump

Each compressor shall be belt driven oil-less rotary scroll single stage, air-cooled oil-less construction with absolutely no oil needed for operation. The rotary design shall not require any inlet or exhaust valves and shall be rated for 100% continuous duty. Direct drive compressors shall not be used. Tip seals shall be of a composite PTFE material and be rated for 10,000 hours operation. Compressor bearings shall be external to the air compression chamber and shall all be serviceable for extended compressor life. Bearing maintenance shall not be required until 10,000 run hours. Compressors with bearings that are not accessible for service have a limited life span and shall not be accepted. Compressors shall have an integral radial flow fan for cooling and shall not require any additional electric cooling fans. Each compressor shall have flexible connectors on discharge.

Each compressor pump shall be provided with an electric drive motor, discharge check valve, an air-cooled after-cooler, and a high discharge temperature shut down switch.

Motor

Each compressor shall be belt driven by a 1750 RPM, ODP, NEMA construction motor. Motors running at speeds higher than 1750 RPM shall not be acceptable. Three phase motors are EISA compliant and premium efficient.

[1] With the exception of 5 HP single phase units, which only have a UL508A listed control panel.

Air Receiver

The system shall include an internal 13 gallon ASME air receiver rated for 175 PSI MAWP. The tank shall be equipped with a safety relief valve and a manual or optional automatic electronic tank drain with manual override. The tank will also have corrosion resistant FDA approved material tank lining if that option is selected.

System Controls

The system shall include a control panel with lighted on/off switch magnetic starter overload protection, hour meter, and high temperature shutoff switch.

Inlet Filters

The system shall include a single inlet filter system. The inlet filter system shall be located on the compressor pump.

Optional Desiccant Air Dryer

Each twin-tower desiccant dryer shall be sized for the peak calculated system demand to provide a pressure dew point of 0oF. Dryer controls shall include a re-pressurization cycle to prevent shocking of the desiccant bed prior to switching towers. An integral purge saving control system shall be provided and shall suspend the purge air loss during periods of low demand. When the dryer is in purge control mode, the tower switching valves shall not operate, and only one desiccant tower shall be on-line. Dryers that continue to operate the switching valves on a fixed cycle, while in purge control mode shall not be acceptable. Desiccant dryer controls are to be powered from a separate supply, not through compressor controls.

Optional Refrigerant Air Dryer

The refrigerated air dryer is non-cycling, direct expansion type, using R-134 A refrigerant (CFC free). A hot gas by-pass system maintains a consistent temperature at all load conditions. Heat exchangers are made of copper tube construction and fully insulated. Dryers shall have power on and high temperature lights, internal 3-micron filter/separator with stainless steel bowl, and timed electric condensate drain. Refrigerated dryers are to be powered from a separate supply, not through the compressor controls.

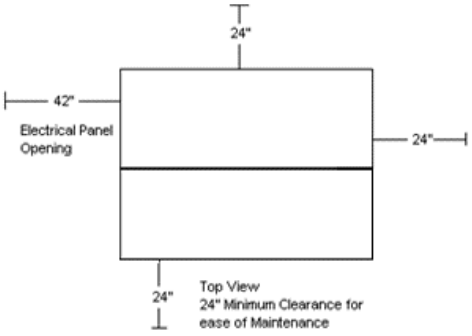
Optional Dewpoint Monitor

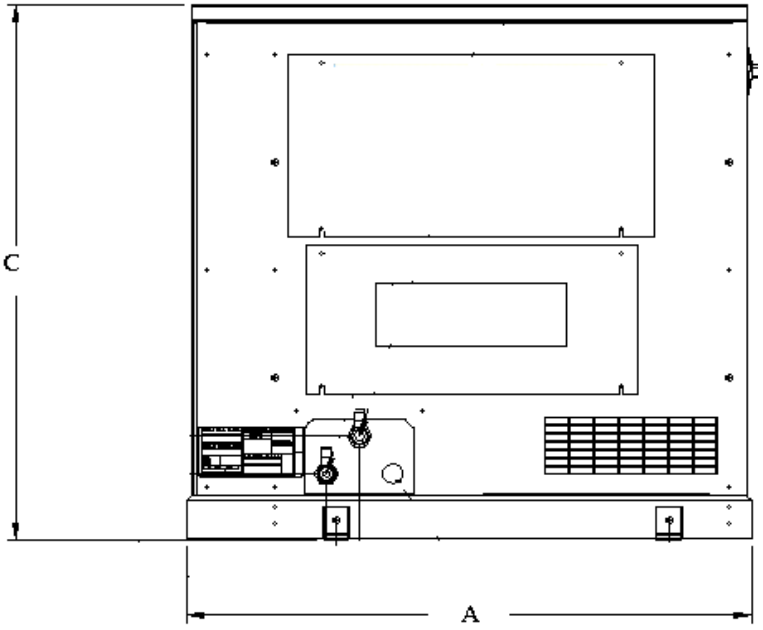
The system-integrated hygrometer shall be equipped with an LCD dew point display and high dew point alarm with dry contacts for remote monitoring. The sensor shall include an auto calibration feature to ensure the accuracy of the dew point measurement. Dew point monitor powered separately.

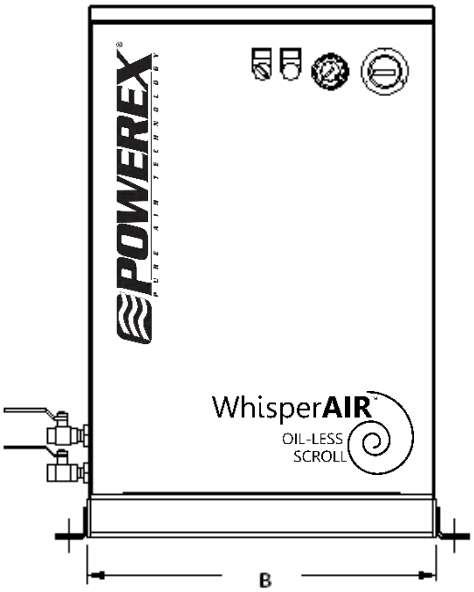
Optional Carbon Monoxide Monitor

The carbon monoxide (CO) monitor is provided in an enclosure with LCD display of CO concentrations. The monitor shall continuously display the CO content of the discharge air and shall provide audible and visual high CO alarms. High alarm is set at 10 ppm. Dry contacts are provided for remote monitoring of the high CO alarm. Carbon monoxide monitor powered separately.

Dimensions				
Model	Dim. A	Dim. B	Dim. C	Outlet
SES0308	34"	21"	33"	3/8"
SES1308	34"	21"	33"	3/8"
SES0508	34"	21"	33"	3/8"
SES1518	34"	21"	33"	3/8"







Enclosed Scroll Air Compressors										
Model[5]	HP[1]	SCFM @ 100 PSIG [5]	Maximum Pressure (PSIG)	Tank Size (gal)[6]	BTU/Hr	dB(A) Level	System F.L.A.			System Weight (lbs)
							208V	230V	460V	
SES0308	3	8.8	116	13	7,635	49	9.0	8.1	4.2	310
SES0308HP	3	7.1	145	13	7,635	49	9.0	8.1	4.2	310
SES1308	3	8.8	116	13	7,635	49	-	13	-	336
SES1308HP	3	7.1	145	13	7,635	49	-	13	-	336
SES0508	5	15.2	116	13	12,725	51	14.5	13.1	6.6	335
SES0508HP	5	12.5	145	13	12,725	51	14.5	13.1	6.6	335
SES1518	5	15.2	116	13	12,725	51		23.4	-	345
SES1518HP	5	12.5	145	13	12,725	51		23.4	-	345

Notes:

1 – Actual BHP is less than rated name plate. Contact Powerex for BHP rating.

2 – 3 Year Limited Warranty

3 – Single Phase 3HP units will require installation of an additional 30 gal. external tank and 5HP units will require the installation of an additional 60 gal. external tank.

4 – UL/CSA Certified with the exception of 5 HP single phase units, which only have a UL508A listed control panel.

5 – HP after a model number indicates high pressure model. SCFM for high pressure units are @ 145 PSIG.

6 – Tank is located inside the enclosure

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Process & Instrument Diagram

Holt Texas LTD.

Holt CAT Dual Lance (C175) SCR Systems

VPN 1040249

Published December 2022

• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

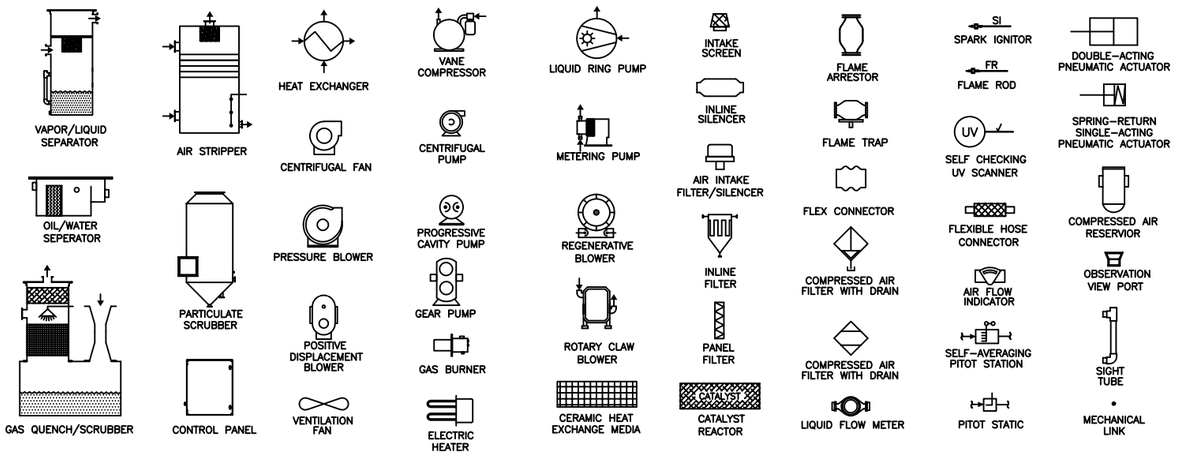
VALVES AND PIPING

- GLOBE
- BALL
- BUTTERFLY
- CHECK
- GATE
- ORIFICE METERING
- LUBRICATED PLUG
- VACUUM RELIEF
- PRESSURE RELIEF
- FORWARD PRESSURE REDUCING REGULATOR INTERNAL RELIEF
- BACK PRESSURE REGULATOR INTERNAL RELIEF
- PRESSURE REDUCING EXTERNAL PRESSURE
- PRESSURE REDUCING DIFFERENTIAL PRESSURE
- PRESSURE REDUCING VENTED
- 3 WAY
- REDUCER
- Y–STRAINER
- SAMPLE/TEST PORT
- FLANGE
- UNION
- ORFICE PLATE
- VALVE NORMALLY OPEN
- VALVE NORMALLY CLOSED

OPERATORS

- M 01 — MOTOR
- MV 01 — MOTORIZED VALVE
- PA 01 — PNEUMATIC ACTUATOR
- PV 01 — PNEUMATIC VALVE
- VFD 01 — VARIABLE FREQUENCY DRIVE
- SV 01 — SOLENOID VALVE
- MANUAL
- MV 01 — MANUAL VALVE

EQUIPMENT



TRANSDUCERS

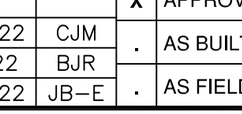
EXAMPLE:

FY I/P — CURRENT TO PNEUMATIC TRANSDUCER (MOUNTED BEHIND–THE–PANEL)

A	ANALOG
D	DIGITAL
E	VOLTAGE
F	FREQUENCY
I	CURRENT
P	PNEUMATIC
PF	PULSE FREQUENCY
PD	PULSE DURATION

INSTRUMENT IDENTIFICATION

BUBBLE SYMBOL



INSTRUMENT LOCATION SYMBOL

- FIELD MOUNTED INSTRUMENT
- PANEL MOUNTED INSTRUMENT
- BEHIND–THE–PANEL MOUNTED INSTRUMENT
- (GREEN) PILOT LIGHT/ALARM LIGHT (LIGHT COLOR)
- PROGRAMMABLE LOGIC CONTROLS

SPECIAL CASES

- HS 4 OO — ON AND OFF EVENT LIGHTS
- HS 4 OC — OPENED AND CLOSED POSITION LIGHTS
- HS 4 OC — OPENED AND CLOSED POSITION SWITCHES
- I — INTERLOCKS

TYPE, ACTION, OR CONTROL ABBREVIATIONS

AAH	ANALYTICAL ALARM HIGH
AAL	ANALYTICAL ALARM LOW
AC	ALTERNATING CURRENT
AE	ANALYTICAL ELEMENT
AI	ANALOG INPUT
AM	AUTO MANUAL
AO	ANALOG OUTPUT
AT	ANALYTICAL TRANSMITTER
B	BURNER
CV	CONTROL VALVE
DC	DIRECT CURRENT
DI	DIGITAL INPUT
DO	DIGITAL OUTPUT
DPI	DIFFERENTIAL PRESSURE INDICATOR
DPS	DIFFERENTIAL PRESSURE SWITCH
EH	ELECTRIC HEATER
ENET	ETHERNET
F	FAN
FAR	FORWARD AUTO REVERSE
FE	FLOW ELEMENT/SENSOR
FI	FLOW INDICATOR
FIR	FLOW INDICATING RECORDER
FIT	FLOW INDICATING TRANSMITTER
FS	FLOW SWITCH
HOA	HAND OFF AUTO
HS	HAND SWITCH
HV	HAND VALVE
LAH	LEVEL ALARM HIGH
LAL	LEVEL ALARM LOW
LEL	LOWER EXPLOSIVE LIMIT
LSH	LEVEL SWITCH HIGH
LSHH	LEVEL SWITCH HIGH HIGH
LSL	LEVEL SWITCH LOW
LSLL	LEVEL SWITCH LOW LOW
LT	LEVEL TRANSMITTER
M	MOTOR
MV	MOTORIZED VALVE
N	NOZZLE
NC	NORMALLY CLOSED
NO	NORMALLY OPENED
OC	OPEN–CLOSE
OCA	OPEN–CLOSE–AUTO
OO	ON–OFF
OOA	ON–OFF–AUTO
OOR	ON–OFF–REMOTE
P	PUMP
PAH	PRESSURE ALARM HIGH
PAL	PRESSURE ALARM LOW
PC	PRESSURE CONTROL
PCV	PRESSURE CONTROL VALVE
PI	PRESSURE INDICATOR
PIR	PRESSURE INDICATING RECORDER
PIS	PRESSURE INDICATING SWITCH
PIT	PRESSURE INDICATING TRANSMITTER
PLC	PROGRAMMABLE LOGIC CONTROLLER
PRV	PRESSURE RELIEF VALVE
PRX	PRESSURE RELIEF RUPTURE DISK
PS	PRESSURE SWITCH
PSH	PRESSURE SWITCH HIGH
PSL	PRESSURE SWITCH LOW
PT	PRESSURE TRANSMITTER
SR	SPRING RETURN
SS	START–STOP
SSOV	SAFETY SHUT OFF VALVE
SV	SOLENOID VALVE
TAH	TEMPERATURE ALARM HIGH
TAL	TEMPERATURE ALARM LOW
TCV	TEMPERATURE CONTROL VALVE
TE	TEMPERATURE ELEMENT
TI	TEMPERATURE INDICATOR
TIC	TEMPERATURE INDICATING CONTROLLER
TIR	TEMPERATURE INDICATING RECORDER
TIT	TEMPERATURE INDICATING TRANSMITTER
TS	TEMPERATURE SWITCH
TSH	TEMPERATURE SWITCH HIGH
TSL	TEMPERATURE SWITCH LOW
TT	TEMPERATURE TRANSMITTER
VFD	VARIABLE FREQUENCY DRIVE
VRV	VACUUM RELIEF VALVE
XCV	CHECK VALVE
XDA	DETONATION ARRESTOR
XFA	FLAME ARRESTOR
XFT	FLAME TRAP
XHE	HEAT EXCHANGER
XIF	INLET FILTER
XIS	INLET SCREEN
XJ	FLEX CONNECTOR/EXPANSION JOINT
XS	SILENCER
XSI	SPARK IGNITER
XUV	UV DETECTOR
XV	UNCLASSIFIED VALVE
YC	EVENT CLOSED
YI	EVENT INDICATOR
YO	EVENT OPEN
ZAC	POSITION ALARM CLOSED
ZAO	POSITION ALARM OPEN
ZS	POSITION SWITCH
ZSC	POSITION SWITCH CLOSED
ZSO	POSITION SWITCH OPEN
ZT	POSITION TRANSMITTER

LINE LEGEND

- PIPING
- PROCESS DUCTWORK
- COMPRESSED AIR
- PNEUMATIC SIGNAL
- ELECTRICAL SIGNAL OTHER
- ANALOG SIGNAL
- NON CONNECTING LINES
- CONNECTING LINES
- DATA LINK
- HOSE
- LINE SIZE 6 — FLOW DIRECTION
- OTHERS — CCC

PROCESS FLOW DIAGRAM LEGEND

- °F — TEMPERATURE DEGREES FAHRENHEIT
- SCFM — VAPOR FLOW STANDARD CUBIC FEET PER MINUTE
- PSIG — PRESSURE POUNDS PER SQUARE INCH GAGE
- PPM — CONCENTRATION PARTS PER MILLION
- GPM — WATER FLOW GALLONS PER MINUTE
- PROCESS NO.

NOTES

1. SPECIFICATIONS AND DIMENSIONS ARE SUBJECT TO CHANGE WITHOUT NOTIFICATION.
2. REFERENCE ANSI/ISA–S5.1 FOR SYMBOLS NOT SHOWN ON THIS LEGEND.
3. THIS IS A STANDARD LEGEND, THEREFORE, NOT ALL OF THIS INFORMATION MAY APPLY.
4. THESE SYMBOLS AND ABBREVIATIONS ARE SPECIFIC TO CATALYTIC COMBUSTION CORPORATION AND MAY DIFFER FROM ISA.

REV	DESCRIPTION	DATE	BY
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02	UPDATED TO "AS–BUILT"	9/28/22	CJM
01	UPDATED NUMBERING FOR DOSING PANELS	8/4/22	BJR
00	INITIAL DUAL LANCE CUSTOMER SUBMITTAL	5/17/22	JB–E

	DRAWING STATUS:	DATE:	BY:
.	PRELIMINARY	.	.
.	FOR APPROVAL	.	.
X	APPROVED FOR FAB	9/28/22	CJM
.	AS BUILT	.	.
.	AS FIELD MODIFIED	.	.

MATERIAL: SEE BOM

WEIGHT: N/A

TOLERANCES:
.X = 0.06
.XX = 0.03
.XXX = 0.015
∠ = 0.5°

THIRD ANGLE PROJECTION

INCH [mm]

CATALYTIC COMBUSTION EMISSION TECHNOLOGIES

Catalytic Combustion Corporation
311 Riggs Street
Bloomer, WI 54724

Telephone: 715–568–2882
Fax: 715–568–2884

www.catalyticcombustion.com

DATE: 05/17/2022

SCALE: NTS

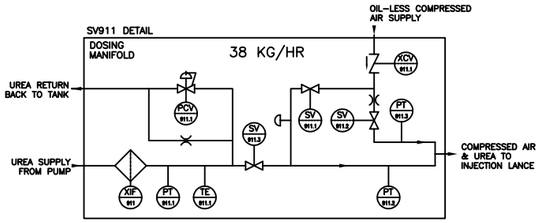
DRAWN BY: JB–E

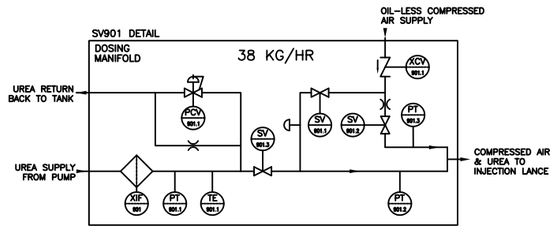
CHECKED BY: CM

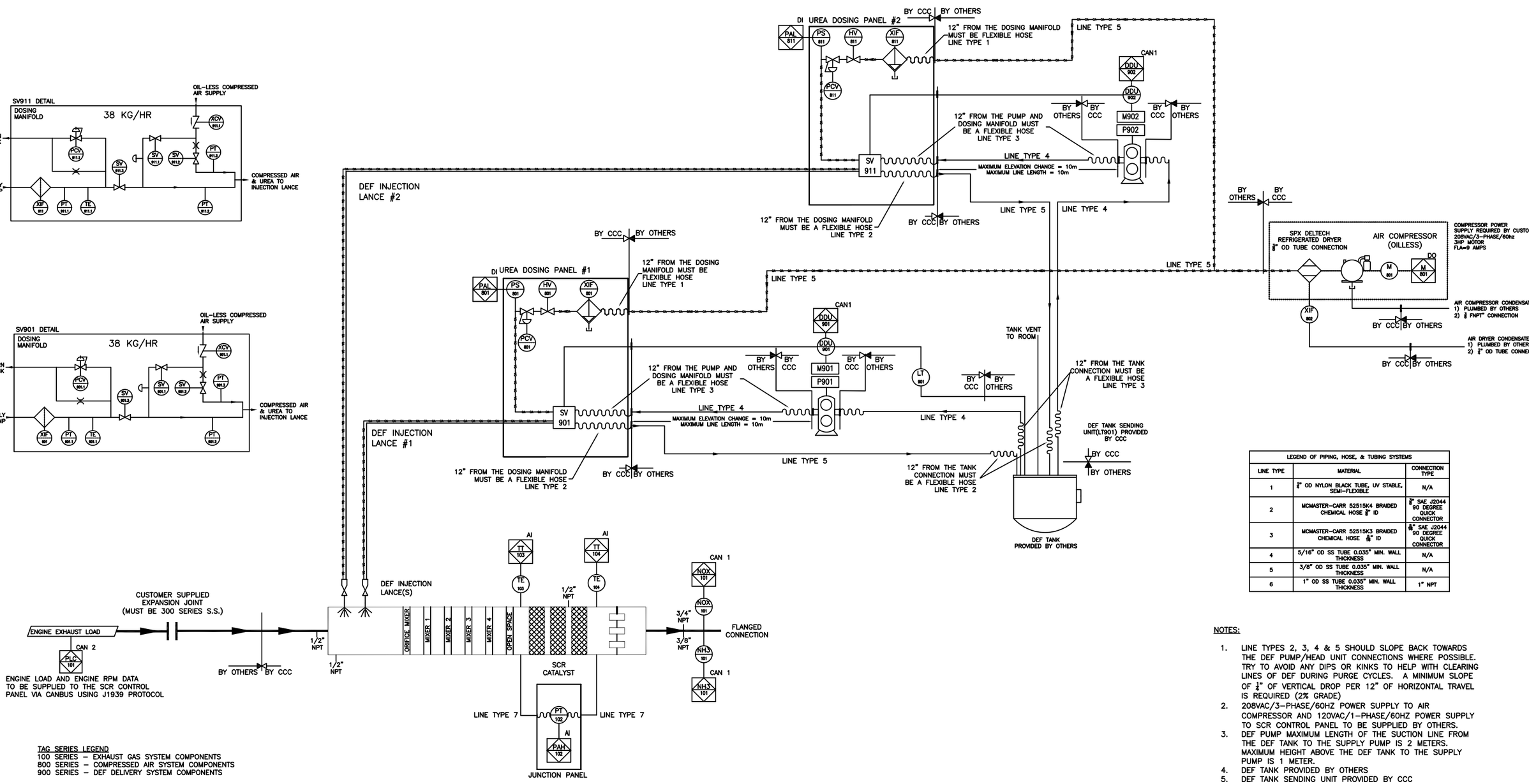
CUSTOMER: HOLT CAT & ALIGNED ENERGY TOAD & BLUE – DUAL INJECTION

TITLE: SELECTIVE CATALYST REDUCTION SYSTEM PROCESS & INSTRUMENTATION DIAGRAM

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
W0172978	500	02	B







TAG SERIES LEGEND
100 SERIES – EXHAUST GAS SYSTEM COMPONENTS
800 SERIES – COMPRESSED AIR SYSTEM COMPONENTS
900 SERIES – DEF DELIVERY SYSTEM COMPONENTS

LEGEND OF PIPING, HOSE, & TUBING SYSTEMS		
LINE TYPE	MATERIAL	CONNECTION TYPE
1	1/4" OD NYLON BLACK TUBE, UV STABLE, SEMI-FLEXIBLE	N/A
2	MCMASTER-CARR 52515K4 BRAIDED CHEMICAL HOSE 1/2" ID	1/2" SAE J2044 90 DEGREE QUICK CONNECTOR
3	MCMASTER-CARR 52515K3 BRAIDED CHEMICAL HOSE 3/8" ID	3/8" SAE J2044 90 DEGREE QUICK CONNECTOR
4	5/16" OD SS TUBE 0.035" MIN. WALL THICKNESS	N/A
5	3/8" OD SS TUBE 0.035" MIN. WALL THICKNESS	N/A
6	1" OD SS TUBE 0.035" MIN. WALL THICKNESS	1" NPT

NOTES:

1. LINE TYPES 2, 3, 4 & 5 SHOULD SLOPE BACK TOWARDS THE DEF PUMP/HEAD UNIT CONNECTIONS WHERE POSSIBLE. TRY TO AVOID ANY DIPS OR KINKS TO HELP WITH CLEARING LINES OF DEF DURING PURGE CYCLES. A MINIMUM SLOPE OF 1/4" OF VERTICAL DROP PER 12" OF HORIZONTAL TRAVEL IS REQUIRED (2% GRADE)
2. 208VAC/3-PHASE/60HZ POWER SUPPLY TO AIR COMPRESSOR AND 120VAC/1-PHASE/60HZ POWER SUPPLY TO SCR CONTROL PANEL TO BE SUPPLIED BY OTHERS.
3. DEF PUMP MAXIMUM LENGTH OF THE SUCTION LINE FROM THE DEF TANK TO THE SUPPLY PUMP IS 2 METERS. MAXIMUM HEIGHT ABOVE THE DEF TANK TO THE SUPPLY PUMP IS 1 METER.
4. DEF TANK PROVIDED BY OTHERS
5. DEF TANK SENDING UNIT PROVIDED BY CCC
6. DUAL 38KG/HR DOSING SYSTEMS TO BE USED FOR THIS NOX REDUCTION APPLICATION.

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.	AS BUILT	.	.
.	AS FIELD MODIFIED	.	.

MATERIAL: SEE BOM

WEIGHT: N/A

TOLERANCES:
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.XXX = 0.015
∠ = 0.5°

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THIRD ANGLE PROJECTION

INCH [mm]

DATE: 05/17/2022

SCALE: NTS

DRAWN BY: JB-E

CHECKED BY: CM

CUSTOMER: HOLT CAT
ALIGNED ENERGY LLC

TITLE: TOAD & BLUE – DUAL INJECTION PROCESS & INSTRUMENTATION DIAGRAM

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
W0172978	501	02	B

BILL OF MATERIALS – MECHANICAL

SHEET	DEVICE ID	CCC P/N	DESCRIPTION	QTY / SCR
501	TE 103 TE 104	1026482	THERMOCOUPLE K68U–012–05C–19HT–F3A060–4	2
501	PT 102	1035675	DIFFERENTIAL PRESSURE TRANSMITTER 0–50 IN W.C. ASHCROFT	1
501	NOX 101	1027235	NOX SENSOR	1
501	NOX 101	1027237	NOX SENSOR MODULE/ECU	1
501	NH3 101	1027236	NH3 SENSOR	1
501	NH3 101	1027238	NH3 SENSOR MODULE/ECU	1
501	SCR	1039367	FFCE RCC–1920F–02–20SC–SCR20 W/O LIFTING LUGS	27
N/A	N/A	1006777	GASKET VERMICULITE FIBERGLASS W/PRESSURE SENSITIVE ADHESIVE DROP WARP 3.0" WIDE X $\frac{1}{4}$" THICK	130 FT
N/A	N/A	1031617	GASKET VERMICULITE FIBERGLASS W/PRESSURE SENSITIVE ADHESIVE DROP WARP 1.5" WIDE X $\frac{1}{4}$" THICK (AMOUNT NEEDED WHEN CHANGING CATALYST)	30 FT

BILL OF MATERIALS – MECHANICAL

SHEET	DEVICE ID	CCC P/N	DESCRIPTION	QTY / SCR
501	M801	1036652	AIR COMPRESSOR, POWEREX, MODEL SES0308, 8 CFM, 208VAC 3PH	1
501	N/A	1039726	SPX DELTECH 5–10CFM REFRIGERATED DRYER	1
501	N/A	1031080	INJ LANCE 1025–063–38–4A–01	2
501	PS801 PS811	1026054	STT EMTEC AIR PRESSURE REGULATOR, FILTER, & SWITCH REGULATOR	2
501	SV901 SV911	1030099	STT EMTEC, DOSING MANIFOLD, 38 KG/HR	2
501	M901, P901 M902, P902	1025637	STT EMTEC DEF PUMP ASSY, 38 KG/HR	2
N/A	N/A	1032959	FILTER DEF 40 MICRON (INSIDE DEF TANK)	2
501	LT901	1030877	SHAW MULTI–FUNCTION SENDING UNIT	1

REV	DESCRIPTION	DATE	BY
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MATERIAL: SEE BOM

WEIGHT: N/A

TOLERANCES:
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THIRD ANGLE PROJECTION

INCH [mm]

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CUSTOMER: HOLT CAT & ALIGNED ENERGY
TOAD & BLUE – DUAL INJECTION

TITLE: SELECTIVE CATALYST REDUCTION SYSTEM
PROCESS & INSTRUMENTATION DIAGRAM

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
W0172978	502	02	B

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Troubleshooting Guide

Holt Texas LTD.

Holt CAT Dual Lance (C175) SCR Systems

VPN 1040249

Published December 2022

• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

ISO 9001 Certified
Verisys Registrars®

Integrity | Service | Excellence

Catalytic Combustion Corporation introduced cutting edge technology in 1950 with the development of the first ever US patented catalyst to destroy VOCs (Volatile Organic Compounds). Since that time, the company has expanded into the design and supply of catalysts and emission control system for a wide variety of industries. The Selective Catalytic Reduction System installed on this engine represents the most advanced and least maintenance intensive system enabling compliance with US EPA and MARPOL IMO 3 regulations.

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1. General Information

Alarms are grouped into one of three categories:

1. **Critical Alarm:** Critical alarms will shut down the engine and are communicated locally on the HMI. Critical alarms include:
    a. SCR Inlet temperature high
    b. SCR outlet temperature high
    c. E-Stop engaged
2. **Pre-Alarm:** Pre-alarms will not shut down the engine, however may disable the SCR system. Pre-Alarm conditions include:
    a. Engine Communication loss
    b. TE10x signal fail
    c. NOx10x or NH3-10x sensor fault
    d. NOx10x or NH3-10x communication fault
    e. Dosing Fault, Air Flow
    f. Dosing Fault, DEF Flow
    g. Dosing Fault, DEF pressure
    h. Dosing Fault, Injection Nozzle blocked
3. **Global Alarm:** Global alarms will not shut down the engine, however may disable the SCR system. Global alarm conditions include:
    a. SCR (PT102) differential pressure signal fail
    b. SCR (PT102) differential pressure high
    c. Dosing ECU communication loss
    d. Loss of air pressure
    e. DEF Level in Day Tank critically low
    f. Dosing Fault, System frozen
    g. Dosing fault, Control unit
    h. Dosing Fault, system voltage
    i. Dosing Fault, PT9x1.1 DEF pressure signal fail
    j. Dosing Fault, PT9x1.2 Injection pressure signal fail
    k. Dosing Fault, PT9x1.3 Air pressure signal fail
    l. Dosing Fault, Failure to dose
    m. Dosing Fault, Air Flow shutdown
    n. Dosing Fault, DEF flow shutdown
    o. Dosing Fault, DEF pressure shutdown
    p. Dosing Fault, Dosing nozzle blocked

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Items listed as “Not User Serviceable” indicate that these items must be serviced by Catalytic Combustion Corporation only.

2. Troubleshooting Guide

Alarm	Probable Cause	Remedy
TE10x Signal Fail	Failure of thermocouple TE10x	Test thermocouple TE10x and replace if necessary
PT10x D/P Signal Fail	Failure of pressure transducer PT10x	Test pressure transducer PT10x and replace if necessary
NOx10x Sensor Fault	NOx wiring loose/broken NOx sensor failure ECU failure	Check sensor wiring Check/replace NOx sensor Check/replace ECU
NH310x Sensor Fault	NOx wiring loose/broken NOx sensor failure ECU failure	Check sensor wiring Check/replace NOx sensor Check/replace ECU
NOx10x Comms loss	NOx wiring loose/broken NOx sensor failure ECU failure	Check sensor wiring Check/replace NOx sensor Check/replace ECU
NH310x Comms loss	NOx wiring loose/broken NOx sensor failure ECU failure	Check sensor wiring Check/replace NOx sensor Check/replace ECU
Dosing ECU Comm Loss		Not user serviceable
SCR High Temperature (outlet)	Improper engine operation	Investigate per engine manufactures guidelines
SCR High Temperature (inlet)	Improper engine operation	Investigate per engine manufactures guidelines
Catalyst High Differential Pressure	Catalyst clogged by PM Failure of pressure transducer Clogged sensing lines	Check exhaust mixer and SCR chamber for deposits Test pressure transducer and replace if necessary Check sensor hoses for water/soot
Loss of Air Pressure	Loss of supply air to air regulator Clogged air filter Failed pressure transducer PS8x1	Verify air pressure on gauge at air regulator, investigate loss of air per engine manufactures guidelines Replace Not user serviceable. Replace air regulator and set

DEF Level Low (Day Tank)	Low fluid level	Fill Day Tank
DEF Critical Low (Day Tank)	Low fluid level	Fill Day Tank
Day Tank Level Sensor Fail	Failure of level transducer LT901	Test level transducer LT901
Dosing Fault, Air Flow	Loss of air pressure Improper injection nozzle operation	Investigate per "Loss of Air Pressure" above
Dosing Fault, DEF Flow	Improper pump operation	Not user serviceable
Dosing Fault, DEF Pressure (SV9x1.1)	Improper pump operation	Not user serviceable
Dosing Fault, Nozzle Blocked		Not user serviceable
Dosing Fault, System Frozen	System temperature below -8°C	Not user serviceable
Dosing Fault, Control Unit		Not user serviceable
Dosing Fault, Supply Voltage	Unstable bus voltage	Investigate per engine manufactures guidelines
DEF Pressure Signal Fail	PT9x1.1	Not user serviceable
Injection Pressure Signal Fail	PT9x1.2	Not user serviceable
Nozzle Air Pressure Sensor Fail	PT9x1.3	Not user serviceable
Failure to Dose		Not user serviceable
Dosing Airflow Shutdown		Not user serviceable
Dosing DEF Flow Shutdown		Not user serviceable
Dosing DEF Pressure Shutdown	PT9x1.1	Not user serviceable
Dosing Nozzle Blocked Shutdown		Not user serviceable

** Above table is a general troubleshooting guideline for CCC's SCR system not unit specific. **

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CATALYTIC COMBUSTION
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Selective Catalytic Reduction (SCR) System

Safety Data Sheets

Holt Texas LTD.

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SAFETY DATA SHEET

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

CCC SCR Catalyst D on Metallic Foil Substrate, for SCR Applications

Date SDS Revised: Rev A, June 2019 *Date SDS reviewed:* Rev A, June 2019

SECTION 1 — CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Identifier:	CCC SCR D Catalyst on Metallic Foil Substrate, for SCR Applications
Product Use:	SCR NOx reduction process, on exhaust of reciprocating engines, Gas Turbines and Chemical processes.
Manufacturer's Name	Catalytic Combustion Corporation
Street Address	311 Riggs Street
City, State, Zip Code	Bloomer, WI 54724
Telephone Number:	715-568-2882
Fax Number:	715-568-2884
Emergency Phone Number:	715-568-2882
Date SDS Revised:	June 2019 REV A
Date SDS Prepared:	November 2016

SECTION 2 — COMPOSITION/INFORMATION ON INGREDIENTS

Note:

This product is HAZARDOUS. This section refers only to dust or fumes which may be generated under conditions other than normal handling or use.

Hazardous Ingredients *(specific)*	**CAS Number**	**Concentration**
Divanadium pentoxide	1314-62-1	< .6% W/W

SECTION 3 — HAZARDS IDENTIFICATION

No adverse health effects would be expected during normal handling of this product. Health effects should be considered if this product is further worked, such as cutting, grinding, or crushing.

Routes of Entry: ☒ Skin Contact ☒Eye Contact ☒ Inhalation ☐ Skin Absorption ☒ Ingestion

	Hazard Category	Signal Word	Hazard Statement	Pictograms
Inhalation Hazard	4	Warning	When dusting occurs, the dust is classed as a hazardous dust and should be treated accordingly. Use NIOSH respirator, and collect loose dust with Vacuum Cleaner, with HEP filters	
Germ Cell mutagenicity	2	Warning	When dusting occurs, the dust is classed as a hazardous dust and should be treated accordingly. Use NIOSH respirator, and collect loose dust with Vacuum Cleaner, with HEP filters.	
Reproductive Toxicity	2	Warning	When dusting occurs, the dust is classed as a hazardous dust and should be treated accordingly. Use NIOSH respirator, and collect loose dust with Vacuum Cleaner, with HEP filters.	
Specific target organ toxicity, repeated exposure	1	Warning	When dusting occurs, the dust is classed as a hazardous dust and should be treated accordingly. Use NIOSH respirator, and collect loose dust with Vacuum Cleaner, with HEP filters.	
Acute aquatic toxicity	3	Warning	When dusting occurs, the dust is classed as a hazardous dust and should be treated accordingly. Use NIOSH respirator, and collect loose dust with Vacuum Cleaner, with HEP filters.	

Signs / Symptoms of Short-Term Exposure:

Inhalation	May cause irritation to the nose, throat and respiratory tract.
Eye Contact	May cause irritation and conjunctivitis
Skin Contact	May cause dehydration and irritation
Ingestion	None known

Hazard statements:

H332 Harmful if Inhaled.
H341 Suspected of causing genetic defects.
H361d Suspected of damaging the unborn child.
H372 Causes damage to organs though prolonged or repeated exposure.
H412 Harmful to aquatic life with long lasting effects.

Precautionary statements:

Prevention:
P201 Obtain Special instructions before use or handling this product.
P202 Do not handle until all safety precautions have been read and understood.
P260 Do not breathe dust/ fume/ gas/ mist/ vapors/ spray.
P264 Wash skin thoroughly after handling.
P270 Do not drink, eat or smoke when using, handling this product.
P271 Use only outdoors or in a well-ventilated area.
P273 Avoid release to the environment.
P280 Wear protective gloves/ protective clothing/ eye protection/ face protection.

Response:
P304 + P340 +P312 If dust inhaled: Remove person to fresh air and keep comfortable for breathing. Call a Poison Center if you feel unwell.
P308 + P313 If exposed or concerned: Get medical advice/ attention.

Storage:
P405 Store locked up.

Disposal:
P501 Dispose of contents/ container to an approved waste disposal plant.

Additional Labelling
The following percentage of the mixture consists of ingredient(s) with unknown acute toxicity: 4.99%

Other hazards
None known.

SECTION 4 — FIRST AID MEASURES

General advice	Show this Safety Data Sheet to the doctor in attendance. Remove victim to fresh air. Do not leave the victim unattended.
If Inhaled	Call a physician or poison control center immediately.
In case of skin contact	If on clothes, remove clothes. Cover wound with sterile dressing.
In case of eye contact	Remove contact lenses. Flush eyes with water, as a precaution. Protect unharmed eye. Keep eye wide open while rinsing. If eye irritation persists, consult a specialist.
If swallowed	Keep respiratory tract clear. Do not give milk or alcoholic beverages. Never give anything by mouth to an unconscious person. If symptoms persist, call a physician.
Most important symptoms and effects, both acute and delayed	None known.

SECTION 5 – FIRE AND EXPLOSION HAZARDS

Suitable extinguishing media:	Not combustible. Do not inhale dust.
Unsuitable extinguishing media:	High volume water jet.
Specific hazards during fire-fighting:	Do not allow run-off from fire-fighting to enter drains or water streams.
Hazardous combustion products:	Metal Oxides.
Further information:	Collect contaminated fire extinguishing water separately. This must not be discharged into drains. Fire residues and contaminated fire extinguishing water must be disposed in accordance with local regulations.
Special protective equipment for firefighters:	Use self-contained breathing apparatus in the danger area. Use protective clothing.

SECTION 6 — ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures:	Use personal protective equipment.
Environmental precautions:	Prevent product from entering drains. Prevent leakage or spillage if safe to do so. It the product contaminates rivers and lakes or drains, inform respective authorities.
Methods and materials for containment and cleaning up:	Pick up and transfer to properly labelled containers.

SECTION 7 — HANDLING AND STORAGE

Advice on protection against fire and explosion:	Normal measures for preventive fire protection.
Advice on safe handling:	Do not inhale dust. Avoid contact with skin and eyes. For personal protection see section 8. Smoking, eating and drinking shall be prohibited in the application area.
Conditions for safe storage:	Keep container tightly closed in a dry and well-ventilated place.
Material to avoid:	No Material to be especially mentioned.
Further information on storage stability:	Keep in dry place.

SECTION 8 — EXPOSURE CONTROL / PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value Type (forms of exposure)	Control Parameters / Permissible concentration	Basis
Divanadium pentoxide	1314-62-1	TWA (Inhalable fraction)	.05 mg/m³ (Vanadium)	ACGIH
		C (Fumes)	.05 mg/m³ (V_2O_5)	OSHA Z-1
		C (Respirable dust)	.05 mg/m³ (V_2O_5)	OSHA Z-1
		TWA (Respirable dust fraction)	.05 mg/m³ (V_2O_5)	OSHA P0
		TWA (Fumes)	.05 mg/m³ (V_2O_5)	OSHA P0
		C (Dust)	.05 mg/m³ (Vanadium)	NIOSH REL
		C (Fumes)	.05 mg/m³ (Vanadium)	NIOSH REL
		8 hour time weighted average	.02 mg/m³ (V_2O_5)	OSHA / TWA

Respiratory Protection: Wear a NIOSH – approved Respirator, Particulates type.

Ventilation Local exhaust to TLV

Protective Gloves Natural rubber, neoprene or nitrile are acceptable. Thickness .9 mm
Break through time > 480 min.

Eye Protection Safety glasses / goggles

Other Protective Clothing If dusts are generated, coveralls and NIOSH respirator

Work/Hygienic Practices If dusts are generated, wash skin and/or eyes in running water and remove to fresh air.

SECTION 9 — PHYSICAL AND CHEMICAL PROPERTIES

Physical State	Solid, like a thin steel foil, micro-corrugated.
Odor and Appearance	No odor, pale green coated metallic foil with wash coat.
Melting Point	1,400°C
Flash Point	Not applicable
Vapor Density (air = 1)	Not applicable
Decomposition Temperature	More than 1,000°C
Evaporation Rate (butyl acetate = 1)	Not applicable
Boiling Point (° C)	Not applicable
Freezing Point (° C)	Not applicable
Flammability (Solid, Gas)	Not classified as a flammability hazard
Coefficient of Water/Oil Distribution	Not applicable
Solubility in Water	Insoluble

SECTION 10 – STABILITY AND REACTIVITY

Stability	Stable.
Conditions to Avoid	None known.
Incompatible	None known.
Hazardous Decomposition Products	Will not occur if stored and applied as directed.
Hazardous Polymerization	Will not occur.

SECTION 11 — TOXICOLOGICAL INFORMATION

Acute Toxicity

Components:

Divanadium pentoxide:

Acute oral toxicity:	LD50 - rat, orally: 400 mg/kg.
Acute inhalation toxicity:	LC50 - rat, inhaled: 4.3 mg/liter.
Acute dermal toxicity:	Assessment: No data available.

IARC	Divanadium pentoxide	1314-62-1
OSHA	No components of this product present at levels greater than or equal to 0.1% is on OSHA list of regulated carcinogens.	
NTP	No components of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.	

STOT- single exposure

Components:

Divanadium pentoxide:

Target Organs: Respiratory Tract.

Assessment: May cause respiratory irritation.

STOT- repeated exposure

Components:

Divanadium pentoxide:

Assessment: Caused damage to respiratory organs through prolonged or repeated exposure.

Germ Cell mutagenicity

No information available. Product contains ingredient (divanadium pentoxide) that is hazardous to reproductive.

Carcinogenicity

No information available.

Reproductive toxicity

No information available. Product contains ingredient (divanadium pentoxide) that is hazardous to reproductive.

SECTION 12 – ECOLOGICAL INFORMATION

Ecotoxicity

Components:

Divanadium pentoxide:

Toxicity to fish:	LC50 (Oncorhyncus mykiss (rainbow trout)): 5.2 mg/l Exposure time: 96h Remarks: Fresh water
Toxicity to daphnia and other aquatic invertebrates:	EC50 (Daphnia magna (water flea)): 1.52 mg/l Exposure time: 48h Remarks: Fresh Water
Toxicity to fish (Chronic toxicity):	NOEC (Pimephales promelas (fathead minnow)): .12 mg/l Exposure time: 28 Days Remarks: Fresh Water
Ozone-Depletion Potential:	Regulation: 40 CFR Protection of Environment; Part 82 Protection of Stratospheric Ozone-CAA Section 602 Class I substances. Remarks: This product neither contains, nor was manufactured with a Class I or Class II ODS as defined by the U.S. clean Air act Section 60 (40CFR 82, Subpt. A, App.A+B)
Additional ecological information:	Harmful to aquatic life with long lasting effects.

SECTION 13 — DISPOSAL CONSIDERATIONS

Disposal Methods.

Waste from residues:	The product shall not be allowed to enter drains, water streams or the soil. Do not contaminate ponds, waterways or ditches with chemical or used container. Send to a licensed waste management company. Dispose of as hazardous waste in compliance with local and national regulations.
Contaminated packaging:	Empty remaining contents. Dispose of as unused product. Do not re-use empty containers.

SECTION 14 — TRANSPORT INFORMATION

International Regulations

UNRTDG
Not regulated as a dangerous good

IATA-DGR
Not regulated as a dangerous good

IMDG-Code
Not regulated as a dangerous good

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC code
Not applicable for product as supplied

National Regulations

49 CFR – DOT
Not regulated as a dangerous good

Special precautions for user
Not applicable

SECTION 15 — REGULATORY INFORMATION

EPCRA – Emergency Planning and Community Right-to-Know Act

CERCLA Reportable Quantity

Components	CAS-No.	Component RQ (lbs)	Calculated product RQ (lbs)
Divanadium pentoxide	1314-62-1	1000	Read note A
Note A: Calculated product RQ can exceed reasonably attainable upper limit			

SARA 304 Extremely Hazardous Substances Reportable Quantity

Components	CAS-No.	Component RQ (lbs)	Calculated product RQ (lbs)
Divanadium pentoxide	1314-62-1	1000	Read note A
Note A: Calculated product RQ can exceed reasonably attainable upper limit			

SARA 302 Extremely Hazardous Substances Threshold Planning Quantity

Components	CAS-No.	Component TPQ (lbs)
Divanadium pentoxide	1314-62-1	10000
Divanadium pentoxide	1314-62-1	100

SARA 311/312 Hazards:	Acute toxicity (any route of exposure)
	Germ cell mutagenicity
	Reproductive toxicity
	Specific target organ toxicity (single or repeated exposure)
SARA 313:	The following components are subject to reporting levels established by SARA Title III, Section 313:
	Divanadium pentoxide 1314-62-1 >= 1 - 5%

Clean Air Act

This product neither contains, nor was manufactured with a Class I or Class II ODS as defined by the U.S. Clean Air Act Section 602 (40 CFR 82, Subpart. A, App.A+B).

This Product does not contain any hazardous air pollutants (HAP), as defined by the U.S. Clean Air Act Section 112 (40 CFR 61).

This product does not contain any chemicals listed under the U.S Clean Air Act Section 112® for Accidental Release Preventions (40 CFR 68.130, Subpart F).

This product does not contain any chemicals listed under the U.S. Clean Air Act Section 111 SOCMI Intermediate or Final VOC's (40 CFR 60.489).

Clean Water Act

The following Hazardous Substances are listed under the U.S. Clean Water Act, Section 311, Table 116.4A:

Divanadium pentoxide 1314-62-1 4.99%

The following Hazardous Substances are listed under the U.S. Clean Water Act, Section 31, Table 117.3:

Divanadium pentoxide 1314-62-1 4.99%

This product does not contain any toxic pollutants listed under the U.S. Clean Water Act, Section 307.

US States Regulations

Massachusetts Right to Know

Components	CAS-No.
Divanadium pentoxide	1314-62-1

Pennsylvania Right to Know

Components	CAS-No.
Divanadium pentoxide	1314-62-1

California Prop 65.

Warning: This product can expose you to chemicals including divanadium pentoxide which is/are known to the State of California to cause cancer.

For more information go to www.P65Warnings.ca.gov.

California List of Hazardous Substances

Components	CAS-No.
Divanadium pentoxide	1314-62-1

California Permissible Exposure Limits for Chemical Contaminants

Components	CAS-No.
Divanadium pentoxide	1314-62-1

The components of this products are reported in the following inventories:

CH INV	On the inventory, or in compliance with the inventory.
DSL	All components of this products are on the Canadian DSL.
AICS	On the inventory, or in compliance with the inventory.
NZIoC	Not in compliance with the inventory.
ENCS	Not in compliance with the inventory.
ISHL	Not in compliance with the inventory.
KECI	On the inventory, or in compliance with the inventory.
PICCS	On the inventory, or in compliance with the inventory.
IECSC	On the inventory, or in compliance with the inventory.
TCSI	On the inventory, or in compliance with the inventory.
TSCA	ON TSCA inventory.

TSCA List

No substances are subject to a Significant New Use rule.

No substances are subject to TSCA 12(b) export notification requirements.

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

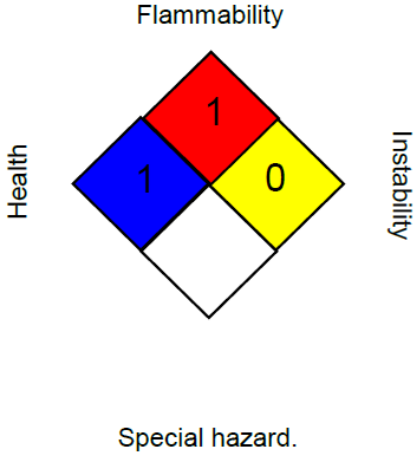
CCC SCR Catalyst D on Metallic Foil Substrate, for SCR Applications

Date SDS Revised: Rev A, June 2019 *Date SDS reviewed:* Rev A, June 2019

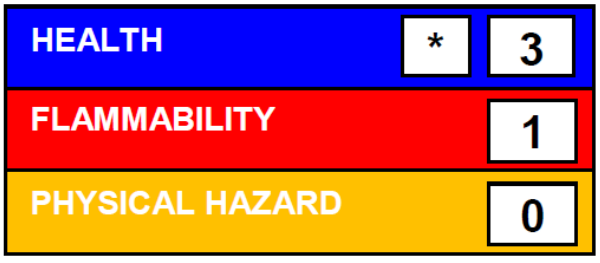
SECTION 16 — OTHER INFORMATION

Further information

NFPA:



HMIS® IV:



HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks. The "*" represents a chronic hazard, while the "/" represents the absence of a chronic hazard.

Full Text of other abbreviations

ACGIH	USA. ACGIH Threshold Limit Values (TLV)
NIOSH REL	USA. NIOSH Recommended Exposure Limits
OSHA P0	USA. OSHA - TABLE Z-1 Limits for Air Contaminants 1910.1000
OSHA Z-1	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
OSHA Z-3	USA. Occupational Exposure Limits (OSHA) - Table Z-3 Mineral Dusts
ACGIH/ TWA	8-hour, time – weighted average
ACGIH/ STEL	Short-term exposure limit
NIOSH REL / TWA	Time – weighted average concentration for up to a 10-hour workday during a 40-hour workweek
NIOSH REL / ST	STEL-15-minute TWA exposure that should not be exceeded at any time during a workday
NIOSH REL / C	Ceiling value not to be exceeded at any time
OSHA P0 / TWA	8-hour time weighted average
OSHA P0 / STEL	Short-term exposure limit
OSHA Z-1 / TWA	8-hour time weighted average
OSHA Z-1 / C	Ceiling
OSHA Z-3 / TWA	8-hour time weighted average

AICS - Australian Inventory of Chemical Substances; ASTM - American Society for the Testing of Materials; bw – Body weight; CERCLA - Comprehensive Environmental Response, Compensation and Liability Act; CMR - Carcinogen, Mutagen or Reproductive Toxicant; DIN - Standard of the German Institute for Standardization; DOT - Department of Transport; DSL - Domestic Substances List (Canada); ECx - Loading rate associated with x% response; EmS - Emergency Schedule; ENCS - Existing and New Chemical Substances (Japan); ErCx - Concentration associated with x% growth rate response; ERG - Emergency Response Guide; GHS - Globally Harmonized System; GLP - Good Laboratory Practice; HMIS - Hazardous Materials Identification System; IARC - International Agency for research on Cancer; IATA - International Air transport Association; IBC - International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk; IC50 – Half maximum inhibitory concentration; ICAO – International Aviation Organization; IECSC - Inventory of existing Chemical Substances in China; IMDG - International Maritime Dangerous Goods; IMO - International Maritime Organization; ISHL - Industrial and Safety Health Law (Japan); ISO - International Organization for Standardization; KECI - Korea Existing Chemicals Inventory; LC50 - Lethal concentration to 50% of test population (Median Lethal Dose); MARPOL - International Convention for the prevention of Pollution from Ships; MSHA - Mine Safety and Health Administration; n.o.s. - Not Otherwise Specified; NFPA - National Fire Protection Association; NO(A)EC - No Observable (Adverse) Effect Concentration; NO(A)EL - No Observable (Adverse) Effect Level; NOELR - No Observable Effect Loading Rate; NTP - National Toxicology Program; NZIoC - New Zealand Inventory of Chemicals; OECD - Organization for Economic Cooperation and Development; OPPTS - Office of the Chemical Safety and Pollution Prevention; PBT - Persistent Bio-Accumulative and Toxic substance; PICCS - Philippines Inventory of Chemicals and Chemical Substances; (Q)SAR - (Quantitative) Structure Activity Relationship; RCRA - Resources Conservation and Recovery Act; REACH - Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorization and Restriction of Chemicals; RQ - Reportable Quantity; SADT - Self- Accelerating Decomposition Temperature; SARA - Superfund Amendment and Reauthorization Act; SDS - Safety Data Sheet; TCSI - Taiwan Chemical Substance Inventory; TSCA - Toxic Substances Control Act (United States); UN - United nations; UNRTDG - United nations Recommendations on the transport of Dangerous Goods; vPvB – Very Persistent and Very Bio-Accumulative.

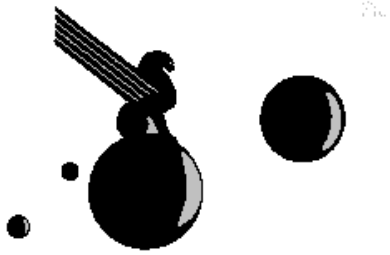
Revision date 06/06/2019

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

US
DrP

***Note**:*

The information in this Safety Data Sheet should be provided to all who use, handle, store, transport or are otherwise exposed to this product. CCC believes the information in this document to be reliable and up to date as of the publication, but makes no guarantee that it is.



Initial Preparation Date: ***3/30/09***
Last Revision Date: ***4/2/09***
Effective Date: ***12/11/09***

MATERIAL SAFETY DATA SHEET

PRODUCT IDENTITY: BlueDEF™ DIESEL EXHAUST FLUID

1. CHEMICAL PRODUCT & COMPANY INFORMATION

OLD WORLD INDUSTRIES, INC.
4065 COMMERCIAL AVENUE
NORTHBROOK, ILLINOIS 60062
PHONE: 847-559-2000
EMERGENCY PHONE: 1-800-424-9300 (CHEMTREC)

2. COMPOSITION / INFORMATION ON INGREDIENTS

No hazardous components identified per 29 CFR 1910.1200.

			TLV (ACGIH)	
Material	***CAS#***	***% by Wt.***	***STEL***	***TWA***
Urea	57-13-6	32 – 33	Not established	10 mg/m^3 (AIHA WEEL)

NOTE: State, local or other agencies or advisory groups may have established more stringent limits. Consult an industrial hygienist or similar professional, or your local agencies, for further information.

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

Avoid contact with eyes, skin and clothing. Wash thoroughly after handling.

Lowest Known LD50 (Oral): Not known

Lowest Known LD50 (Skin): Not known

Carcinogency: Not identified as a carcinogen

National Toxicology Program: Not identified as a carcinogen

International Agency for Research on Cancer: Not identified as a carcinogen

OSHA: Not identified as a carcinogen

HAZARD RATING SYSTEM

NPFA: HEALTH: 1 **FLAMMABILITY:** 0 **REACTIVITY:** 0
HMIS: HEALTH: 1 **FLAMMABILITY:** 0 **REACTIVITY:** 0 **PERSONAL PROTECTION:**

KEY: 0 - Minimal 1 - Slight 2 - Moderate 3 – Serious 4 - Severe

POTENTIAL HEALTH EFFECTS

Eye: Contact may cause mild eye irritation, including stinging, watering and redness.

Skin: Contact may cause mild skin irritation, including redness and burning. No harmful effects from skin absorption have been reported.

Inhalation (Breathing): No information available. Studies by other exposure routes suggest a low degree of toxicity by inhalation.

Ingestion (Swallowing): No harmful effects reported from ingestion.

Cancer: Inadequate evidence available to evaluate the cancer hazard of this material.

Target Organs: No data available.

Developmental: Inadequate evidence available for this material.

Pre-Existing Medical Conditions: None known.

4. FIRST AID MEASURES
Ensure physician has access to this MSDS.

Routes of Entry: Inhalation, Skin, Ingestion

Signs and Symptoms of Exposure: Effects of overexposure may include irritation of the nose, throat and digestive tract, headaches, coughing, nausea, vomiting and transient disorientation.

TREATMENT

Eyes: If irritation or redness develops, move victim away from exposure and into fresh air. Flush eyes with clean water. If symptoms persist, seek medical attention.

Skin: Remove contaminated shoes and clothing and cleanse affected area(s) thoroughly by washing with mild soap and water. If irritation or redness develops and persists, seek medical attention.

Inhalation: If respiratory difficulties develop, move victim away from source of exposure and into fresh air. If symptoms persist, seek medical attention. If victim is not breathing, clear airway and immediately begin artificial respiration. If breathing difficulties develop, oxygen should be administered by qualified personnel. Seek immediate medical attention.

Ingestion: Do NOT induce vomiting. First aid is not normally required; however, if swallowed and symptoms develop, seek medical attention.

Notes to Physician: None.

5. FIRE FIGHTING MEASURES

FIRE & EXPLOSION HAZARD DATA

Flammable Properties

Flash Point:	None to boiling
Method Used:	

Flammability Limits - % of vapor concentration at which product can ignite in presence of spark.

LEL:	No data
UEL:	No data

Hazardous Combustion Products: Closed containers exposed to extreme heat can rupture due to pressure building. Carbon oxides, nitrogen oxides, ammonia, biuret, cyanuric acid and other irritating fumes and smoke.

Extinguishing Media: Use extinguishing agent suitable for type of surrounding fire.

Fire Fighting Instructions: Isolate immediate hazard area and keep unauthorized personnel out. Stop spill / release if it can be done with minimal risk. Move undamaged containers from immediate hazard area if it can be done with minimal risk. Water spray may be useful in minimizing or dispersing vapors. Cool equipment exposed to fire with water, if it can be done with minimal risk.

Protective Equipment For Fire Fighters: For fires beyond the incipient stage, emergency responders in the immediate hazard area should wear bunker gear. When the potential chemical hazard is unknown, in enclosed or

confined spaces, or when explicitly required by DOT, a self-contained breathing apparatus should be worn. In addition, wear other appropriate protective equipment as conditions warrant. (See Section 8.)

6. ACCIDENTAL RELEASE MEASURES

Protect People: Wear appropriate protective equipment, including respiratory protection, as conditions warrant. (See Section 8.)

Protect the Environment: To prevent spilled material from entering sewers, storm drains or natural watercourses, contain material with a dike or with appropriate absorbent materials such as sand, clay, soil or commercially available absorbent. Place reclaimed liquid and absorbent into recovery or salvage drums for disposal. Refer to Section 13 for appropriate disposal.

Cleanup: Stop the source of the release if it can be done without risk. Immediately isolate the hazard area and restrict access to authorized personnel only.

7. HANDLING AND STORAGE

Handling: Do not enter confined spaces such as tanks or pits without following proper entry procedures such as ASTM D-4276 and 29CFR 1910.146. The use of appropriate respiratory protection is advised when concentrations exceed any established exposure limits. (See Sections 2 and 8.) Wash thoroughly after handling. Do not wear contaminated clothing or shoes. Use good personal hygiene practice.

Storage: Keep container(s) tightly closed. Do not heat or contact with strong oxidizers. Use and store this material in cool, dry, well-ventilated areas. Do not store at temperatures below 40º F. Store only in approved containers. Keep away from any incompatible material. (See Section 10.) Protect container(s) against physical damage.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Respiratory Protection: Respiratory protection is not usually required. If significant spray or mist occurs, wear a NIOSH approved or equivalent dust respirator.

Skin Protection: The use of gloves impermeable to the specific material handled is advised to prevent skin contact, possible irritation and absorption. (See glove manufacturer for information on permeability.)

Eye Protection: Approved eye protection to safeguard against potential eye contact, irritation or injury is recommended. Depending on conditions of use, a face shield may be necessary.

Engineering Controls: If current ventilation practices are not adequate to minimize exposure, additional ventilation or exhaust systems may be required.

Other Protective Equipment: A source of clean water should be available in the work area for flushing eyes and skin. Impervious clothing should be worn as needed.

9. PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point:	>212º F
Crystallization Point:	12º F
Pounds/Gallon:	9.09
Specific Gravity (Water =1):	1.09
Vapor Pressure (mm of Hg):	Not applicable
Vapor Density (Air=1):	0.6 H20, >1
Water Solubility:	100%
Appearance:	Colorless, clear liquid
Odor:	None to slight ammonia
Evaporation Rate:	<1

10. STABILITY & REACTIVITY DATA

Stability: Stable under normal conditions of storage and handling.

Conditions to Avoid: None known.

Incompatibility (Materials to Avoid): Avoid contact with strong oxidizing agents such as chlorine (bleach), peroxides, chromates, nitric acid, perchlorates, concentrated oxygen or permanganates. Contact can generate heat, fires, explosions and release toxic fumes.

Hazardous Decomposition Products: If involved in a fire, oxides of carbon and nitrogen may be generated; exposure to heat may generate ammonia fumes.

Hazardous Polymerization: Will not occur.

11. TOXICOLOGICAL INFORMATION

No definitive information available on carcinogenicity, mutagenicity, target organs or developmental toxicity.

Toxicological data: There is no available data for the product itself, only for the ingredients. See below for individual ingredient acute toxicity data.

Ingredients	LC_{50} (4 hr) Inh, rat	LD_{50}	
		Oral	Dermal
Urea	N/Av	8471 mg/kg (rat)	8200 mg/kg (rabbit)

12. ECOLOGICAL INFORMATION

No data available.

13. DISPOSAL CONSIDERATIONS

This material, if discarded as produced, is not a RCRA “listed” or “characteristic” hazardous waste. Use resulting in chemical or physical change or contamination may subject it to regulation as a hazardous waste. Along with properly characterizing all waste materials, consult state and local regulations regarding the proper disposal of this material.

If this product becomes a waste, it does not meet the criteria of a hazardous waste as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261, since it does not have the characteristics of Subpart C, nor is it listed under Subpart D. As a non-hazardous liquid waste, it should be solidified with stabilizing agents such as sand, fly ash, or clay absorbent, so that no free liquid remains before disposal to an industrial waste landfill.

RCRA # Not listed

14. TRANSPORT INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION (DOT): NOT CONTROLLED UNDER DOT.

Proper Shipping Name:	Labels Required:
Hazard Class:	Placard:
UN Identification:	Exemption:
Packing Group:	Reportable Quantity:

ICAO/IATA: NOT CONTROLLED UNDER ICAO/IATA.

Proper Shipping Name:	Labels Required:
Hazard Class:	Placard:
UN Identification:	Exemption:
Packing Group:	Reportable Quantity:

IMDG: NOT CONTROLLED UNER IMDG.

Proper Shipping Name:	Labels Required:
Hazard Class:	Placard:
UN Identification:	Exemption:
Packing Group:	Reportable Quantity:

15. REGULATORY INFORMATION

Sara Title III: This material contains the following chemicals subject to the reporting requirements of SARA 313 and 40 CFR 372: **None**

California Proposition 65: This material contains the following chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm, and are subject to the requirements of California Proposition 65 (CA Health & Safety Code Section 25249.5): **None known**

EPA (CERCLA) Reportable Quantity: **None**

Canadian Regulations:

WHMIS Information: This product is not a WHMIS controlled product in Canada. Refer elsewhere in the MSDS for specific warnings and safe handling information. Refer to the employer's workplace education program. All ingredients appear on the Domestic Substances List (DSL).

16. OTHER INFORMATION

Contact: Thomas Cholke **Phone**: (847) 559-2225

Old World Industries, Inc. makes no warranty, representation or guarantee as to the accuracy, sufficiency or completeness of the material set forth herein. It is the user's responsibility to determine the safety, toxicity and suitability of his own use, handling and disposal of this product. Since actual use by others is beyond our control, no warranty, expressed or implied, is made by Old World Industries, Inc. as to the effects of such use, the results to be obtained or the safety and toxicity of this product, nor does Old World Industries, Inc. assume liability arising out of the use by others of this product referred to herein. The data in this MSDS relates only to the specific material designated herein and does not relate to use in combination with any other material or in any process.

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Wiring Schematic

Holt Texas LTD.

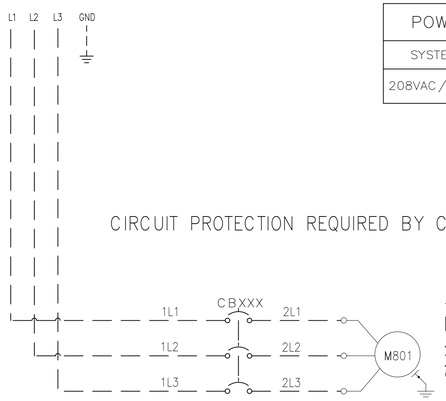
Holt CAT Dual Lance (C175) SCR Systems

VPN 1040249

Published December 2022

• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

POWER SOURCE: SUPPLIED FROM OTHERS		
SYSTEM VOLTS	FULL LOAD AMPS	SCCR
208VAC/3-PH/60HZ	9 AMPS FLA	5KA

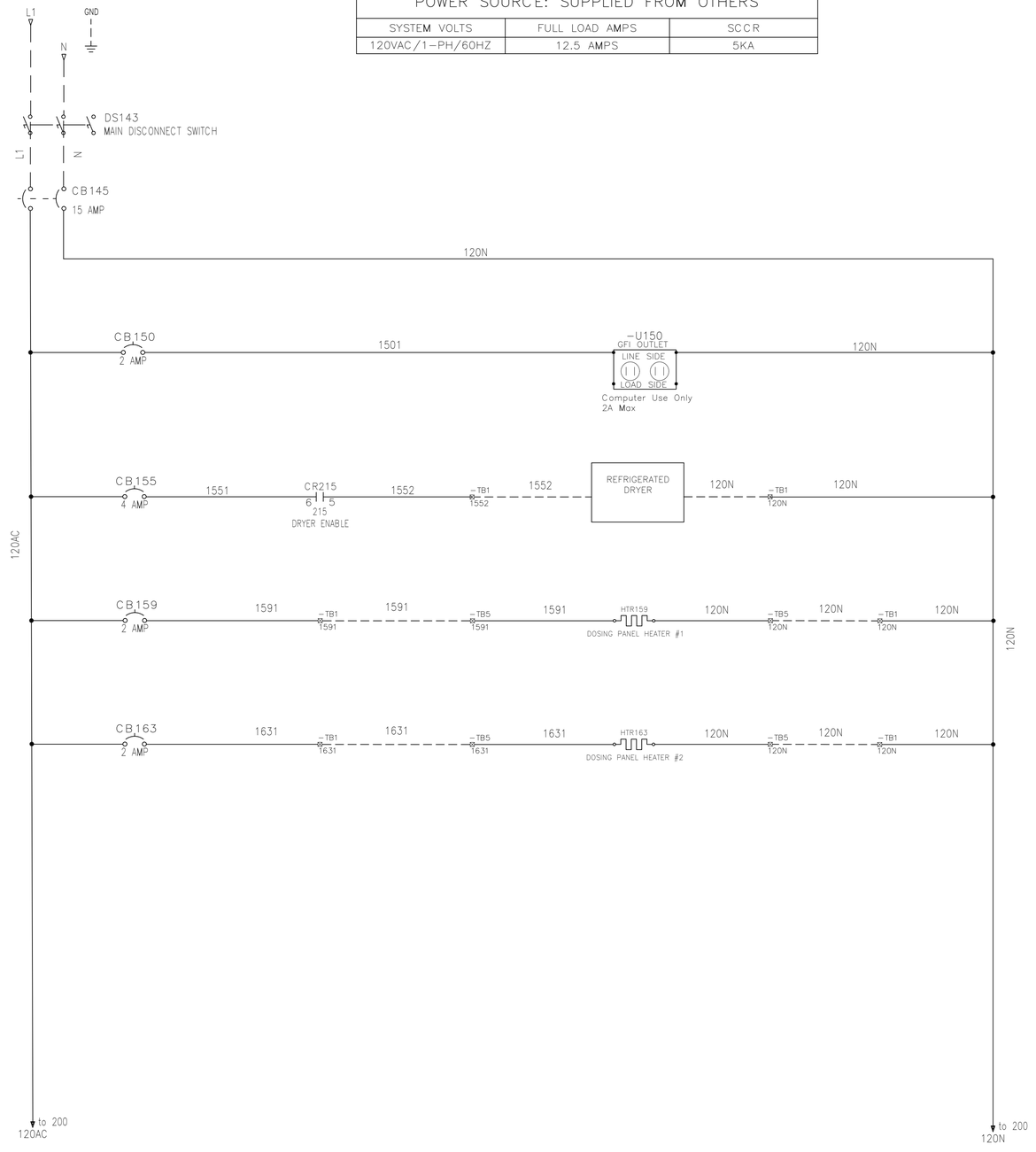


CIRCUIT PROTECTION REQUIRED BY CUSTOMER

-M801
POWEREX SES 0308 AIR COMPRESSOR
3 HP
208VAC/3PH/60HZ
9 AMPS FLA

————	DENOTES INTERNAL WIRING
— — — —	DENOTES FIELD WIRING

POWER SOURCE: SUPPLIED FROM OTHERS		
SYSTEM VOLTS	FULL LOAD AMPS	SCCR
120VAC/1-PH/60HZ	12.5 AMPS	5KA



REV	DESCRIPTION	DATE	BY
00	INITIAL DUAL LANCE CUSTOMER SUBMITTAL	5/17/2022	J.B-E
01	APPROVED FOR FAB	8/24/2022	CJY
A	AS BUILT	9/23/2022	CJY
.			
.			
.			
.			

DRAWING STATUS:		DATE:	BY:
	PRELIMINARY		
X	FOR APPROVAL	5/17/2022	J.B-E
X	APPROVED FOR FAB	8/24/2022	CJY
X	AS BUILT	9/23/2022	CJY
	AS FIELD MODIFIED		

MATERIAL: SEE BOM
WEIGHT: N/A
TOLERANCES: .X = 0.06, .XX = 0.03, .XXX = 0.015, ∠ = 0.5°
THIRD ANGLE PROJECTION
INCH [mm]

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Catalytic Combustion Corporation
311 Riggs Street
Bloomer, WI 54724
Telephone: 715-568-2882
Fax: 715-568-2884
www.catalyticcombustion.com

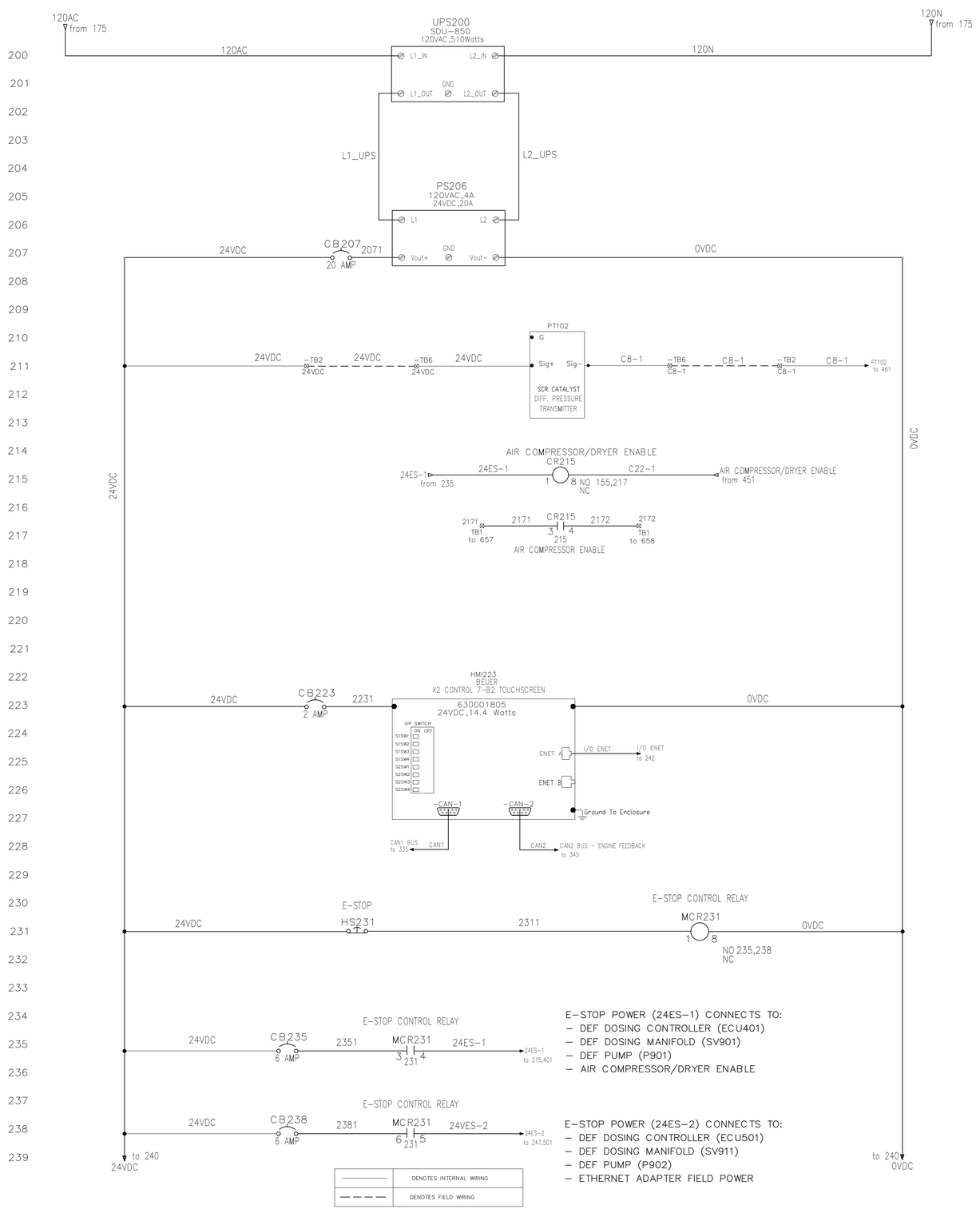
DO NOT SCALE THIS DRAWING

DATE: 08/24/2022
SCALE: NTS
DRAWN BY: CJY
CHECKED BY: BR

CUSTOMER: PN-1040158
CP-B7-238KG-3030-NA-NA-UZ-1

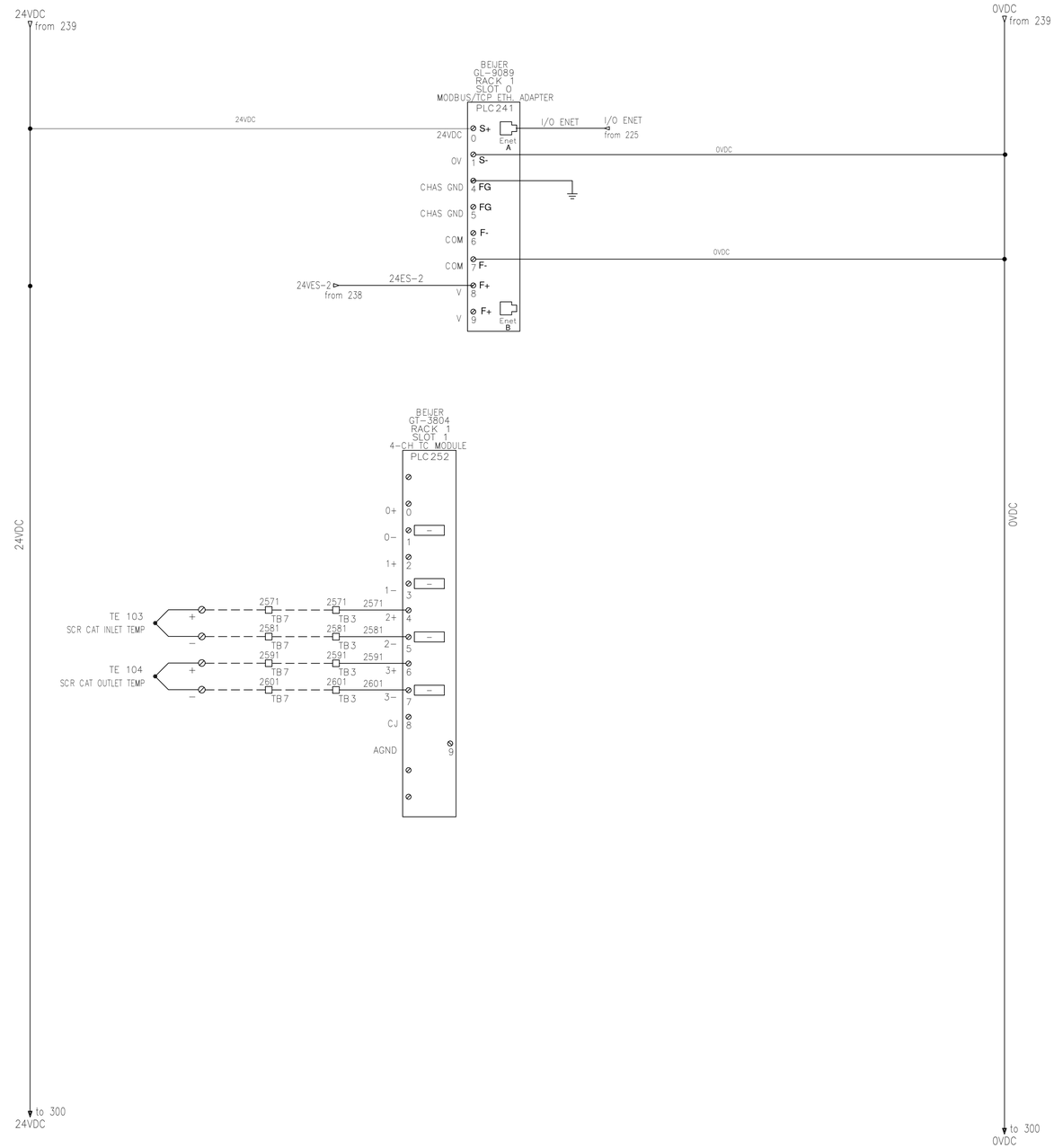
TITLE: SELECTIVE CATALYST REDUCTION SYSTEM
ELECTRICAL SCHEMATICS

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
SCR-DUAL	301	A	D



E-STOP POWER (24ES-1) CONNECTS TO:
- DEF DOSING CONTROLLER (ECU401)
- DEF DOSING MANIFOLD (SV901)
- DEF PUMP (P901)
- AIR COMPRESSOR/DRYER ENABLE

E-STOP POWER (24ES-2) CONNECTS TO:
- DEF DOSING CONTROLLER (ECU501)
- DEF DOSING MANIFOLD (SV911)
- DEF PUMP (P902)
- ETHERNET ADAPTER FIELD POWER



REV	DESCRIPTION	DATE	BY
00	INITIAL DUAL LANCE CUSTOMER SUBMITTAL	5/17/2022	J.B-E
01	APPROVED FOR FAB	8/24/2022	CJY
A	AS BUILT	9/23/2022	CJY
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	DRAWING STATUS:	DATE:	BY:
.	PRELIMINARY		
X	FOR APPROVAL	5/17/2022	J.B-E
X	APPROVED FOR FAB	8/24/2022	CJY
X	AS BUILT	9/23/2022	CJY
.	AS FIELD MODIFIED		

MATERIAL: SEE BOM
WEIGHT: N/A
TOLERANCES: .X = 0.06, .XX = 0.03, .XXX = 0.015, ∠ = 0.5°
THIRD ANGLE PROJECTION
INCH [mm]

CATALYTIC COMBUSTION EMISSION TECHNOLOGIES
Catalytic Combustion Corporation
311 Riggs Street
Bloomer, WI 54724
Telephone: 715-568-2882
Fax: 715-568-2884
www.catalyticcombustion.com

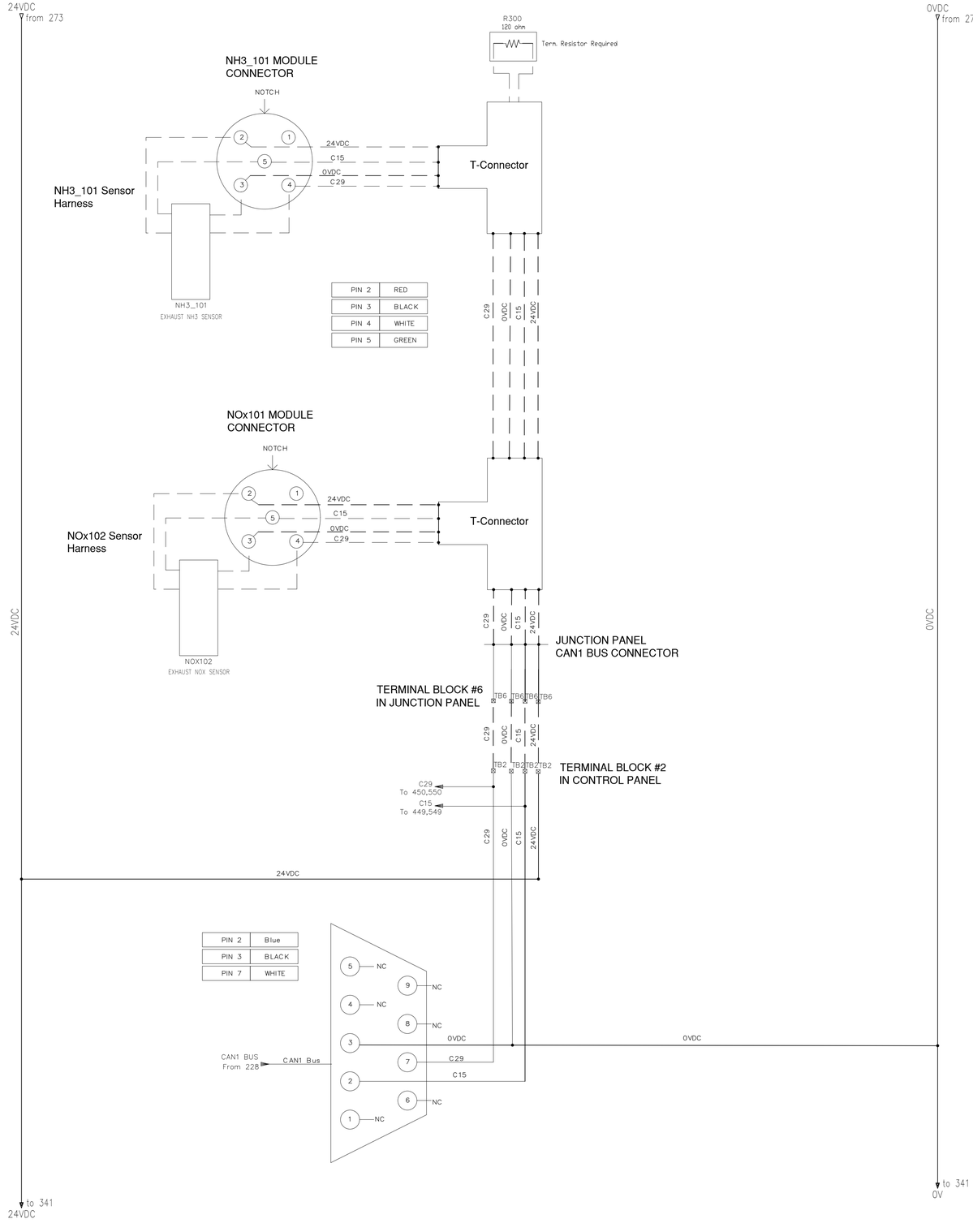
DO NOT SCALE THIS DRAWING

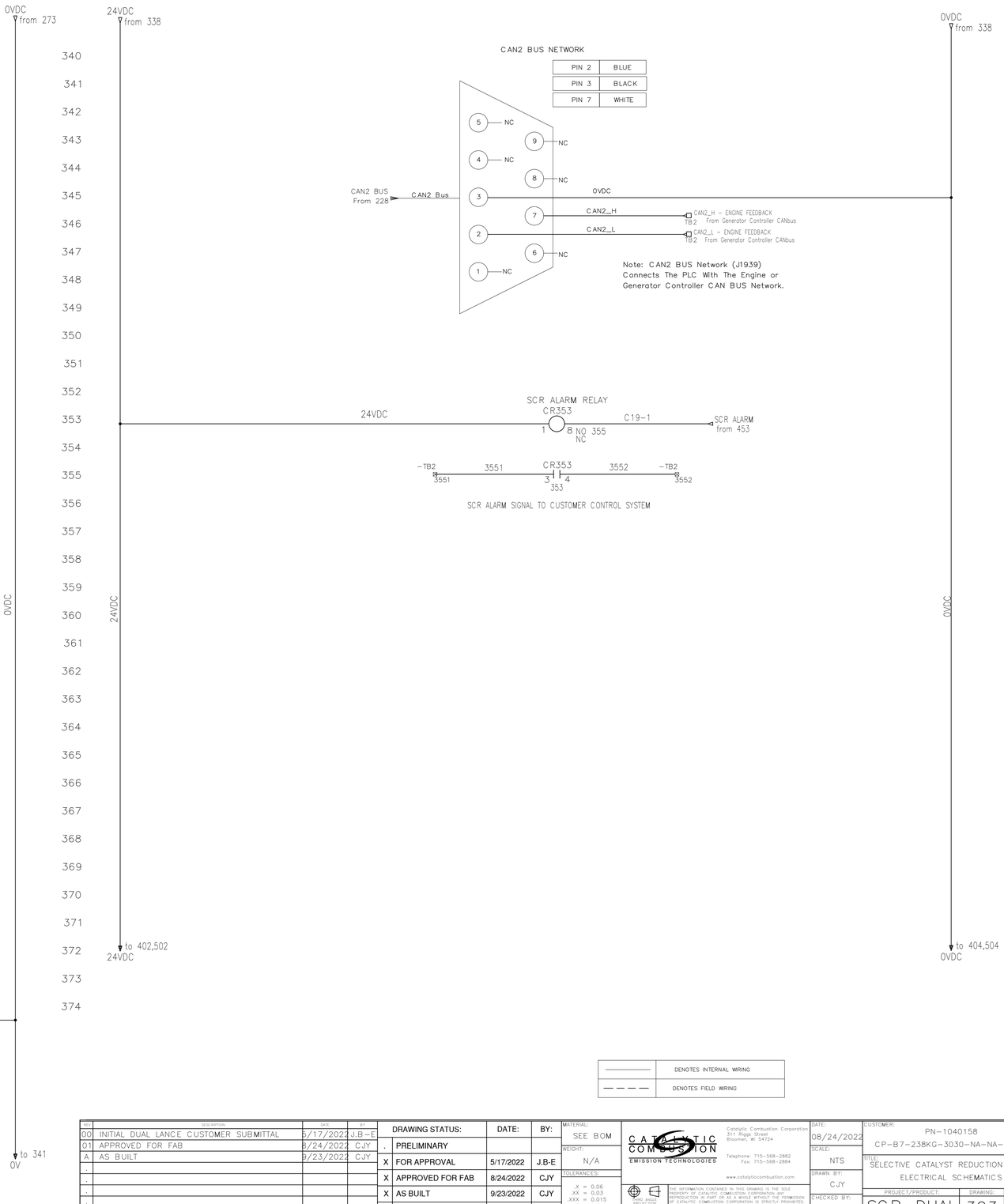
DATE: 08/24/2022
SCALE: NTS
DRAWN BY: CJY
CHECKED BY: BR

CUSTOMER: PN-1040158
CP-B7-238KG-3030-NA-NA-UZ-1

TITLE: SELECTIVE CATALYST REDUCTION SYSTEM ELECTRICAL SCHEMATICS

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
SCR-DUAL	302	A	D





———	DENOTES INTERNAL WIRING
— — —	DENOTES FIELD WIRING

REV	DESCRIPTION	DATE	BY
00	INITIAL DUAL LANCE CUSTOMER SUBMITTAL	5/17/2022	J.B-E
01	APPROVED FOR FAB	8/24/2022	CJY
A	AS BUILT	9/23/2022	CJY
.			
.			
.			
.			
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	DRAWING STATUS:	DATE:	BY:
.	PRELIMINARY		
X	FOR APPROVAL	5/17/2022	J.B-E
X	APPROVED FOR FAB	8/24/2022	CJY
X	AS BUILT	9/23/2022	CJY
.	AS FIELD MODIFIED		

MATERIAL: SEE BOM
WEIGHT: N/A
TOLERANCES: .X = 0.06, .XX = 0.03, .XXX = 0.015, ∠ = 0.5°

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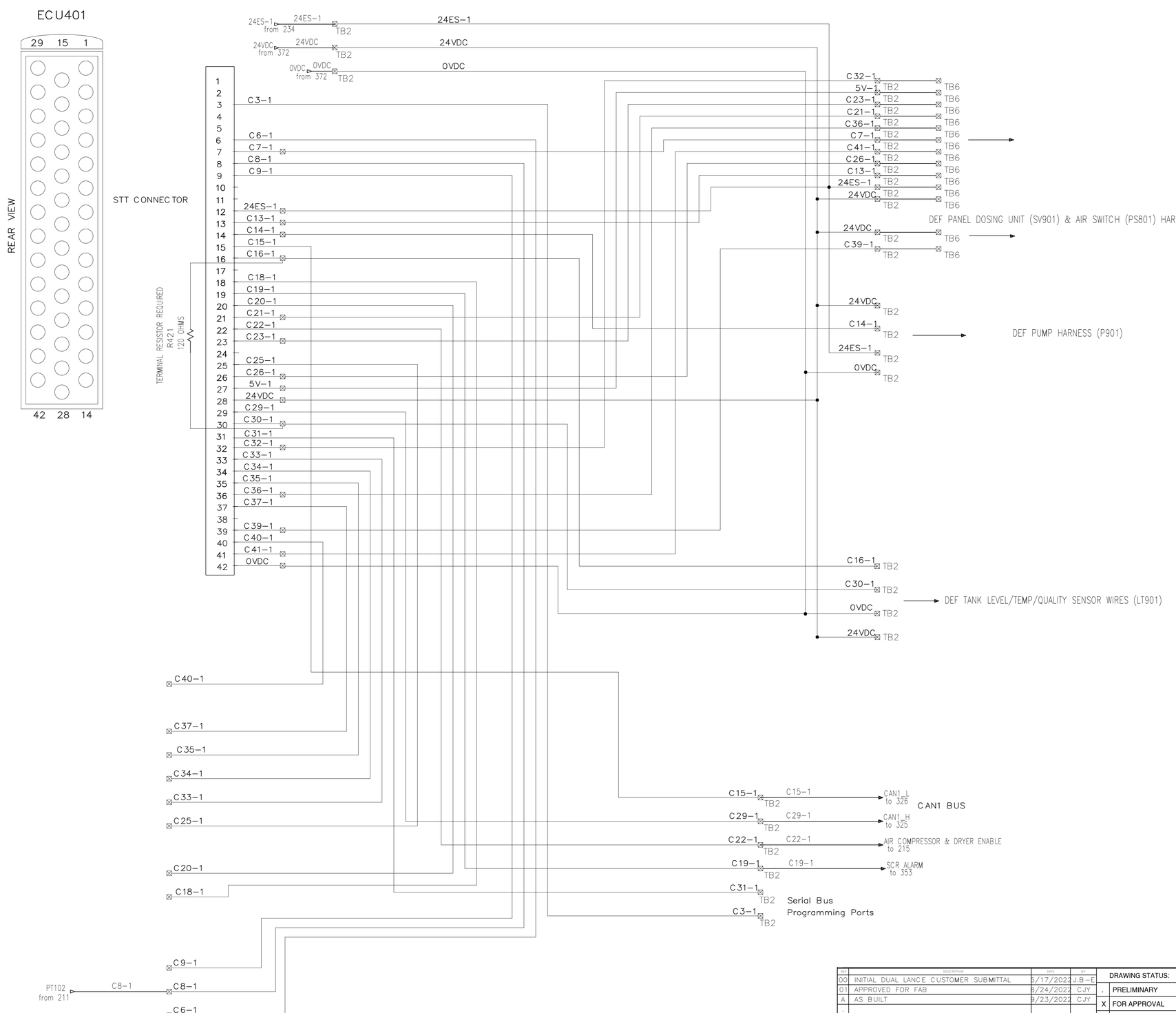
DATE:	08/24/2022
SCALE:	NTS
DRAWN BY:	CJY
CHECKED BY:	BR

CUSTOMER: PN-1040158
CP-B7-238KG-3030-NA-NA-UZ-1

TITLE: SELECTIVE CATALYST REDUCTION SYSTEM ELECTRICAL SCHEMATICS

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
SCR-DUAL	303	A	D



Wire #	Signal	Wire Color	Description
C3-1	TXD	BLUE	Prog. Port
C6-1	AIN1-	BLUE	SPARE
C7-1	PAIR	BLUE	PT901.3
C8-1	AIN5	BLUE	PT102
C9-1	AIN8	BLUE	SPARE
24ES-1	DIG2	BLUE	HS231 (E-Stop)
C13-1	AIR	BLUE	SV901.2
C14-1	PRPM	BLUE	P901
C15	CAN1_L	BLUE	CAN1_L
C16-1	CAN1.1_L	BLUE	CAN1.1_L
C18-1	AIN10	BLUE	SPARE
C19-1	ACT5	BLUE	SCR ALARM
C20-1	AIN2+	BLUE	SPARE
C21-1	PDEF1	BLUE	PT901.1
C22-1	ACT6	BLUE	M801
C23-1	TDEF1	BLUE	TE901.1
C25-1	DIG3	BLUE	SPARE
C26-1	FLUSH	BLUE	SV901.1
5V-1	5VDC	BLUE	5VDC
24VDC	VDDS	BLUE	24VDC
C29	CAN1_H	BLUE	CAN1_H
C30-1	CAN1.1_H	BLUE	CAN1.1_H
C31-1	RXD	BLUE	Prog. Port
C32-1	0VDC	BLUE	0VDC
C33-1	AIN11	BLUE	SPARE
C34-1	AIN1+	BLUE	SPARE
C35-1	AIN2-	BLUE	SPARE
C36-1	PDEF2	BLUE	PT901.2
C37-1	AIN6	BLUE	SPARE
C39-1	DIG1	BLUE	PS801
C40-1	DIG4	BLUE	SPARE
C41-1	INJ	BLUE	SV901.3
0VDC	VSS	WHT/BLU	0VDC

———	DENOTES INTERNAL WIRING
— — — —	DENOTES FIELD WIRING

REV	DESCRIPTION	DATE	BY
00	INITIAL DUAL LANCE CUSTOMER SUBMITTAL	5/17/2022	J.B-E
01	APPROVED FOR FAB	8/24/2022	CJY
A	AS BUILT	9/23/2022	CJY

	DRAWING STATUS:	DATE:	BY:
.	PRELIMINARY		
X	FOR APPROVAL	5/17/2022	J.B-E
X	APPROVED FOR FAB	8/24/2022	CJY
X	AS BUILT	9/23/2022	CJY
.	AS FIELD MODIFIED		

MATERIAL: SEE BOM
WEIGHT: N/A
TOLERANCES: .X = 0.06, .XX = 0.03, .XXX = 0.015, ∠ = 0.5°
THIRD ANGLE PROJECTION
INCH [mm]

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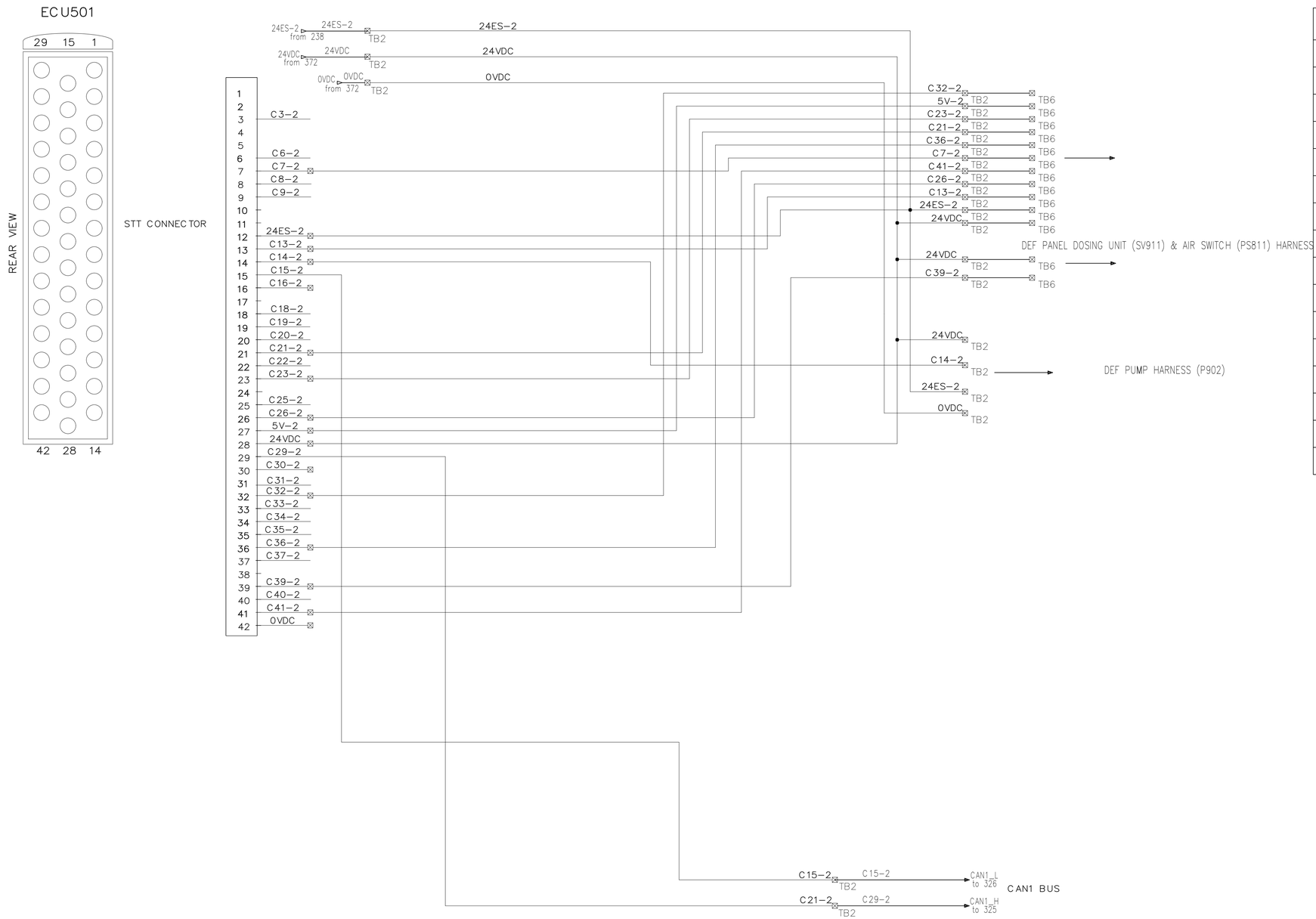
DATE: 08/24/2022
SCALE: NTS
DRAWN BY: CJY
CHECKED BY: BR

CUSTOMER: PN-1040158
CP-B7-238KG-3030-NA-NA-UZ-1
TITLE: SELECTIVE CATALYST REDUCTION SYSTEM ELECTRICAL SCHEMATICS

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
SCR-DUAL	304	A	D



Wire #	Signal	Wire Color	Description
C7-2	PAIR	BLUE	PT911.3
24ES-2	DIG2	BLUE	HS231 (E-Stop)
C13-2	AIR	BLUE	SV911.2
C14-2	PRPM	BLUE	P911
C15	CAN1_L	BLUE	CAN1_L
C21-2	PDEF1	BLUE	PT911.1
C23-2	TDEF1	BLUE	TE911.1
C26-2	FLUSH	BLUE	SV911.1
5V-2	5VDC	BLUE	5VDC
24VDC	VDDS	BLUE	24VDC
C29	CAN1_H	BLUE	CAN1_H
C32-2	0VDC	BLUE	0VDC
C36-2	PDEF2	BLUE	PT911.2
C39-2	DIG1	BLUE	PS811
C41-2	INJ	BLUE	SV911.3
0VDC	VSS	WHT/BLU	0VDC

———	DENOTES INTERNAL WIRING
— — — —	DENOTES FIELD WIRING

REV	DESCRIPTION	DATE	BY
00	INITIAL DUAL LANCE CUSTOMER SUBMITTAL	5/17/2022	J.B-E
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A	AS BUILT	9/23/2022	CJY

	DRAWING STATUS:	DATE:	BY:
.	PRELIMINARY		
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X	AS BUILT	9/23/2022	CJY
.	AS FIELD MODIFIED		

MATERIAL: SEE BOM
WEIGHT: N/A
TOLERANCES: .X = 0.06, .XX = 0.03, .XXX = 0.015, ∠ = 0.5°
THIRD ANGLE PROJECTION
INCH [mm]

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DATE: 08/24/2022
SCALE: NTS
DRAWN BY: CJY
CHECKED BY: BR

CUSTOMER: PN-1040158
CP-B7-238KG-3030-NA-NA-UZ-1
TITLE: SELECTIVE CATALYST REDUCTION SYSTEM
ELECTRICAL SCHEMATICS

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
SCR-DUAL	305	A	D

————	DENOTES CCC RESPONSIBLE WIRING
- - - - - - - -	DENOTES WIRING RESPONSIBLE BY OTHERS

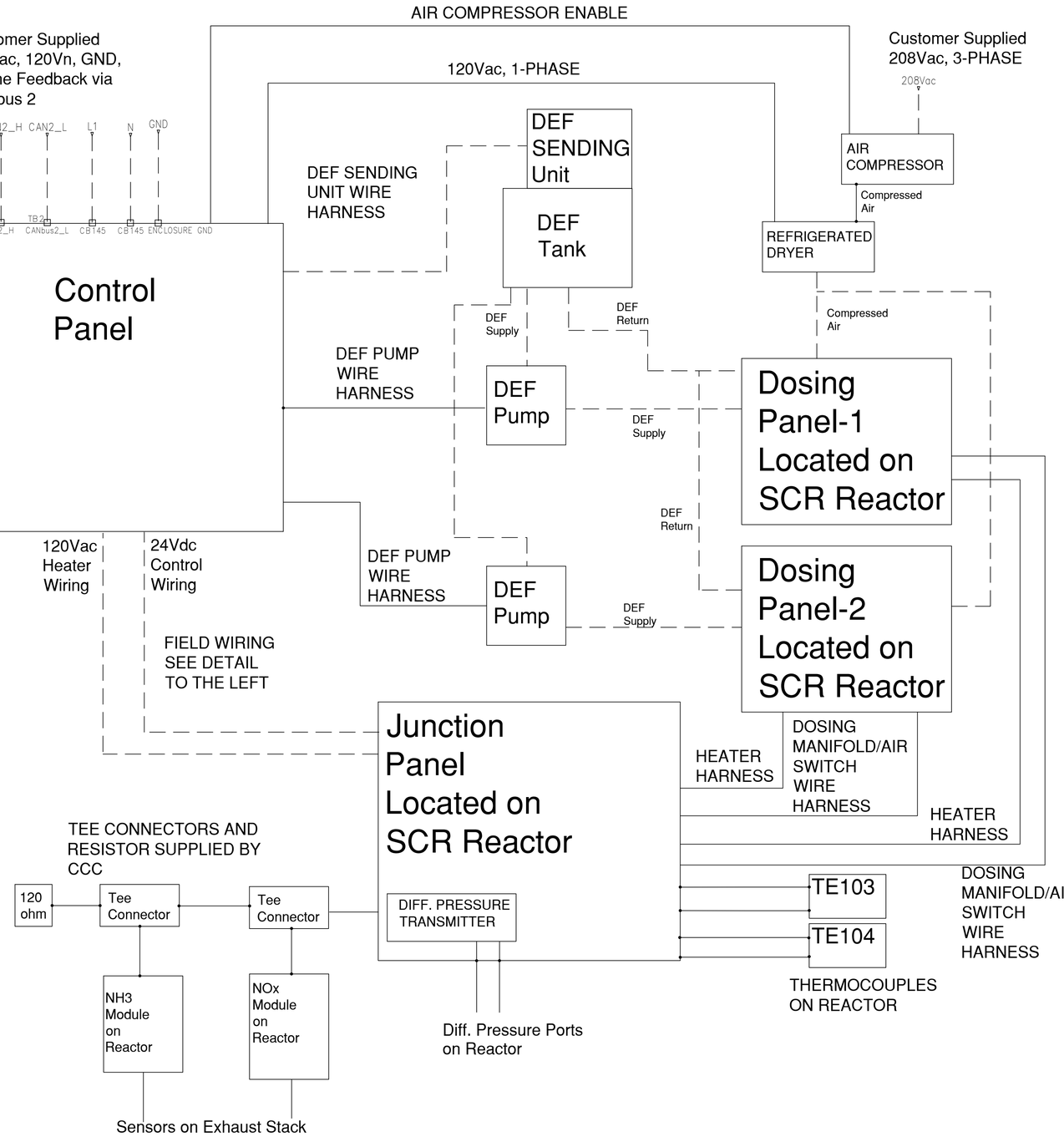
Interconnect Wiring

CONTROL PANEL — JUNCTION PANEL

TB3	2571	TYPE-K EXTENSION WIRE, 20AWG	TB7
TB3	2581		TB7
TB3	2591	TYPE-K EXTENSION WIRE, 20AWG	TB7
TB3	2601		TB7
TB2	C29	CANbus1, TWISTED PAIR, 20AWG	TB6
TB2	C15		TB6
TB2	24VDC	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	24VES-1	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	5V-1	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	0V	WHITE w/ BLUE STRIPE, 18 AWG, THHN, STRANDED	TB6
TB2	C7-1	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C13-1	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C21-1	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C23-1	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C26-1	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C32-1	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C36-1	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C8-1	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C39-1	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C41-1	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	5V-2	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	24VES-2	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C7-2	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C13-2	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C21-2	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C23-2	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C26-2	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C32-2	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C36-2	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C39-2	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C41-2	BLUE, 18 AWG, THHN, STRANDED	TB6

120VAC Wiring

TB1	1631	RED, 18 AWG, THHN, STRANDED	TB5
TB1	1591	RED, 18 AWG, THHN, STRANDED	TB5
TB1	120N	WHITE, 18 AWG, THHN, STRANDED	TB5



REV	DESCRIPTION	DATE	BY
00	INITIAL DUAL LANCE CUSTOMER SUBMITTAL	5/17/2022	J.B-E
01	APPROVED FOR FAB	8/24/2022	CJY
A	AS BUILT	9/23/2022	CJY

	DRAWING STATUS:	DATE:	BY:
.	PRELIMINARY		
X	FOR APPROVAL	5/17/2022	J.B-E
X	APPROVED FOR FAB	8/24/2022	CJY
X	AS BUILT	9/23/2022	CJY
.	AS FIELD MODIFIED		

MATERIAL: SEE BOM
WEIGHT: N/A
TOLERANCES: .X = 0.06, .XX = 0.03, .XXX = 0.015, ∠ = 0.5°

CATALYTIC COMBUSTION EMISSION TECHNOLOGIES
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www.catalyticcombustion.com

THIRD ANGLE PROJECTION
INCH [mm]
DO NOT SCALE THIS DRAWING

DATE: 08/24/2022
SCALE: NTS
DRAWN BY: CJY
CHECKED BY: BR

CUSTOMER: PN-1040158
CP-B7-238KG-3030-NA-NA-UZ-1

TITLE: SELECTIVE CATALYST REDUCTION SYSTEM
ELECTRICAL SCHEMATICS

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
SCR-DUAL	306	A	D

Junction Panel

Control Panel

Dosing Panel #1

C32–1
5V–1
C23–1
C21–1
C36–1
C7–1
C41–1
C26–1
C13–1
24ES–1
24VDC

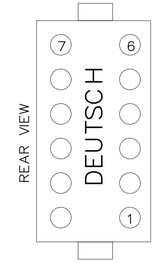
DOSING MANIFOLD AND AIR PRESSURE SWITCH WIRES

C32–1	1
5V–1	2
C23–1	3
C21–1	4
C36–1	5
C7–1	6
C41–1	7
C26–1	8
C13–1	9
24ES–1	10
24VDC	11
	12

SV901
DEF DOSING UNIT

DEUTSCH CONNECTOR			
PAIR 1	B	PIN 1	C32–1
	W	PIN 2	5V–1
PAIR 2	B	PIN 3	C23–1
	W	PIN 4	C21–1
PAIR 3	B	PIN 5	C36–1
	W	PIN 6	C7–1
PAIR 4	B	PIN 7	C41–1
	W	PIN 8	C26–1
PAIR 5	B	PIN 9	C13–1
	W	PIN 10	24ES–1
PAIR 6	B	PIN 11	24VDC
	W	PIN 12	NA

–PLUG 1



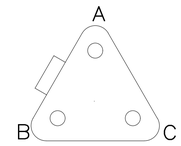
24VDC
C39–1

24VDC	A
C39–1	B
	C

PS801
AIR PRESSURE SWITCH

DEUTSCH CONNECTOR			
PAIR 7	B	PIN B	24VDC
	W	PIN C	C39–1

–PLUG 2



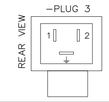
DOSING PANEL HEATER HARNESS

1591
120N

1591	1
120N	2

SQR. DIN CONNECTOR			
	R	PIN 1	1591
	W	PIN 2	120N

–PLUG 3



0V
24VDC
C14–1
24ES–1

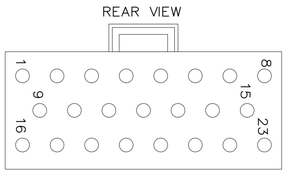
UREA PUMP WIRES

0V	1
24VDC	2
C14–1	3
24ES–1	4
	5
	6..
	..23

M901
P901
DEF. PUMP

AMP CONNECTOR			
PAIR 1	B	PIN 1	0V
	W	PIN 2	24VDC
		PIN 3	NA
PAIR 2	B	PIN 4	C14–1
	W	PIN 5	24ES–1
		PIN 6–23	NA

REAR VIEW



–PLUG 4

0V
24VDC
C14–2
24ES–2

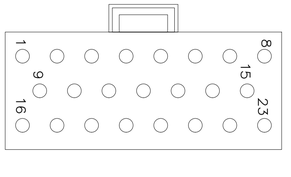
UREA PUMP WIRES

0V	1
24VDC	2
C14–2	3
24ES–2	4
	5
	6..
	..23

M902
P902
DEF. PUMP

AMP CONNECTOR			
PAIR 1	B	PIN 1	0V
	W	PIN 2	24VDC
		PIN 3	NA
PAIR 2	B	PIN 4	C14–2
	W	PIN 5	24ES–2
		PIN 6–23	NA

REAR VIEW



–PLUG 5

C16–1
C30–1
0V
24VDC

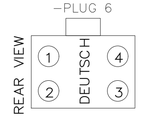
UREA TANK SENSOR WIRES

C16–1	1
C30–1	2
0V	3
24VDC	4

LT901
DEF LEVEL SENSOR

DEUTSCH CONNECTOR			
PAIR 1	B	PIN 1	C16–1
	W	PIN 2	C30–1
PAIR 2	B	PIN 3	0V
	W	PIN 4	24VDC

–PLUG 6



2171 — Wire 101
2172 — Wire 001

M801
Air Compressor Enable

Remove Start/Stop Switch and wire nut wires 2171 and 2172 to wires 101 & 001

1552 — Brown
120N — White

Refrigerated Dryer

Remove green power switch and wire nut brown & white wire together.Wire nut black wire by itself.

REV	DESCRIPTION	DATE	BY
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01	APPROVED FOR FAB	8/24/2022	CJY
A	AS BUILT	9/23/2022	CJY

	DRAWING STATUS:	DATE:	BY:
.	PRELIMINARY		
X	FOR APPROVAL	5/17/2022	J.B-E
X	APPROVED FOR FAB	8/24/2022	CJY
X	AS BUILT	9/23/2022	CJY
.	AS FIELD MODIFIED		

MATERIAL: SEE BOM
WEIGHT: N/A
TOLERANCES: .X = 0.06, .XX = 0.03, .XXX = 0.015, ∠ = 0.5°

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INCH [mm]
DO NOT SCALE THIS DRAWING

DATE: 08/24/2022
SCALE: NTS
DRAWN BY: CJY
CHECKED BY: BR

CUSTOMER: PN–1040158
CP–B7–238KG–3030–NA–NA–UZ–1

TITLE: SELECTIVE CATALYST REDUCTION SYSTEM ELECTRICAL SCHEMATICS

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
SCR–DUAL	307	A	D

Junction Panel

C32–2
5V–2
C23–2
C21–2
C36–2
C7–2
C41–2
C26–2
C13–2
24ES–2
24VDC

DOSING MANIFOLD AND AIR PRESSURE SWITCH WIRES

24VDC
C39–2

DOSING PANEL HEATER HARNESS
1631
120N

Dosing Panel #2

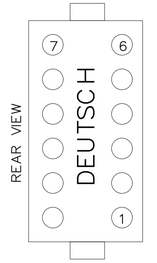
C32–2
5V–2
C23–2
C21–2
C36–2
C7–2
C41–2
C26–2
C13–2
24ES–2
24VDC

1 2 3 4 5 6 7 8 9 10 11 12

SV911
DEF DOSING UNIT

DEUTSCH CONNECTOR			
PAIR 1	B	PIN 1	C32–2
	W	PIN 2	5V–2
PAIR 2	B	PIN 3	C23–2
	W	PIN 4	C21–2
PAIR 3	B	PIN 5	C36–2
	W	PIN 6	C7–2
PAIR 4	B	PIN 7	C41–2
	W	PIN 8	C26–2
PAIR 5	B	PIN 9	C13–2
	W	PIN 10	24ES–2
PAIR 6	B	PIN 11	24VDC
	W	PIN 12	NA

–PLUG 7



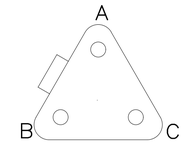
24VDC
C39–2

A B C

PS811
AIR PRESSURE SWITCH

DEUTSCH CONNECTOR			
PAIR 7	B	PIN B	24VDC
	W	PIN C	C39–2

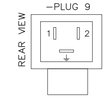
–PLUG 8



1 2

SQR. DIN CONNECTOR			
	R	PIN 1	1631
	W	PIN 2	120N

–PLUG 9



REV	DESCRIPTION	DATE	BY
00	INITIAL DUAL LANCE CUSTOMER SUBMITTAL	5/17/2022	J.B–E
01	APPROVED FOR FAB	8/24/2022	CJY
A	AS BUILT	9/23/2022	CJY
.			
.			
.			
.			
.			

	DRAWING STATUS:	DATE:	BY:
.	PRELIMINARY		
X	FOR APPROVAL	5/17/2022	J.B-E
X	APPROVED FOR FAB	8/24/2022	CJY
X	AS BUILT	9/23/2022	CJY
.	AS FIELD MODIFIED		

MATERIAL: SEE BOM
WEIGHT: N/A
TOLERANCES: .X = 0.06, .XX = 0.03, .XXX = 0.015, ∠ = 0.5°

THIRD ANGLE PROJECTION
INCH [mm]

CATALYTIC COMBUSTION EMISSION TECHNOLOGIES
Catalytic Combustion Corporation
511 Ridge Street
Bloomer, WI 54724
Telephone: 715–568–2882
Fax: 715–568–2884
www.catalyticcombustion.com

DO NOT SCALE THIS DRAWING

DATE: 08/24/2022
SCALE: NTS
DRAWN BY: CJY
CHECKED BY: BR

CUSTOMER: PN–1040158
CP–B7–238KG–3030–NA–NA–UZ–1

TITLE: SELECTIVE CATALYST REDUCTION SYSTEM ELECTRICAL SCHEMATICS

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
SCR–DUAL	308	A	D

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

General Arrangement Drawings

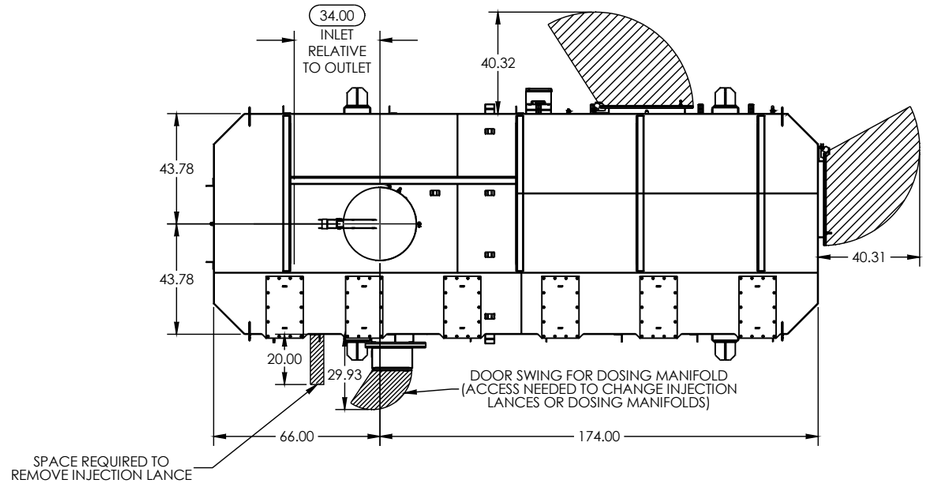
Holt Texas LTD.

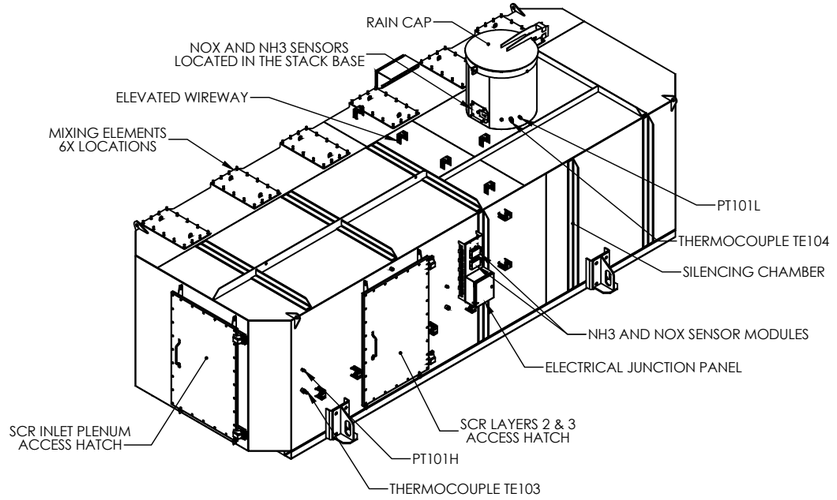
Holt CAT Dual Lance (C175) SCR Systems

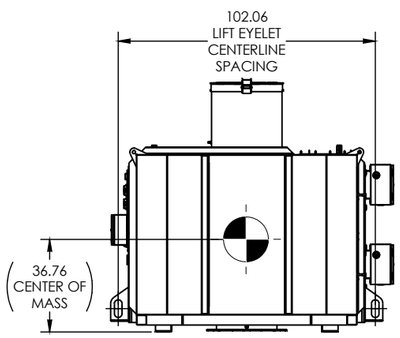
VPN 1040249

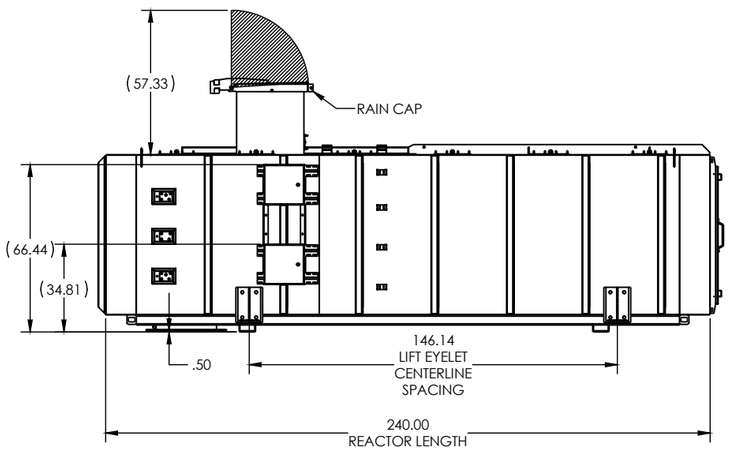
Published December 2022

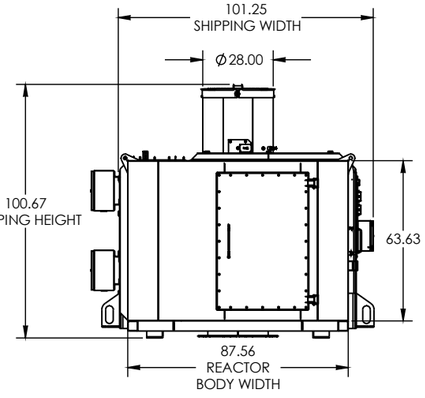
• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

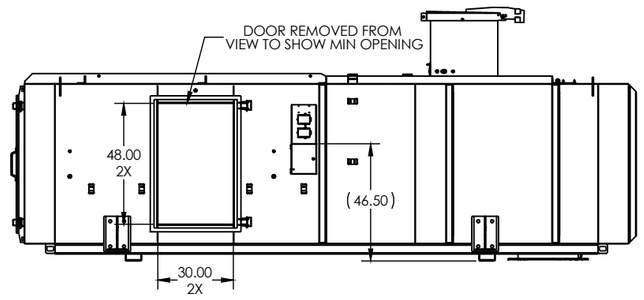


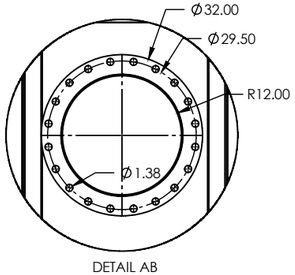




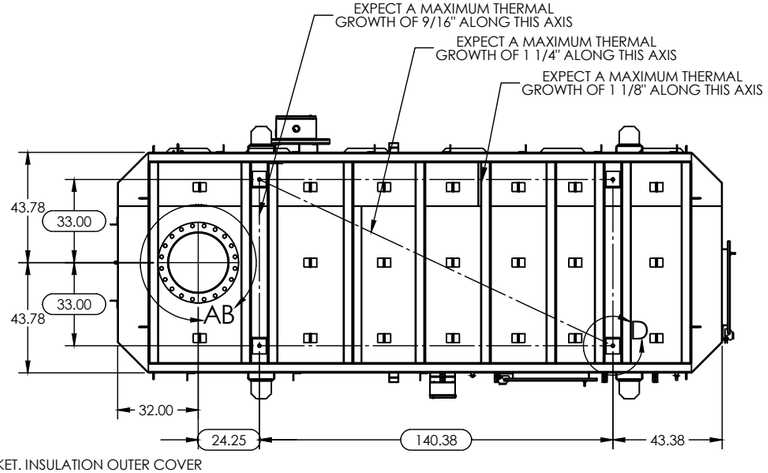


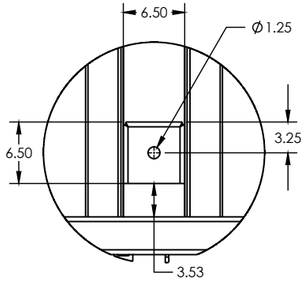




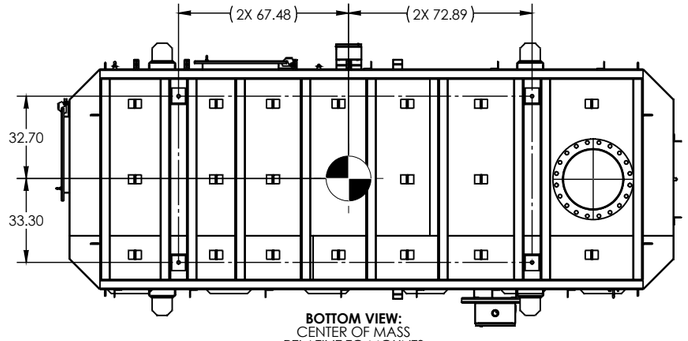


DETAIL AB
SCALE 1 : 15
INLET DETAIL





DETAIL D
SCALE 1 : 8
4X PLACES



BOTTOM VIEW:
CENTER OF MASS
RELATIVE TO MOUNTS

NOTES:

1) APPROXIMATE WEIGHT: 13,800 LBS

2) EXTERIOR WILL BE COVERED WITH FABRIC INSULATION BLANKET. INSULATION OUTER COVER WILL BE GRAY WITH SS FASTENERS.

3) SCR BODY CONSTRUCTION IS 3/16" 304 SS PANELS.

4) ALLOW 5" FROM THE OUTSIDE FACES TO CLOSEST OBSTRUCTION.

REV.	ECN	TIER	DESCRIPTION	DATE	APPROVED BY
01				07/20/2022	jbartlett
A	N/A	2	RELEASED TO PRODUCTION	07/20/2022	blewan
B					

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGULAR: FABRICATED ±1.0°
MACHINED ±0.5°
ONE PLACE DECIMAL ±0.1
TWO PLACE DECIMAL ±0.06
THREE PLACE DECIMAL ±0.030
DUAL DIMENSIONS IN. (MM)
REMOVE ALL BURRS AND
BREAK SHARP EDGES

	NAME	DATE
DRAWN:	jbartlett	07/12/2022
MATERIAL:		

THIRD ANGLE PROJECTION

DO NOT SCALE DRAWING

CATALYTIC COMBUSTION
311 RIGGS ST.
RICHMOND, WI 54724
TEL: 715-568-3882
FAX: 715-568-3884

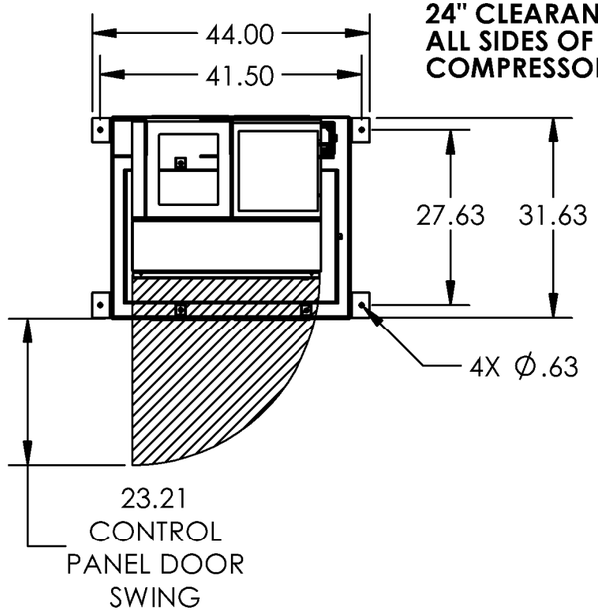
DESCRIPTION:
SCR-S-TIER IV-S24S28-3R3C3L-SCR+SIL-HOLT 3.1 MW-02

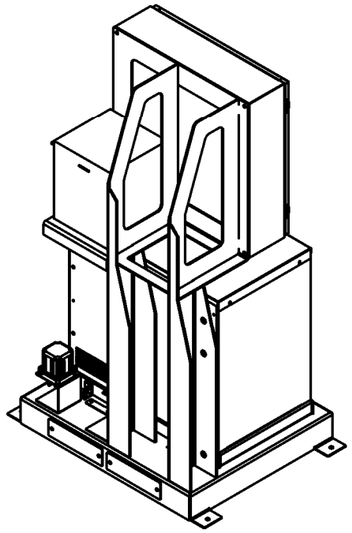
VISUAL PART NO. 1040200

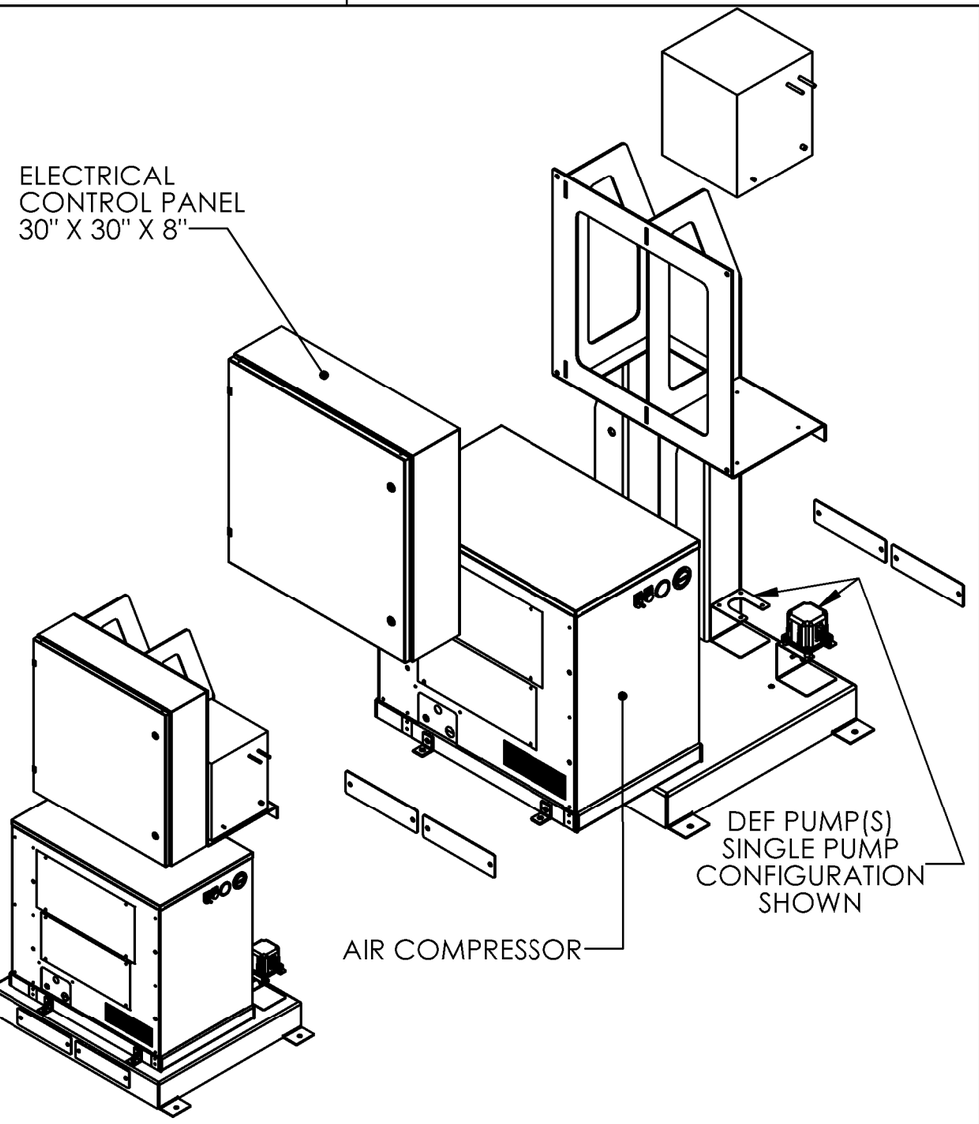
SIZE D | DRAWING NO. 706026 | REV B

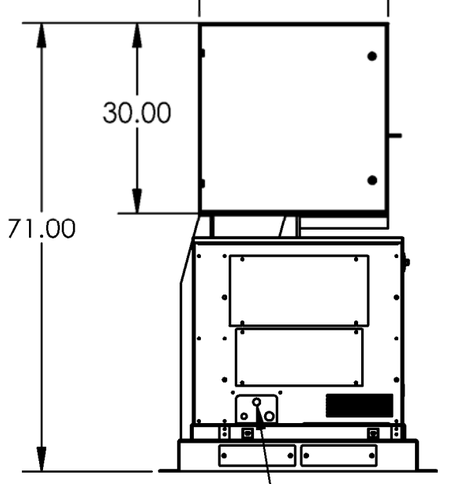
SCALE: 1:30 WT: | SHEET 1 OF 7

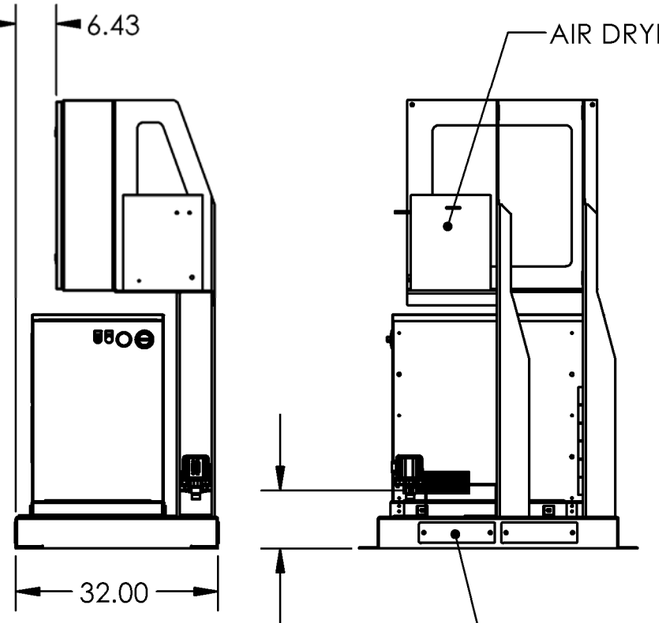
NOTE:
24" CLEARANCE REQUIRED ON ALL SIDES OF SKID FOR COMPRESSOR MAINTENANCE.











DEF PUMP LIMITATIONS:
-MOUNTING: MAX 1.0M ABOVE TOP OF DEF TANK
-MAX 2.0M SUCTION LINE LENGTH FROM DEF TANK TO PUMP
-MAX 10.0M PRESSURE LINE LENGTH VERTICAL OR HORIZONTAL BETWEEN PUMP AND DOSING MANIFOLD

REV.	ECN	TIER	DESCRIPTION	DATE	APPROVED BY
A	N/A	2	RELEASED TO PRODUCTION	02/02/2022	lszura
B	N/A	3	4X MOUNT HOLES UPDATED FOR 3/8" HARDWARE	06/02/2022	blewan
C	N/A	3	ADDED CONFIGURATION FOR DUAL PUMPS	07/07/2022	lszura

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGULAR: FABRICATED ±1.0°
MACHINED ±0.5°
ONE PLACE DECIMAL ±0.1
TWO PLACE DECIMAL ±0.06
THREE PLACE DECIMAL ±0.030
DUAL DIMENSIONS IN. {MM}

REMOVE ALL BURRS AND BREAK SHARP EDGES

	NAME	DATE
DRAWN	cccintern	01/07/2022

MATERIAL:

THIRD ANGLE PROJECTION

VISUAL PART NO.
SEE TABLE

DO NOT SCALE DRAWING

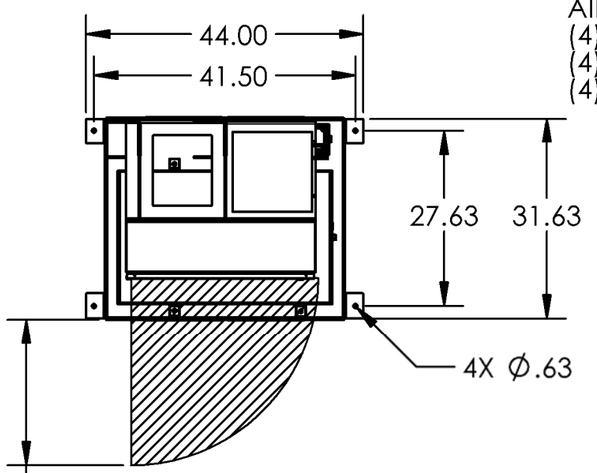
CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES
311 RIGGS ST.
BLOOMER, WI 54724
TEL. 715-568-2882
FAX 715-568-2884

DESCRIPTION:
Aux Skid Assy - 30x30 Controls - Compressor - Single or Dual Pumps - Type 01

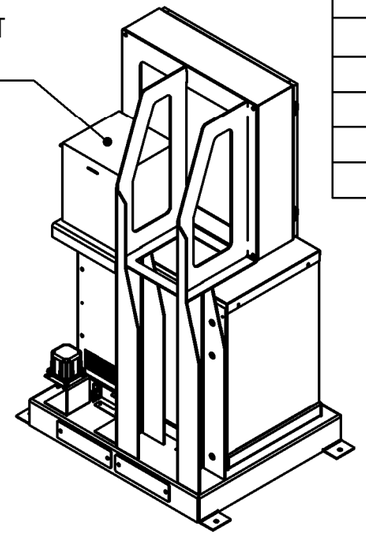
SIZE	DRAWING NO.	REV
B	701455	C

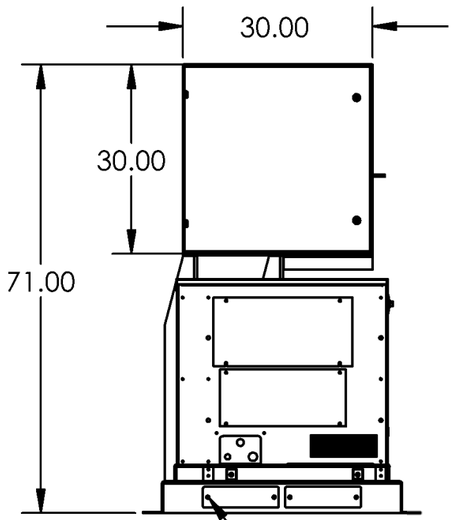
SCALE: 1:24 WT: SHEET 1 OF 2

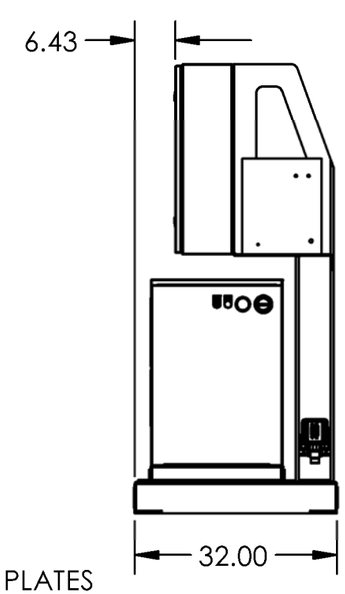
ITEM NO.	DRAWING NUMBER	REVISION	CONFIGURATION	VISUAL P/N	DESCRIPTION	MATERIAL	WEIGHT	QTY.
1	701457	D	Default	N/A	COMPRESSOR SKID FRAME WELDMENT		286.72	1
2	586623	D	Outboard Anchor Pads Shown	SEE TABLE	AIR COMPRESSOR POWEREX SES 0308		17.616	1
3	588338	D	Default	(SEE TABLE)	Deltech Air Cooler/Dryer (HG10/HG15)		86.052	1
4	608690	B	Default	1033211	SAGINAW ENCLOSURE - 30X30X8 SCE-30EL3008LP		13.154	1
5	593488	B	Default	1036890	SKID COVER PLATE 3.25" X 12.0" - BOLT-ON	ASTM A36 Steel	1.471	4
6	571926	B	Default	SEE TABLE	DEF PUMP ASSY - STT EMTEC			1

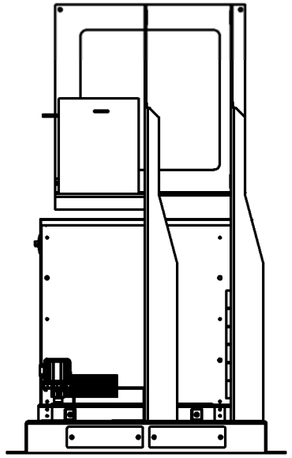


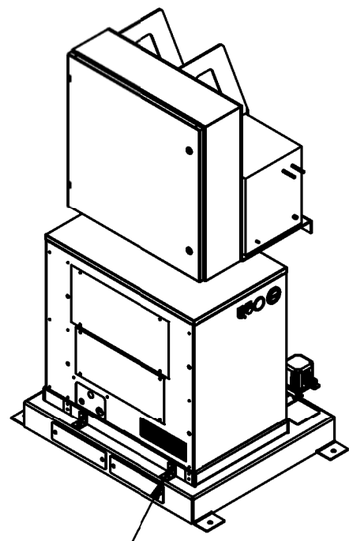
AIR DRYER MOUNTING
(4) 1/4-20 x 1" ZINC HEX BOLT
(4) 1/4" ZINC FLAT WASHER
(4) 1/4" ZINC LOCK WASHER

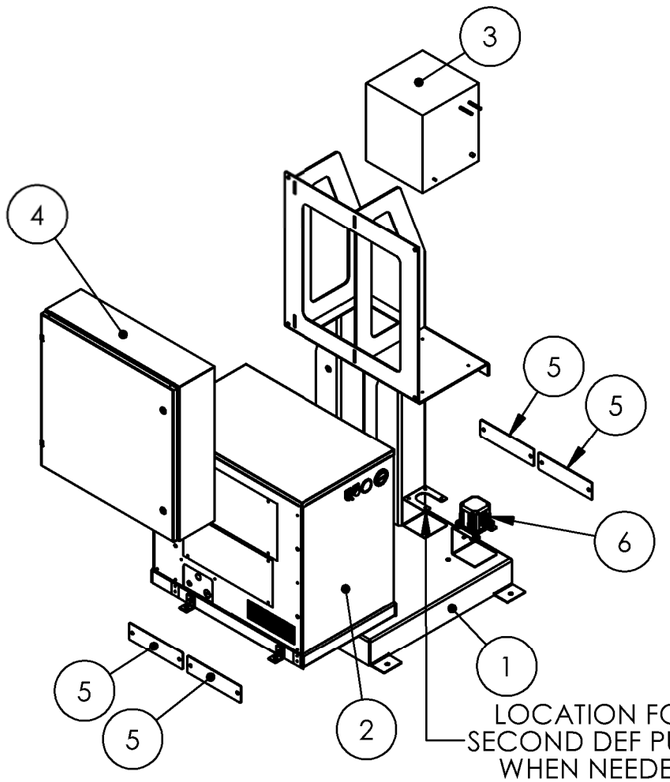












LOCATION FOR
SECOND DEF PUMP
WHEN NEEDED

SKID COVER PLATES
(8) 3/8-16 x 1" ZINC HEX BOLT
(8) 3/8" ZINC FLAT WASHERS
(8) 3/8" ZINC LOCK WASHERS

AIR COMPRESSOR MOUNTING
(4) 3/8-16 x 1.25" HEX BOLT
(4) 3/8 FLAT WASHER
(4) 3/8-16 LOCK WASHER

REV.	ECN	TIER	DESCRIPTION	DATE	APPROVED BY
A	N/A	2	RELEASED TO PRODUCTION	02/02/2022	lszura
B	N/A	3	4X MOUNT HOLES UPDATED FOR 3/8" HARDWARE	06/02/2022	blewan
C	N/A	3	ADDED CONFIGURATION FOR DUAL PUMPS	07/07/2022	lszura

VPN	COMP. VOLTAGE	DEF PUMP CAP.	DRYER MODEL	CONTROLS SPECIFIC TO PROJ.
1038764	208 VAC	SINGLE 57 KG/HR	HG-10	HOLT CATERPILLAR - SINGLE INJECTION
1039784	208 VAC	DUAL 38 KG/HR	HG-10	HOLT CATERPILLAR - DUAL INJECTION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGULAR: FABRICATED ±1.0°
MACHINED ±0.5°
ONE PLACE DECIMAL ±0.1
TWO PLACE DECIMAL ±0.06
THREE PLACE DECIMAL ±0.030
DUAL DIMENSIONS IN. {MM}

REMOVE ALL BURRS AND
BREAK SHARP EDGES

	NAME	DATE
DRAWN	cccintern	01/07/2022

MATERIAL:

THIRD ANGLE PROJECTION

DO NOT SCALE DRAWING

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES
311 RIGGS ST.
BLOOMER, WI 54724
TEL 715-568-2882
FAX 715-568-2884

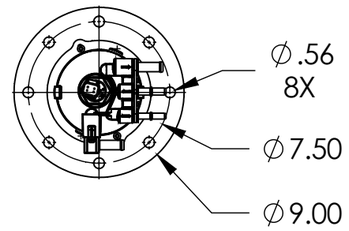
DESCRIPTION:
Aux Skid Assy - 30x30 Controls - Compressor - Single or Dual Pumps - Type 01

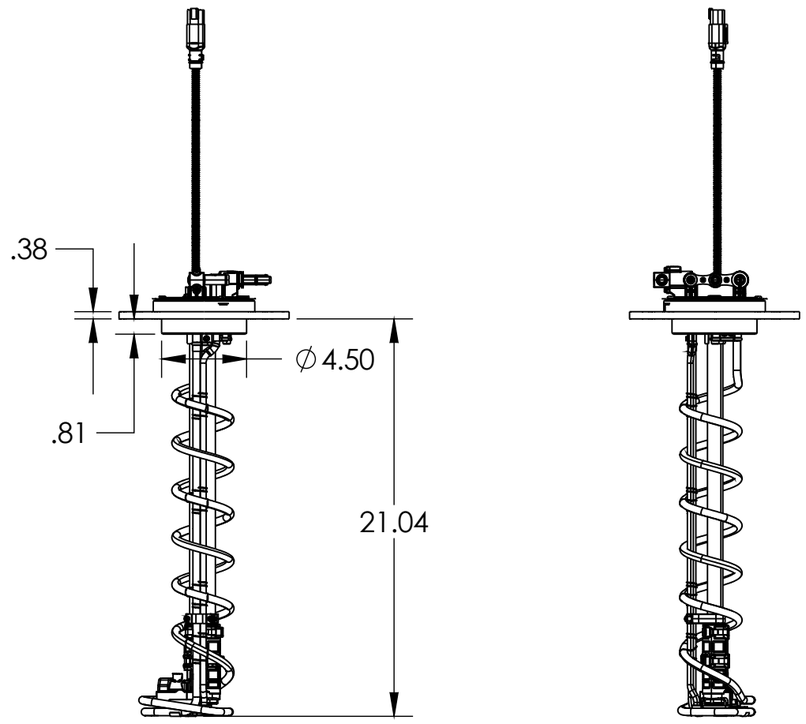
VISUAL PART NO.
SEE TABLE

SIZE B | DRAWING NO. 701455 | REV C

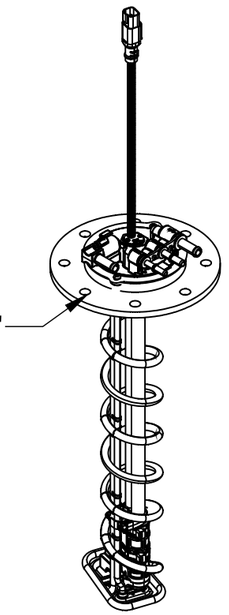
SCALE: 1:24 | WT: | SHEET 2 OF 2

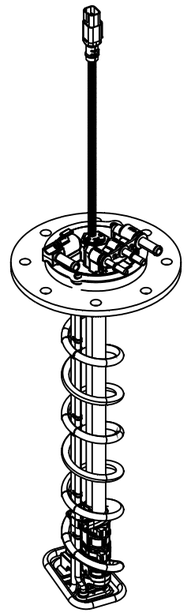
ITEM NO.	DRAWING NUMBER	REVISION	CONFIGURATION	VISUAL P/N	DESCRIPTION	MATERIAL	WEIGHT	QTY.
1	600315	A	Default	SEE TABLE	22INCH SHAW SENDING UNIT		0.003	1
2	600466	E	Default	1036201	SENDING UNIT FLANGE ADAPTER WELDMENT			1





GASKET AND HARDWARE NOT INCLUDED FOR THE 4" ANSI CONNECTION





KIT VPN	KIT DESCRIPTION	SENDING UNIT VPN
1040631	DEF TANK PICKUP KIT - 4" ANSI 150 LB - 21 DEPTH - SINGLE CIRCUIT W/LEVEL SENSING	1030877

REV.	ECN	TIER	DESCRIPTION	DATE	APPROVED BY
01	N/A	1	UPDATED TO INCLUDE DIFFERENT SHAW CONFIGURATIONS	09/09/2022	cmolls
A	N/A	2	RELEASED TO PRODUCTION	09/09/2022	cmolls
B	N/A	1	UPDATED NOMENCLATURE		

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:

ANGULAR: FABRICATED ±1.0°
MACHINED ±0.5°
ONE PLACE DECIMAL ±0.1
TWO PLACE DECIMAL ±0.06
THREE PLACE DECIMAL ±0.030
DUAL DIMENSIONS IN. (MM)

REMOVE ALL BURRS AND BREAK SHARP EDGES

	NAME	DATE
DRAWN	cmolls	10/27/2021

MATERIAL:

THIRD ANGLE PROJECTION

DO NOT SCALE DRAWING

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES
311 RIGGS ST.
BLOOMER, WI 54724
TEL 715-568-2882
FAX 715-568-2884

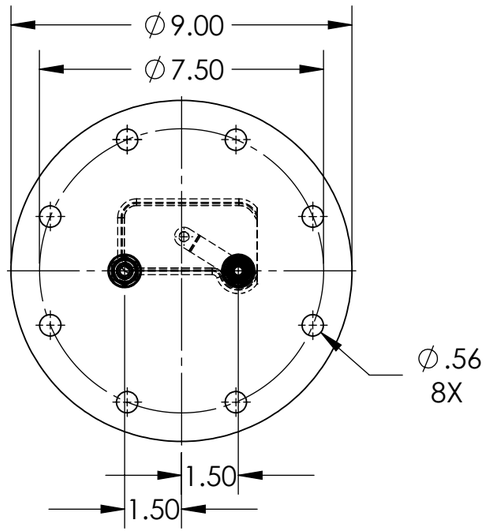
DESCRIPTION:
DEF TANK PICKUP KIT - 4" ANSI 150 LB - 21 DEPTH - SINGLE CIRCUIT W/LEVEL SENSING

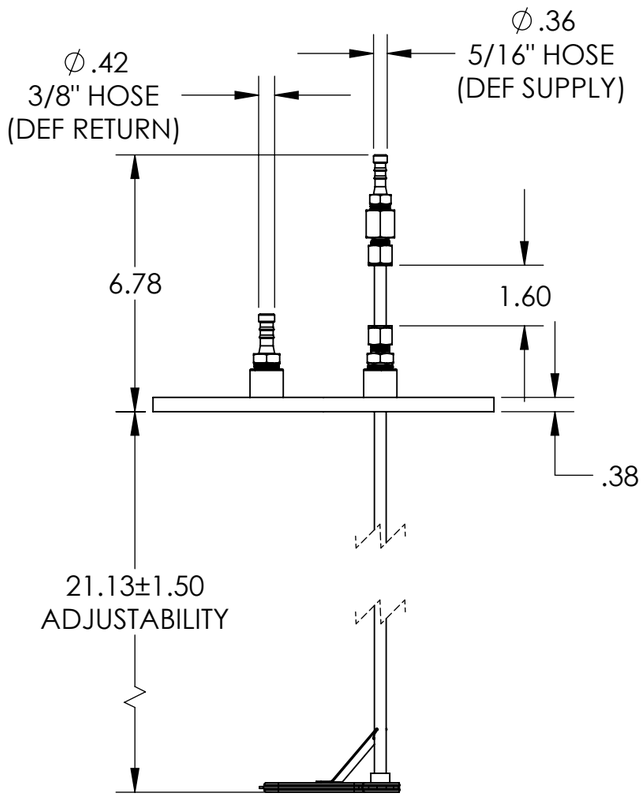
VISUAL PART NO.
SEE TABLE

SIZE B | DRAWING NO. 700379 | REV B

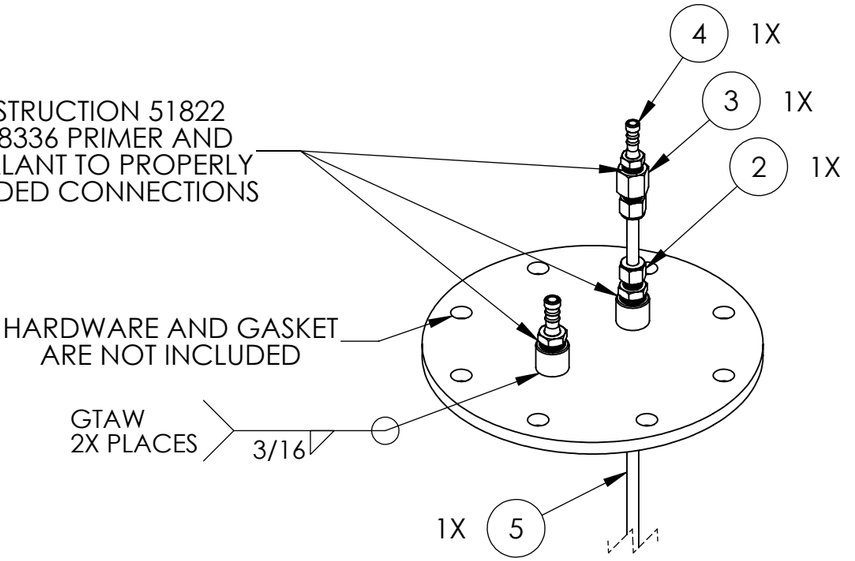
SCALE: 1:8 | WT: | SHEET 1 OF 1

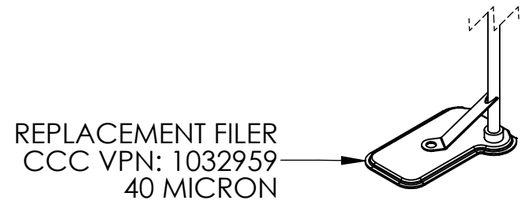
ITEM NO.	DRAWING NUMBER	REVISION	CONFIGURATION	VISUAL P/N	DESCRIPTION	MATERIAL	WEIGHT	QTY.
1	CLASS 3000 HALF-COUPLING, .375 IN	H	CLASS 3000 HALF-COUPLING, .375 IN	SEE CONFIG	HALF COUPLING - THREADED 304 SST	AISI 304	0.226	2
2	705452	00	5182K446	1039855	STR MALE 0.25NPT X 0.3125 TUBE SS BORED THROUGH	316 STAINLESS STEEL		1
3	703151	A	5182K796	1039277	SWAGELOK TUBE FITTING 0.3125 OD X 0.25 FEMALE NPT	316 STAINLESS STEEL		1
4	5361K34	A	5361K34	1031610	BARBED HOSE FITTING - 0.25 NPT X 5/16 TUBE	303/304 STAINLESS STEEL		1
5	707366	A	DEFAULT	N/A	SUCTION TUBE ASSY - 25.625" X 0.3125" TUBE		0.24	1
6	707233	A	DEFAULT	1040635	FITTING 304 SS 0.375" NPT X 0.3125" BARBED	303/304 STAINLESS STEEL		1
7	707369	A	DEFAULT	1040634	FLANGE BLIND 4" 150# PATTERN 304 SS 0.375" DUAL 0.69" CENTER PORTS	AISI 304	4.908	1





FOLLOW WORK INSTRUCTION 51822
UTILIZING VPNS 1028336 PRIMER AND
1002164 THREAD SEALANT TO PROPERLY
SEAL ANY NPT THREADED CONNECTIONS





REV.	ECN	TIER	DESCRIPTION	DATE	APPROVED BY
00	N/A	2	CREATED	09/09/2022	CMOLLS
A	N/A	2	RELEASED TO PRODUCTION	09/09/2022	CMOLLS

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:

ANGULAR: FABRICATED ±1.0°
MACHINED ±0.5°
ONE PLACE DECIMAL ±0.1
TWO PLACE DECIMAL ±0.06
THREE PLACE DECIMAL ±0.030
DUAL DIMENSIONS IN. (MM)

REMOVE ALL BURRS AND
BREAK SHARP EDGES

	NAME	DATE
DRAWN	CMOLLS	09/09/2022

MATERIAL:

THIRD ANGLE PROJECTION

DO NOT SCALE DRAWING

CATALYTIC COMBUSTION
311 RIGGS ST.
BLOOMER, WI 54724
TEL. 715-568-2882
FAX 715-568-2884

DESCRIPTION:
DEF TANK PICKUP KIT - 4" ANSI 150 LB - 21" DEPTH - SINGLE CIRCUIT W/O LEVEL SENSING

VISUAL PART NO.
1040633

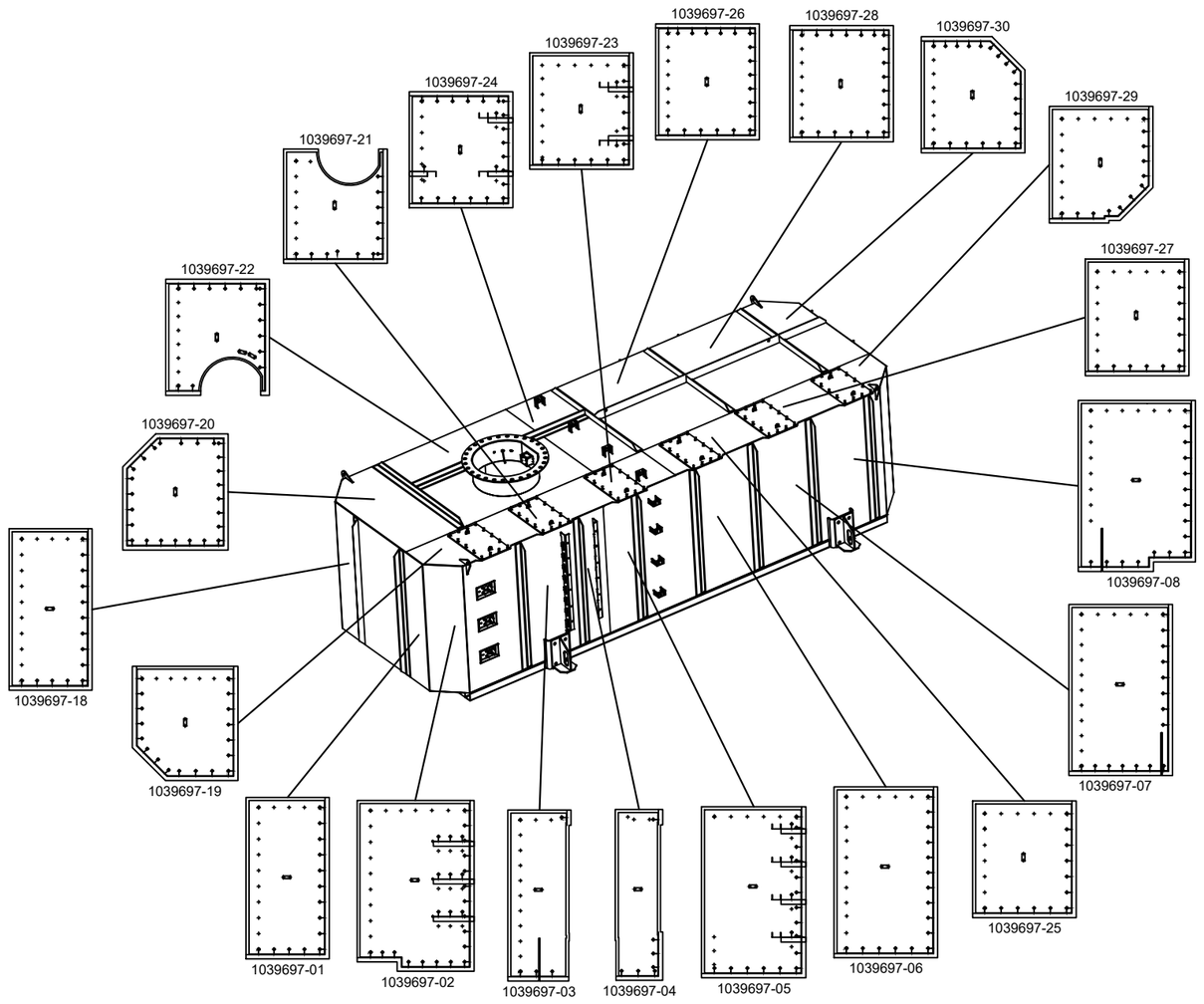
SIZE
B

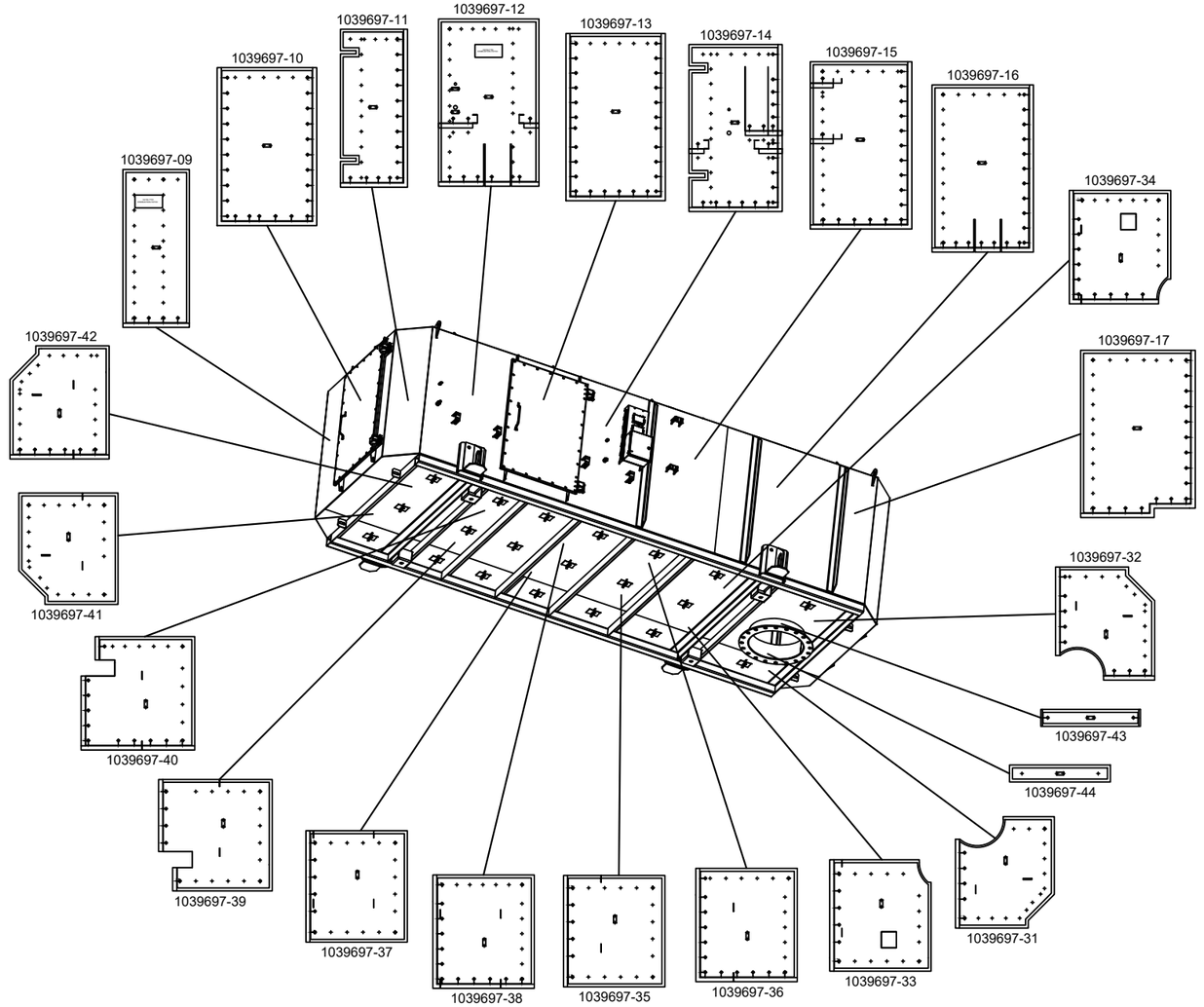
DRAWING NO.
707365

REV
A

SCALE: 1:8 | WT: 7.01 | SHEET 1 OF 1

P# 1039697
ASSEMBLY DRAWING





InsulTech
3530 W GARRY AVE • SANTA ANA • CA • 92704
TEL: 714.384.0506 • FAX: 714.384.0507

DRAWING NUMBER:
1039697 ASSEMBLY_MAP

ENGINEER: AR | DATE: 8/28/22 | REV: A

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Warranty

Holt Texas LTD.

Holt CAT Dual Lance (C175) SCR Systems

VPN 1040249

Holt CAT Single Lance (3516E) SCR Systems

VPN 1040251

Published December 2022

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www.catalyticcombustion.com

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

WARRANTY TERMS & CONDITIONS
FOR DOTC and SCR CATALYST APPLICATIONS in RECIPROCATING ENGINES.
And FOR SCR SYSTEM COMPONENTS.

Holt Texas

Holt CAT Dual Lance (C175) SCR Systems VPN 1040249

Holt CAT Single Lance (3516E) SCR Systems VPN 1040251

For the period and subject to other terms and conditions specified below, Catalytic Combustion Corporation ("Catalytic Combustion"), a Wisconsin corporation, warrants to the purchaser to whom this Warranty is addressed ("Purchaser") that the Catalyst sold to Purchaser will conform to the required performance specifications set forth by the Purchaser and as confirmed by our sales proposal for this project.

If the Catalyst fails to meet the foregoing warranty, and notice of such failure is given by Purchaser and received by Catalytic Combustion within either the number of operating hours exposed to exhaust gas or the elapsed time after the date of shipment from Catalytic Combustion based on whichever time period expires first, as shown for the following Catalyst formulation in the table below, Catalytic Combustion at its discretion either supply replacement Catalyst free of charge, supply replacement Catalyst at a pro-rated price to the Purchaser or refund a pro-rated portion of the purchase price. The pro-rated factor will be calculated using the number of hours or months that the catalyst has been operated as a percentage of the warranted hours or months figure shown herein.

Formulation	Time from Shipment
SCR	27 months

Or 2,500 operating hours, whichever is sooner.

Catalytic Combustion warrants that the catalyst has been designed and fabricated to maintain its structural integrity while is service, that it is manufactured from new materials and that for a reciprocating engine: the NOx reduction rate and as referenced in our quotation 001-00-274359 Rev 9 for the application, referenced below, provided that the Diesel Engine is and has been operated properly, the amount of installed Catalyst is in compliance with Catalytic Combustion's recommendations and that the Catalyst is operated in compliance with Catalytic Combustion's prerequisites as listed below.

Prerequisites for this warranty are:

(1) The Diesel Engine is powered with ULSD.

(2) The Diesel Fuel shall not have a sulfur content in excess of 10 ppm.

(3) The Diesel Engine shall be maintained and operated in accordance with the manufacturer's guidelines and shall be operating at a steady state condition.

(4) Ignition of fuel in the exhaust system, otherwise known as a backfire, is avoided.

(5) The SCR Catalysts will be operated within a temperature range of 500°F inlet to 900°F outlet.

To ensure that the catalyst is not exposed to temperatures greater than 900°F it will be the responsibility of the Purchaser to operate and maintain the Diesel Engine such that the 900°F limit is not exceeded.

Successful operation of the Catalyst may require periodic cleaning of the Catalyst according to procedures approved or provided by Catalytic Combustion to remove masking agents, such as, but not limited to, noncombustible particulates.

Due to the potential for certain chemical elements to act as catalyst poisons and deactivation agents this Warranty and Catalytic Combustion's obligations hereunder shall become null and void, and Catalytic Combustion disclaims any Warranty with respect to Catalyst which has been exposed to:

(i) Any halogen-containing compounds,

(ii) Any other poisoning or masking agents, including but not limited to phosphorus, silicon, sulfur, arsenic, and heavy metals such as lead or zinc, at levels in the washcoat that exceed the concentrations seen in the table below or an aggregate total concentration of any combination of contaminants that exceeds the listed value as determined by Catalytic Combustion via X-Ray Fluorescence (XRF) analysis of a representative sample of the washcoat.

Chemical Species	Concentration in the Washcoat (ppmw)
Phosphorus (P)	700
Zinc (Zn)	500
Silicon (Si)	1,000
Sulfur (S)	1,000
Heavy Metals (Pb, Hg, As, Sn, etc.)	1,500
Halogens (Cl, F, Br, etc.)	500
Alkali Earths and Metals (Na, K, Ca, Mg)	1,000
Total Aggregate from all Elemental Contaminants	4,000

(iii) Temperatures in excess of 1,250 ^{o}F as determined through surface area analysis of the washcoat.

(iv) Operation of the turbine such that the catalyst inlet temperature is less than 650 ^{o}F which can result in an accumulation of sulfur leading to rapidly deactivation of the catalyst.

Attempts to clean or wash the catalyst by any process, procedure or entity that has not been approved or authorized by Catalytic Combustion shall also nullify and void the Warranty.

A representative sample of the non-performing Catalyst shall be removed from operation and returned to Catalytic Combustion pursuant to its instructions, and if so returned, freight shall be at Catalytic Combustion's expense.

If it is determined that the Catalyst has failed to perform and that no disqualifying conditions apply and if Catalytic Combustion provides replacement Catalyst the replacement Catalyst shall be Warranted only for the remainder of the stated Warranty period for the original Catalyst.

Catalytic Combustion, in no event, shall be liable for production losses or indirect or consequential damages resulting from a failure of the Catalyst to meet the performance Warranty.

Any failure of Catalyst to conform to this Warranty shall be demonstrated to the satisfaction of Catalytic Combustion by and at the expense of Purchaser. Determination of non-performing Catalyst shall be based upon the calculated average performance of the Catalyst from at least 6 measurements taken over a minimum of a 24-hour period of steady state turbine operation. The analytical data shall be gathered using the most current and appropriate EPA test methods by either a third party qualified to perform the measurements or through the use of a certifiably calibrated measurement instrument operated by trained personnel from either the Purchaser or the end user. Notification of Catalyst's failure to meet performance guarantees and supporting analytical data shall be submitted in writing within 5 (five) days to Catalytic Combustion for review. Catalytic Combustion reserves the right within 30 (thirty) days notice of failure, to request additional analytical measurements and inspection of the turbine's operating condition for the purpose of confirming the Catalyst's failure.

Seller hereby warrants to Buyer that the equipment herein described will be free from any liens or encumbrances, and that good title to said equipment will be conveyed to Buyer. Seller warrants equipment of its own manufacture against defects in material and workmanship under normal conditions of usage and service for thirty-six (36) months from commissioning or forty (40) months from date of shipment, or 2,500 operating hours, whichever is sooner. Equipment not manufactured by Seller shall receive such warranty, if any, of the manufacturer thereof and which are hereby assigned to Buyer without recourse to Seller; Seller agrees to act as a liaison with a manufacturer of equipment supplied hereunder regarding any warranty claims if requested by Buyer. Seller's sole obligation and Buyer's sole remedy under this warranty is limited to and shall be fully discharged by repairing or replacing any defective part F.O.B. point of manufacture. Seller shall not be liable for repair or alterations made without Seller's prior written approval. Seller shall not be liable for damages or delay caused by defective material or workmanship.

As listed in CCC Quote 001-00-274359 Rev 9 / Basis for this Warranty and this Project only.

Proposed Emissions After-Treatment Technology

P/N	QTY	Description
SCR for NOx Only to meet Tier IV NOx & Critical Grade Silencing aftertreatment system for CAT C175 PHX-1000ft and 120°F ambient / 18 Gensets/ TOAD & BLUE VPN 1040249		1) Urea injection, Mixing Duct, SCR catalyst, all integrated in one 304SST Reactor; Includes insulation blanket, Air compressor (with dryer), DEF pump shipped loose, temp and dP sensors, dosing and control panels, short exit exhaust stack (28" long) with a rain cap. <u>This will need "Required Adder additional injection lance" see below.</u> 2) Urea flow at max power is 15.83 gal/hr, at PSV NOx. 3) Maximum back pressure of SCR system is 16" WC clean. 4) Sized for CAT C175-16 rated at 3,100kW and DM8455. 5) **Guaranteed Emissions EPA Tier IV Compliant for NOx:** a. NOx at ≤ 0.50 g/bhp-hr b. Noise is controlled. Critical Grade Silencing integrated. **<u>SCR Reactor Housing Dimensions:</u>** Height = 75" | Width = 92" | Length = 230" Weight (loaded) = 9,500 lbs Inlet – Outlet flanges = 24" and 28" Includes insulation blanket for safety & performance Warranty = 24 month or 27 months after delivery or 2,500 hours, whichever is sooner.
REQUIRED ADDER for C175-16s	18	Additional SS injection lance, DEF pump, mounting bracket on SCR reactor, mounting bracket for DEF pump, control, dosing and sending unit additional wiring, limited engineering and manufacturing time added.

P/N	QTY	Description
SCR for NOx Only to meet Tier IV NOx & Critical Grade Silencing aftertreatment system for CAT 3516E 7 Gensets/ BLUE VPN 1040251		1) Urea injection, Mixing Duct, SCR catalyst, all integrated in one 304SST Reactor; Includes insulation blanket, Air compressor (with dryer), DEF pump shipped loose, temp and dP sensors, dosing and control panels, standard 28" outlet ANSI flange connection with NGB kit. 2) Urea flow at max power is 14.70 gal/hr, at PSV NOx. 3) Maximum back pressure of SCR system is 17" WC clean. 4) Sized for CAT 3516E rated 3,100kW and EM4717. 5) **Guaranteed Emissions EPA Tier IV Compliant for NOx:** a. NOx at ≤ 0.50 g/bhp-hr b. Noise is controlled. Critical Grade Silencing integrated. **SCR Reactor Housing Dimensions:** Height = 75" | Width = 92" | Length = 230" Weight (loaded) = 9,500 lbs Inlet – Outlet flanges = 24" and 28" Includes insulation blanket for safety & performance Warranty = 24 month or 27 months after delivery or 2,500 hours, whichever is sooner.

THE FOREGOING WARRANTY AND REMEDIES ARE EXCLUSIVE. TO THE FULLEST EXTENT PERMITTED BY APPLICABLE LAW, CATALYTIC COMBUSTION DISCLAIMS ANY IMPLIED WARRANTY, INCLUDING ANY WARRANTY OF MERCHANTABILITY, AND, ANY WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE. CATALYTIC COMBUSTION WILL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES, LOSS OF TIME OR PROFITS, OR ANY INCONVENIENCE. CATALYTIC COMBUSTION SHALL NOT BE LIABLE FOR ANY DAMAGES WHICH ARE BASED UPON NEGLIGENCE, BREACH OF WARRANTY, STRICT LIABILITY OR ANY OTHER THEORY OF LIABILITY OTHER THAN THE EXCLUSIVE WARRANTY SET FORTH IN THIS WARRANTY. INCIDENTAL AND CONSEQUENTIAL DAMAGES SHALL NOT BE RECOVERABLE EVEN IF THE REMEDIES OR THE ACTION PROVIDED FOR HEREIN FAIL OF THEIR INTENDED PURPOSE. THIS WARRANTY SHALL BE GOVERNED BY THE LAWS OF THE STATE OF WISCONSIN.

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Test Documents

Holt Texas LTD.

Holt CAT Dual Lance (C175) SCR Systems

VPN 1040249

Published December 2022

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Component level testing is performed at Catalytic Combustion's manufacturing facility. Final functional and system validation will occur as part of the commissioning activities on-site. Once system validation is completed on-site the final testing documents will be added to this O&M document and an updated version provided to the customer.

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Owners and Operators Manual

Selective Catalytic Reduction (SCR) System

Holt Texas LTD.

Holt CAT Single Lance (3516E) SCR Systems

VPN 1040251

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Published December 2022

Owners Manual Selective Catalytic Reduction (SCR) System

Holt CAT Single Lance (3516E) SCR System VPN 1040251

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Operations Manual

Holt Texas LTD.

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CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

ISO 9001 Certified
Verisys Registrars®

Integrity | Service | Excellence

Catalytic Combustion Corporation introduced cutting edge technology in 1950 with the development of the first ever US patented catalyst to destroy VOCs (Volatile Organic Compounds). Since that time, the company has expanded into the design and supply of catalysts and emission control system for a wide variety of industries.

Catalytic Combustion Corporation
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Catalytic Combustion Corporation
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1. Forward

This Operations Manual is intended for CAT 3516E EM4717

Please read and thoroughly understand this manual, the safety warnings and the complete system before attempting to service or maintain the system. Please observe all specifications, guidelines, and notes in the manual.

The graphics and photos may be representative. The parts on your package may not match the photos or drawings in this manual.

Please contact Catalytic Combustion Corporation with questions.

CONTACT INFORMATION

Catalytic Combustion Corporation
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Bloomer, WI 54724
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F: 715-568-2884
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2. System Overview

This manual is intended to provide an overview of the Catalytic Combustion Corporation (CCC) Selective Catalytic Reduction system.

2.1. Definitions

The following definitions may be used throughout this manual.

AUS 32	Aqueous Urea Solution of 32.5%. Synonym for DEF
CCC	Catalytic Combustion Corporation
CFM	Cubic Feet per Minute
DOC	Diesel Oxidation Catalyst
DOTC	Diesel Oxidation Trapping Catalyst
DDU	DEF Dosing Unit
DEF	Diesel Exhaust Fluid, 32.5% solution meeting ISO22241 (also known as Urea)
ECU	Electronic Control Unit
INJ	DEF Injector
NH3	Ammonia
NO	Nitrogen Oxide
NO2	Nitrogen Dioxide
NOx	Oxides of Nitrogen
PID	Proportional Integral Derivative
P&ID	Process and Instrumentation Diagram
PM	Particulate Matter
PSI	Pounds per square inch
SCR	Selective Catalytic Reduction
SOD	System Operations Document
ULSD	Ultra-Low Sulfur Diesel containing <15ppm Sulfur
US EPA	United States Environmental Protection Agency

3. NOx Reduction system

The emission reduction system reduces NO_x emissions generated by the engine during combustion. The NOx reduction system is comprised of the following components:

1. SCR Reactor containing:
    a. DEF Injection Duct
    b. DEF Mixing duct
    c. SCR Catalyst
2. DEF Dosing Components including:
    a. DEF Supply Pump (1)
    b. DEF Dosing Unit (1)
    c. DEF Injection Lance (1)
    d. Compressed Air Pressure Regulator
3. Dosing System Control Panel with Touchscreen Display (control panel door mounted)
4. Temperature Sensors (2)
5. Differential Pressure Transducer (1)
6. NOx Concentration Sensor and Control Unit
7. NH3 Concentration Sensor and Control Unit

The exhaust flows from the engine through an exhaust pipe and into the inlet plenum. The exhaust then moves through the DEF Injection and Mixing section. The DEF is injected into the exhaust stream and passes over/through CCC proprietary exhaust mixers before being routed through the SCR catalysts. The SCR catalyst plus the ammonia (NH_3) generated from the DEF controls the NO_x emissions.

3.1. Engine Exhaust Parameters

Flow:	8,885 CFM wet
NOx emissions:	5.62/bhp-hr
Maximum Temperature:	921°F
Normal Operating Temperature:	902°F

3.2. Lube Oil Requirements

Engine Lube oil must meet or exceed API CJ-4 classification or better for the SCR system. All the lube oil and viscosity specifications in the engine operations and maintenance manual must also be followed.

3.3. Diesel Exhaust Fluid (DEF or AUS 32)

Diesel Exhaust Fluid (DEF) is a clear, non-toxic chemical. It is safe to handle in normal conditions and is not harmful to the environment. Urea is diluted in deionized, distilled water to create a 32.5% solution of DEF. DEF is widely used in 2010 and newer on-road trucks and non-road equipment to control NO_x in the same way it is being used by the CCC emission control system. Please check with your local fuel and/or chemical provider for further information.

All DEF used with this engine package MUST meet ISO22241 standards for quality.

	Failure to use DEF that meets the appropriate ISO standard may void the warranty, cause damage to injection components, poison the SCR catalyst and/or render the engine non-compliant with US EPA regulations.

DEF has a shelf life depending on the storage temperature. Please observe manufacturer storage instructions. Generally, DEF should be stored at less than 32°C (90°F) and higher than -5°C (23°F). Solidified DEF has an approximate volume 7% larger than liquid, therefore frozen DEF may cause the storage container to burst if expansion is not taken into account. Table 1 details DEF shelf life as a function of temperature per ISO22241.

Table 1: DEF Shelf Life as a Function of Temperature Per ISO22241[1]

CONSTANT AMBIENT STORAGE TEMPERATURE		MINIMUM SHELF LIFE (months)
(° C)	° F	
≤ (10)	≤ 50	36
≤ (25[a])	≤ 77	18
≤ (30)	≤ 86	12
≤ (35)	≤ 95	6
> (35)	> 95	–[b]
NOTE: The main factors taken into account to define the shelf life in this table are the ambient storage temperature and the initial alkalinity of the DEF. The difference in evaporation between vented and non-vented storage in an additional factor.		
[a] To prevent decomposition of DEF, prolonged transportation or storage above 25°C (77°F) should be avoided. [b] Significant loss of shelf life. Each batch should be tested prior to use.		

DEF must be stored in a plastic (Polyethylene, Polypropylene, PFA, PFE, PVDF, or PTFE) or stainless steel (304, 304L, 316, 316L only) tank.

Carbon steels, zinc coated carbon steels, mild iron, non-ferrous (copper and copper alloys, zinc, lead), aluminum and aluminum alloys, magnesium and magnesium alloys, and plastic or metals coated with nickel are not recommended for DEF storage.

3.4. DEF/AUS 32 Storage Tank

	Particular care must be observed in maintaining the cleanliness of the DEF tank. While the SCR system is protected from the introduction of large particulate matter (>40 microns), contamination in the tank may be dissolved by DEF (caustic) and will be passed into the SCR system which may lead to non-compliance, accelerated maintenance, component and/or system failure.

	Do not inhale fumes directly from the DEF Storage Tank. Ammonia gas may be present inside the tank. Venting of the storage tanks must be in accordance with governing regulations. CCC is not responsible for tank venting.

[1] International Standard ISO 22241-3, Part 3: Handling, transportation and storage (First Edition, 2008-02-15)

3.5. Diesel Fuel

Ultra-Low Sulfur Diesel fuel containing <15ppm Sulfur must be used with this engine. Filling with other fuel will damage the emission aftertreatment system and may void the warranty. Do not mix any additives in the fuel without written permission from Catalytic Combustion Corporation. Mixing lube oil in the fuel is prohibited.

Biodiesel blends are approved up to a B20 (20% bio content) providing the base diesel fuel <500ppm S. Higher bio concentrations can be approved on a case-by-case basis by Catalytic Combustion Corporation.

3.6. Component Identification

The following components are part of the emission aftertreatment system.

3.6.1. **Reactor**

The reactor is constructed of stainless steel and houses the injection/mixing ducts and SCR catalysts. Access to the catalysts is through bolted hatches located on the side of the reactor. The hatches are gasketed to prevent exhaust leaks.

The DEF/AUS32 injector is bolted on the side of the reactor and is sealed via high temperature gasket.

	Do not operate the engine with the injector removed from the reactor unless a block off plate is installed. Failure to block off the injector mounting location will lead to a massive exhaust leak.
	Do not operate the engine with the injector removed from the reactor unless the aftertreatment system has been disabled. Failure to do so may lead to excessive component wear, component failure and/or dosing from the removed injector.

The reactor is mounted at four points. During operation the reactor will grow significantly due to thermal expansion. The estimated expansion is detailed on drawing 703275. The reactor must be mounted in a manner that allows for the estimated thermal expansion.

The reactor is wrapped in an insulating blanket. It is intended to trap as much heat in the system as possible as well as provide a safe buffer between the hot exhaust system and local area.

	The insulating wrap is intended to prevent burns; however, the surface can be hot to the touch hours after engine shutdown. Assume the exhaust system is hot and use extreme care when working around the exhaust system. Wear appropriate PPE as prescribed by your organization.

3.6.2. **DEF/AUS 32 Injector**

The DEF injector carries the reactant and compressed air to the nozzle tip where they are mixed and the DEF is atomized. Figure below shows the DEF injector and Zone C7/D7, DWG 703275, Sheet 1 shows the mounting position in the reactor.

1. Mounting Flange Gasket
2. Mounting Flange
3. Mounting bolts
4. Gasket, Injector to DDU
5. O-Ring, Injector to DDU
6. Injection Nozzle tip

Figure 1: DEF Injector

The DEF injector is manufactured using a semi-rigid stainless steel tube located within a stainless steel braided hose. The minimum bend radius is 8 inches. Attempting a tighter bend radius may cause the inner hose to kink closed preventing the flow of DEF to the injector tip.

WARNING	Do not attempt to bend the semi rigid hose tighter than an 8-inch bend radius. Failure to comply may lead to the inner hose kinking closed preventing the flow of DEF to the injector. This may lead to denial of a warranty claim, void the warranty, render the system non-compliant and create additional maintenance.

Please review the Maintenance Manual for information on removing, reinstalling and/or servicing the injector.

Please review the Parts Manual for part numbers associated with different components of the injector.

3.6.3. **DEF Dosing Cabinet**

The DEF Dosing Cabinet is located on the Reactor (Figure below).

The DEF Dosing Cabinet contains the DEF Dosing unit and the Compressed Air Regulator/Drier with air pressure switch.

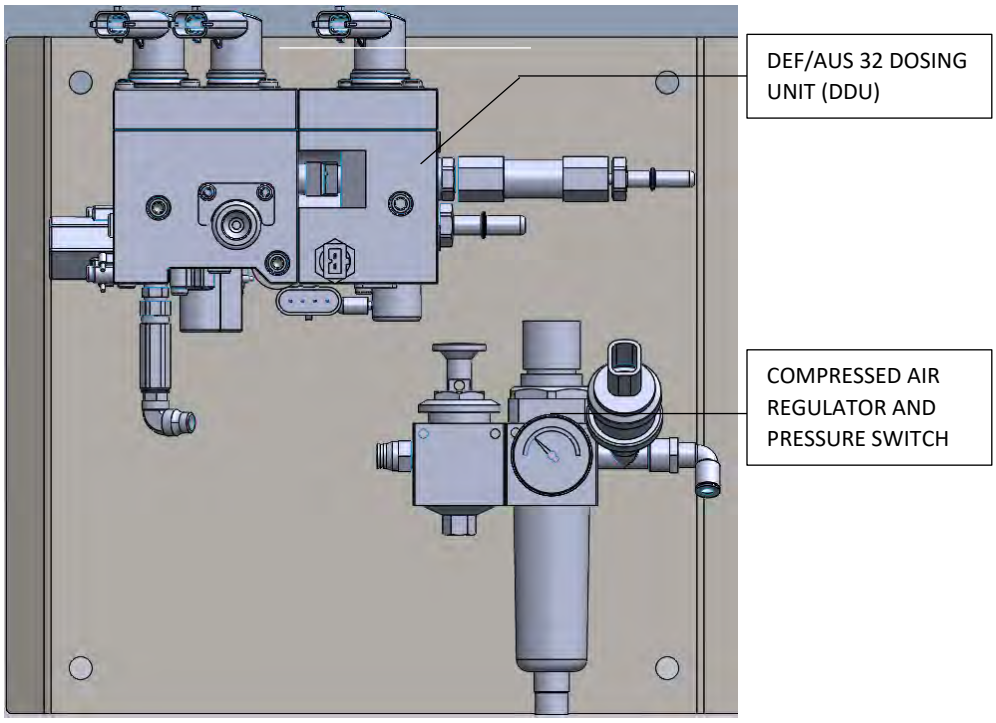

Figure 2: DEF Dosing Cabinet

The DEF Dosing Unit is a DEF metering device controlled by the DEF Dosing System Control Panel. DEF is circulated through a fixed pressure regulator. A DEF valve controls metering. Accuracy is ensured through temperature and pressure sensing up and downstream of the DEF injector. A separate pressure sensor monitors air flow through the DEF injector. Air flow and post-injection flush are controlled by two solenoid valves. The Dosing unit is equipped with a DEF filter to prevent particulates from entering the dosing unit. All liquid connections are via SAE J2044 fitting. Figure below details the DEF Dosing Unit.

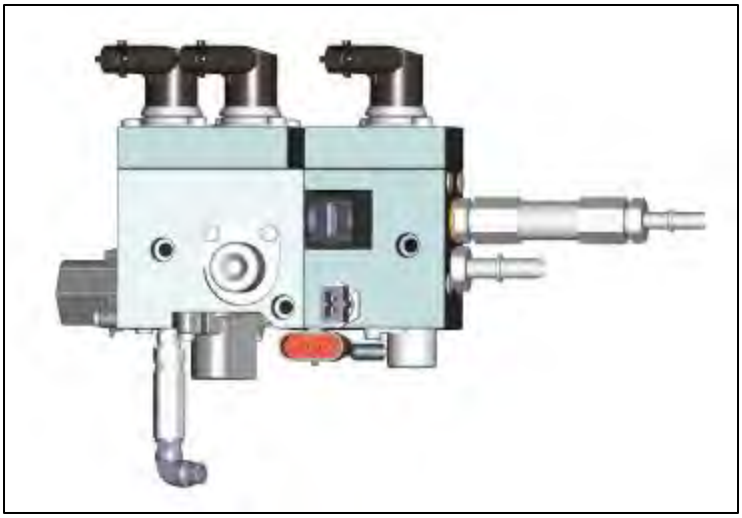

Figure 3: DEF Dosing Unit

WARNING	Please review the Maintenance Manual for information on removing, reinstalling and/or servicing the DEF Dosing Unit.

The DEF Supply Pump delivers DEF from the storage tank to the DEF Dosing Unit. DEF not consumed by the injection process is returned to the storage tank. The pump is speed and direction controlled by the DEF Dosing System Control Panel. All liquid connections are via SAE J2044 fittings. Figure below shows the DEF Supply Pump.

Figure 4: DEF Supply Pump

WARNING	Please review the Maintenance Manual for information on removing, reinstalling and/or servicing the DEF Pump.

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The Compressed Air Regulator/Drier consists of a shut-off switch, an electronic pressure switch, and a condensate trap. The unit regulates the air supply to the DEF Dosing Unit as well as drops out water vapor that may be present in the air supply. Figure below details the Compressed Air Regulator/Drier.

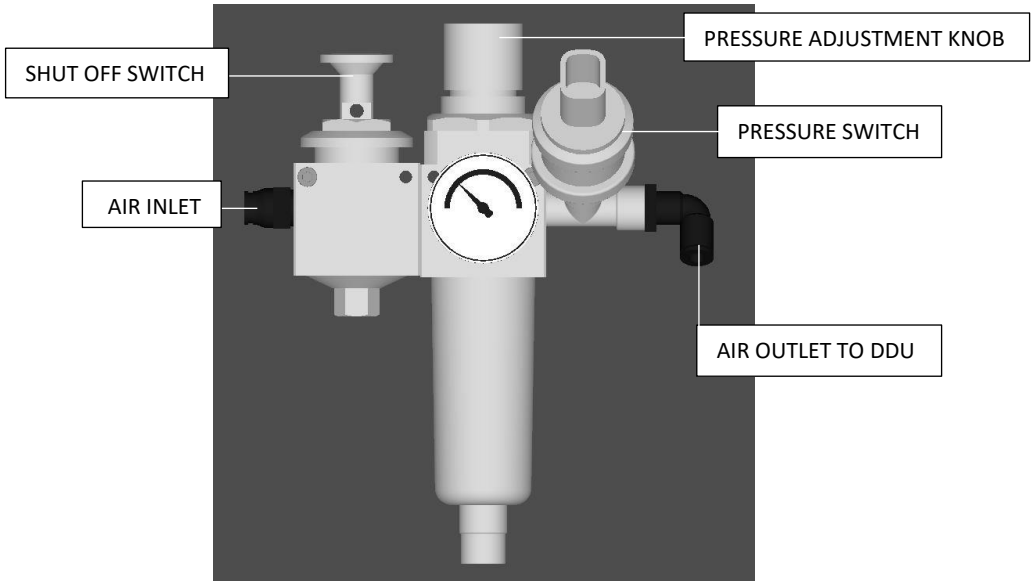

Figure 5: Compressed Air Regulator/Drier

Compressed air should be regulated to between 4 and 5bar on the gauge.

To adjust the pressure:

1. Lift pressure adjustment knob up
2. Rotate knob clockwise to increase pressure or counter clockwise to decrease pressure
3. Adjust pressure so that the gauge shows 5bar while the system is dosing DEF into the exhaust stream
4. Press knob down to lock adjustment

	The air pressure is preset when the aftertreatment system is built. Air pressure should not be changed unless directed to do so by Catalytic Combustion Corporation Technical Personnel. Failure to comply may lead to non-compliance, accelerated maintenance, component and/or system failure.

3.6.4. **DEF Dosing Control Cabinet**

The DEF Dosing Control Cabinet contains electronic components necessary to control the various processes. In most cases, the control cabinet will not need to be opened or serviced. Only trained certified technicians are permitted to service any parts inside the control cabinet.

WARNING	Do not service any components in the DEF Dosing Control Cabinet unless directed by Catalytic Combustion Corporation Technical Personnel Only.

3.6.5. **DEF Dosing System Touch Screen Interface (HMI)**

The emission aftertreatment system includes a touchscreen interface on the door of the Control Panel. This interface communicates important information regarding the state of the emission aftertreatment system.

The touchscreen will go to "sleep" after 10 minutes of inactivity. It can be awakened by touching the screen anywhere.

In most cases, the operator(s) will see the home screen (Figure below) when the screen is awake.

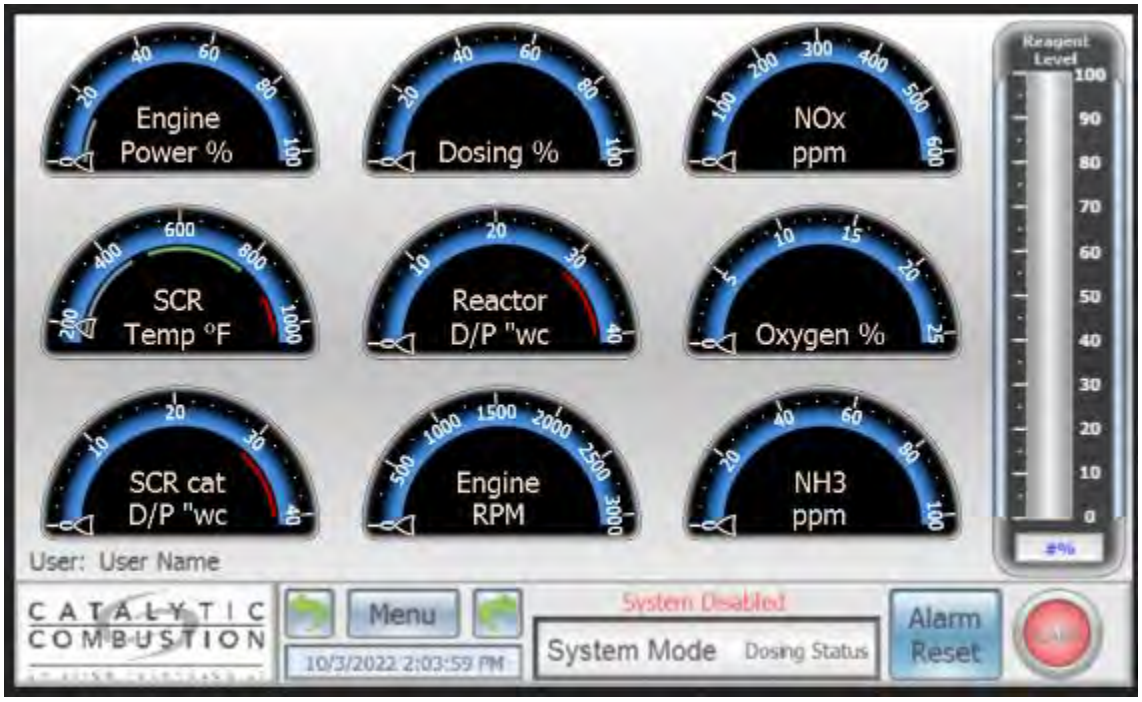

Figure 6: Home Screen of the HMI

The Home screen communicates:

1. Engine Power (%)
2. Dosing Rate (%)
3. NOx Concentration (ppm)
4. SCR Inlet Temperature (°F)
5. Differential Pressure across the SCR catalyst (in WC)
6. Oxygen Concentration in exhaust stream (%)
7. Engine Speed (RPM)
8. NH3 Concentration (if equipped – optional item)

9. DEF Day Tank Level Gauge (if equipped – optional item)
10. Alarm State

The system has multiple levels of password protection. Operators are able to view the Menu screen, the Sensor screen and the Alarms Screen (Figures below). Authorized users are able to access all other functions.

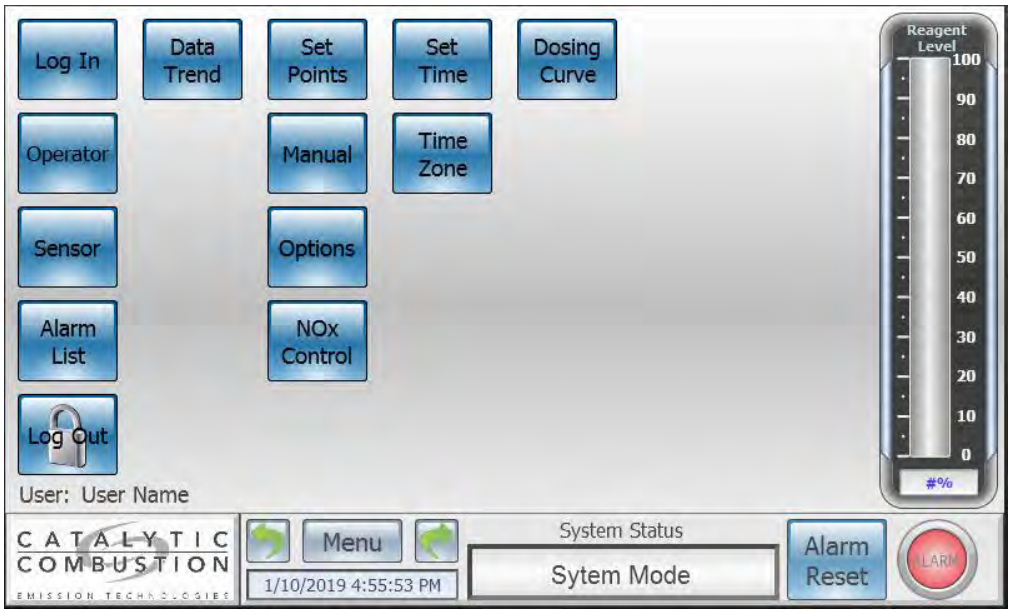

Figure 7: Menu Screen

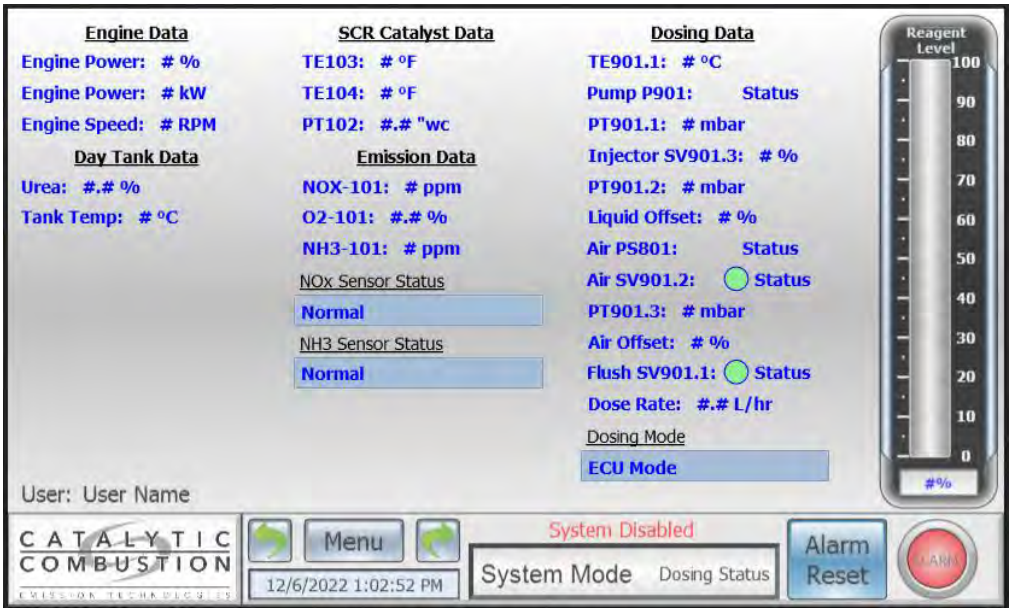

Figure 8: Sensor Screen

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3.6.6. **Alarm State**

Alarms are communicated via the round “lamp” on the bottom right of the Home screen.

A Yellow lamp communicates a Pre-Alarm or Global Alarm.

A Red lamp communicates a Critical Alarm.

An operator can acknowledge the alarm by pressing the Alarm button which will navigate to the Alarm History Screen. Alarms can be viewed by date and time. Alarms can also be acknowledged in this screen. Alarms cannot be erased.

An acknowledged alarm will reassert if the conditions which caused the alarm are not satisfied.

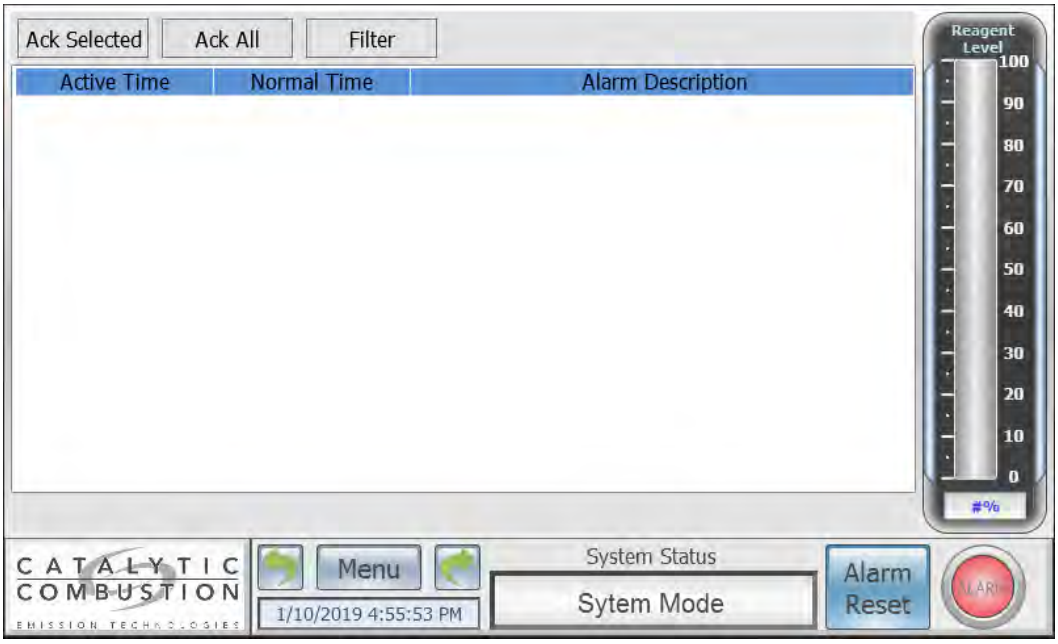

Figure 9: Alarm Screen

3.6.7. **NOx Concentration Sensor**

The NOx concentration sensor is located at the base of the exhaust stack. The sensor is connected to the NOx sensor ECU via a wiring harness. The ECU is mounted on the side of the reactor, refer to Zone C2/D2, DWG 703275, Sheet 1. The sensor and the ECU are serviceable individually. The sensor is a maintenance part and must be replaced after 9,000 hours of operation (or upon request of the emission control system control panel). The ECU must be replaced if it fails.

3.6.8. **NH3 Concentration Sensor**

The NH3 concentration sensor is located at the base of the exhaust stack. The sensor is connected to the NH3 sensor ECU via a wiring harness. The ECU is mounted on the side of the reactor, refer to Zone E2, DWG 703275, Sheet 1. The sensor and the ECU are serviceable individually. The sensor is a maintenance part and must be replaced after

9,000 hours of operation (or upon request of the emission control system control panel). The ECU must be replaced if it fails.

3.6.9. Differential Pressure Transducers and Temperature Sensors

Differential pressure transducers are located inside the Junction Panel. External connection is via ¼" female NPT.

The differential pressure transducers measure the amount of differential pressure being generated by the SCR catalysts. The sensors communicate the pressure to the DEF Dosing System Control unit which will alert the operator via the HMI in the event the differential pressure builds inside the system.

PT102 reads pressure across the SCR catalysts, PT102H is the high-pressure side (pre SCR) and PT102L is the low-pressure side (post SCR).

The system uses 2 – Type K thermocouples to sense the exhaust temperature.

TE103 reads the temperature before the SCR catalyst. TE103 is one of the temperature permissive for the system.

TE104 reads the temperature after the SCR catalyst and is the other temperature permissive for the system.

The systems use a cascading temperature permissive. For example, if TE103 fails, the permissive is automatically transferred to TE104. If both fail, the system will not operate.

Zone E1/E2, DWG 703275, Sheet 1 shows the locations for the pressure taps and thermocouples associated with the SCR.

3.6.10. Electrical

The emission aftertreatment system requires a 208 VAC 3 phase and 120 VAC single phase power supplied by others.

The DEF Supply Pump and DEF Dosing Unit are powered directly from the DEF Dosing System Control Cabinet and each component has a specific wiring harness with a unique weather tight connector.

Please review the wiring schematic for specific wire routing and interconnection.

4. Operation and Handling of the Emission Aftertreatment System

4.1. Daily Operations Checklist

The following items should be checked daily:

1. DEF Tank Level: The HMI located in the door of the control panel provides a DEF Tank Level gauge for your convenience. Please ensure the DEF storage tank is kept above 15% remaining to ensure the tank does not run dry.

2. The HMI should be monitored periodically to ensure the system is not in an alarm state. An alarm state is communicated by the display via a Yellow or Red Alarm Lamp on the bottom right of the HMI screen (Figure below).

Figure 10: Alarm Communication

4.2. Normal Operating Mode

4.2.1. System Start-up

The system will operate automatically. No operator interaction is required except for the periodic monitoring of the Dosing System Display.

The DEF Dosing System activates after each of the following parameters are met:

1. Engine is operating
2. Engine load signal is present
3. Compressed air is available
4. DEF Tank level is OK
5. TE103 or TE104 is >225°C (480°F)
6. The system is not in an alarm state

Once each of the previous parameters are met, the system will activate and prepare to dose DEF into the exhaust stream. DEF dosing will commence after the following parameters are met:

1. DEF pump primes and builds proper pressure to the DEF Dosing Unit
2. DEF dosing unit has appropriate air pressure
3. TE103 is >225°C (480°F)
4. The system is not in an alarm state

The operator can monitor Operational Parameters via the Sensor screen (Figure below).

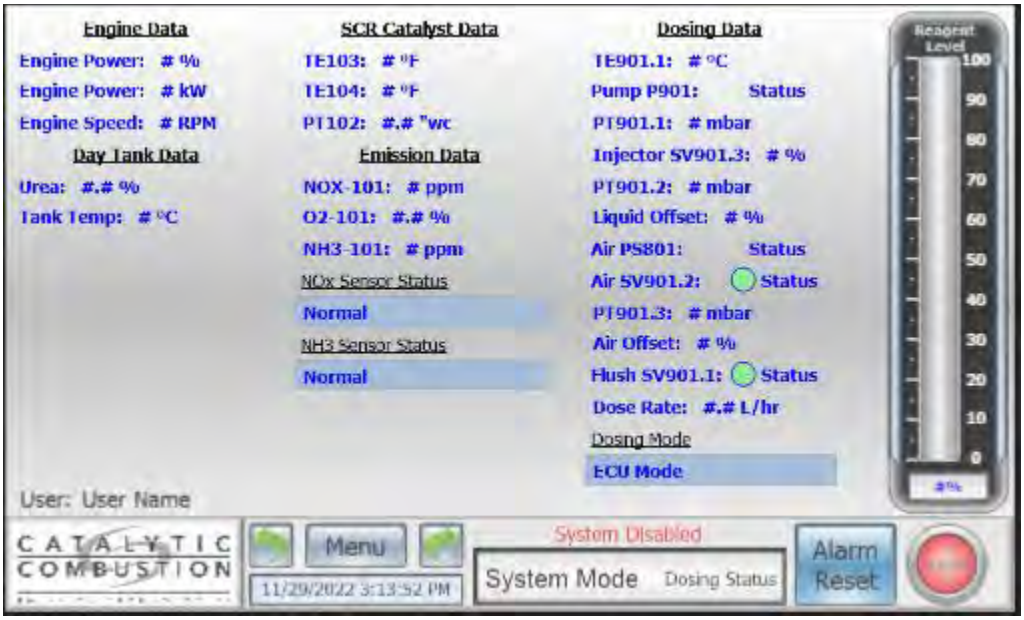

Figure 11: Sensor Screen to Monitor System Status

4.2.2. **System Shut Down**

The DEF Dosing System will shut down automatically if one of the following parameters is active:

1. Engine is off
2. Loss of load signal
3. Loss of compressed air or inadequate air pressure
4. TE103 <225°C (440°F)
5. DEF Day Tank level is too low
6. DEF pressure is too low
7. System enters an alarm state because of a malfunction reported by the DEF Dosing Unit or the DEF Pump

The system follows a specific procedure when it shuts down to prevent DEF from remaining in any of the components and potentially crystalizing. Power must be maintained to the DEF Dosing System for five minutes after the engine has shut down to ensure the system can completely purge before going to sleep. The procedure is as follows:

1. Injection stops
2. The pump evacuates the dosing unit and lines. DEF is returned to the DEF tank.
3. Compressed air is flowed through the various components at different rates to ensure the lines are cleared.

	The power must be maintained to the DEF Dosing System for five minutes after the engine has shut down to ensure the system can completely purge before going to sleep. Failure to do so will lead to plugging of the DEF Dosing System and poor performance and/or non-compliance.

5. Decommissioning/Dismantling/Recycling

The emissions aftertreatment system must remain in good operating order for the life of the engine. Failure to do so may lead to non-compliance with US EPA regulations.

Dismantling of the emissions aftertreatment system should be carried out by a qualified company and technician to ensure all legal and environmental processes are followed. All components should be recycled wherever possible. Ensure there is no electrical power to the system before dismantling the electrical components.

5.1. Disposing/Recycling Metals

The reactor is made of stainless steel and is completely recyclable.

5.2. Disposing/Recycling Catalysts

The DOTC/DOC or SCR catalysts can be returned to Catalytic Combustion for recycling. Costs for transport, packing, handling are the end user's responsibility.

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Maintenance Manual

Holt Texas LTD.

Holt CAT Single Lance (3516E) SCR Systems

VPN 1040251

Published December 2022

• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

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EMISSION TECHNOLOGIES

ISO 9001 Certified
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Integrity | Service | Excellence

Catalytic Combustion Corporation introduced cutting edge technology in 1950 with the development of the first ever US patented catalyst to destroy VOCs (Volatile Organic Compounds). Since that time, the company has expanded into the design and supply of catalysts and emission control system for a wide variety of industries. The Selective Catalytic Reduction System installed on this engine represents the most advanced and least maintenance intensive system enabling compliance with US EPA regulations.

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1. Forward

Please read and thoroughly understand this manual, the safety warnings and the complete system before attempting to service or maintain the system. Please observe all specifications, guidelines, and notes in the manual.

The graphics and photos may be representative. The parts on your package may not match the photos or drawings in this manual.

Please contact Catalytic Combustion Corporation with questions.

CONTACT INFORMATION

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2. Maintenance Schedule

This is a general maintenance schedule for SCR systems. Some equipment in this schedule may not be equipped for a specific SCR system.

			Interval		Interval (Hours)					
Component	**Subcomponent**	**Task**	**Weekly**	**12 Month**	**3,000 Engine Hours**	**6,000 Engine Hours**	**9,000 Engine Hours**	**12,000 Engine Hours**	**15,000 Engine Hours**	**18,000 Engine Hours**
Control Panel	Operators HMI	Review	X	X						
	Control Cabinet	Inspect		X						
	Cooler/Compressed Air Filter	Inspect		X						
		Replace			X	X	X	X	X	X
DEF Level	Level Gauge (HMI)	Inspect	X	X						
	Sending Unit/Pickup	Inspect		X						
	Sending Unit Filter	Replace					X			X
	Supply/Return Hose	Inspect		X						
DEF Dosing Unit	N/A	Inspect		X						
	N/A	Replace					X			X
	Primary DEF Filter	Replace			X	X		X	X	
	Compressed Air Filter	Inspect		X						
		Replace			X	X	X	X	X	X
DEF Pump	N/A	Inspect		X						
	N/A	Replace					X			X
Injection Nozzle	N/A	Inspect		X						
	N/A	Replace		X		X		X		X
NOx Sensor	Sensor Element	Inspect		X						
	Sensor Element	Replace				X		X		X
NH3 Sensor	Sensor Element	Inspect		X						
	Sensor Element	Replace				X		X		X
Thermocouple	N/A	Replace								X
Differential Pressure Sensor	N/A	Replace								X
Reactor	SCR Catalyst	Replace								X
	OC Catalyst (if equipped)	Replace								X
	DPF Modules (if equipped)	Inspect/Clean					X			X
	DOTC Catalyst(if equipped)	Clean					X			
		Replace								X
	Exhaust Pipe and Joints	Inspect		X						
	DEF Piping/Hose	Inspect		X						
	Wiring	Inspect		X						
	Insulation	Inspect		X						
	Compressed Air Supply	Inspect		X						

Figure 1: SCR General Maintenance Schedule

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3. Weekly Maintenance

This section details what maintenance needs to be carried out weekly.

1. Inspect HMI for Day DEF Tank Level. Ensure level is >15%.
2. Ensure the System is not in an alarm condition. An alarm condition is communicated by a Red Flag on the bottom of the HMI.
3. Visually inspect components for obvious signs of leakage or damage

4. Every Twelve (12) Months

This section details what maintenance needs to be carried out every 12 months of service. In addition to weekly checks, perform the following:

1. Inspect Control Cabinet by opening the door and visually inspecting inside for obvious signs of wear, damage, water, or oil intrusion (if equipped with a compressed air panel cooler).

	For systems equipped with a Compressed Air Panel Cooler, oil intrusion inside the Control Cabinet is a sign that the compressed air supply has excessive oil in the stream and does not meet ISO8573 Class 2.4.4 for compressed air cleanliness. Failure to remedy the situation is grounds for warranty denial in the event of a claim.

	Ensure the power supply to the Control Cabinet is disconnected before attempting any service inside the Control Cabinet.

2. If equipped with a compressed air panel cooler, inspect the coalescing filter/dryer for condensate and/or damage.

	The coalescing filter/dryer may be under pressure up to working pressure of the vessel. Ensure the pressure is relieved before attempting to service the coalescing filter/dryer.

3. Inspect the DEF Level Sensing Unit, fill valve and hose connections on the pick-up for visual signs of damage or leaks.
4. Inspect the DEF Dosing Unit located in the panel mounted on the reactor (refer to DWG 703275, Sheet 1, Zone D6 included in the drawings section of the Owners and Operators Manual) for visual signs of damage or leaks around the hoses, fittings and body of the unit.
5. Inspect the DEF Supply Pump located between the DEF Storage Tank and the Control Cabinet for visual signs of damage or leaks around hoses, fittings and body of the unit.

	DEF leaks are characterized by a white powder around fittings or by a snowflake pattern on a flat surface. After the leak is repaired, the area can be cleaned with fresh water.

6. Inspect exhaust pipes for signs of exhaust leaks.
7. Inspect exhaust insulation for signs of damage.
8. Inspect hardware for tightness.

9. Inspect NOx and NH3 Concentration sensor harnesses to ensure it is not chafing or rubbing against fasteners.
10. Inspect DEF Injection Lance hose to ensure it is not chafing or rubbing against fasteners.

5. Every 3,000 Hours of Operation

1. Replace the coalescing air filter element in the coalescing filter/dryer before the Control Panel Compressed Air Cooler (if equipped).
    a. Ensure the air pressure is bled off the system and that the engine is off
    b. Turn the condensate bowl ¼ turn counter clockwise
    c. Remove the existing filter
    d. Replace with new filter
    e. Reinstall the condensate bowl
    f. Repressurize the system and inspect for leaks

	For systems equipped with a Compressed Air Panel Cooler, excessive oil in the filter is a sign that the compressed air supply has excessive oil in the stream and does not meet ISO8573 Class 2.4.4 for compressed air cleanliness.

	Ensure air pressure is bled off the system before attempting to service the coalescing air filter element.

2. Replace the DEF Filter on the DEF Dosing Unit
    a. Ensure the engine is off and cool to the touch.
    b. Ensure the power supply to the control cabinet is off
    c. Open the Dosing Cabinet door. The dosing cabinet is located on the reactor (refer to Drawing 703275, Zone D6, Sheet 1 included in the drawings section of the Owners and Operators Manual).
    d. Locate the DEF Dosing Unit. The DEF Dosing Unit is shown in Figure below.

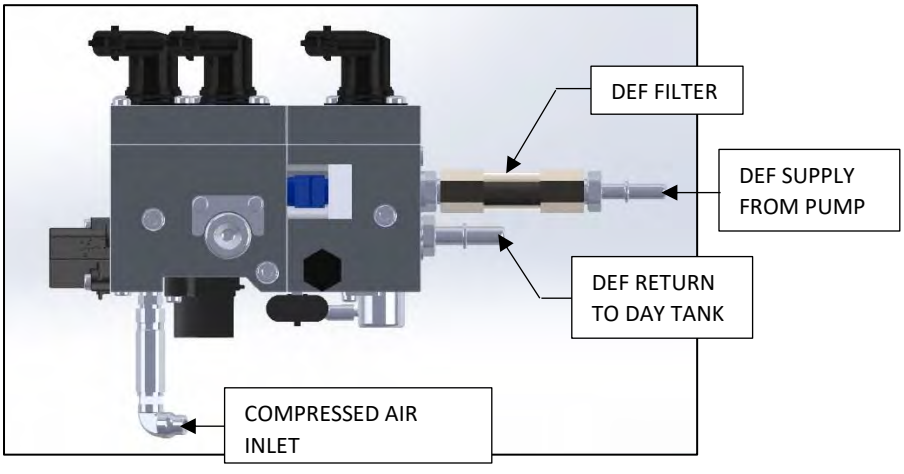

Figure 2: Def Dosing Unit

e. Remove the DEF Supply Hose from the end of the DEF Filter
    i. Lift up on the Locking Tab of the SAE J2044 fitting to unlock the fitting
    ii. Press down on the Thumb Tab and pull the fitting off the fitting on the DEF filter (Figure below)

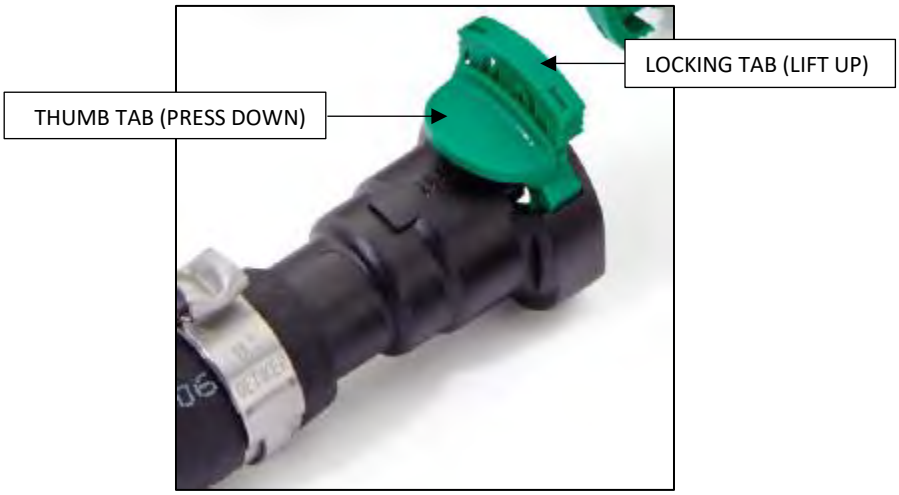

Figure 3: Removal of the DEF Fittings from the DEF Dosing Unit

f. Remove the DEF Filter by turning it counter clockwise with a wrench.

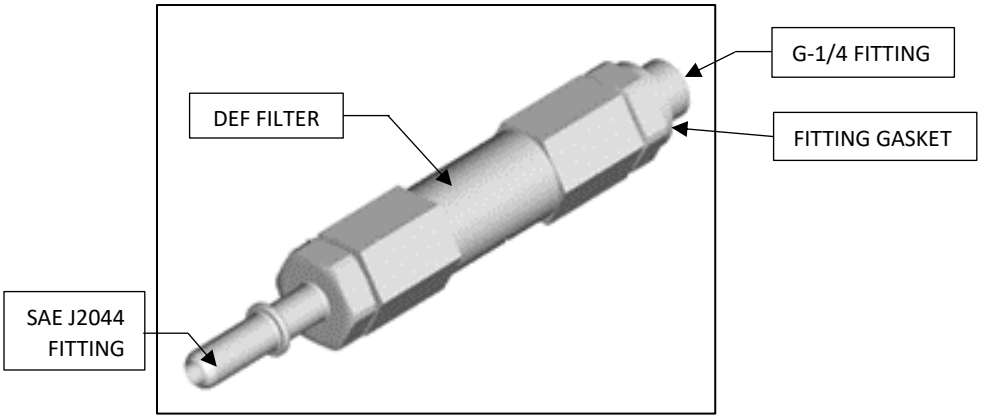

Figure 4: Replacement DEF Filter with Gasket and Fittings

g. Install new filter by threading it into the opening on the DEF Dosing Unit clockwise. The replacement DEF filter is provided complete (Figure 4) with a G-1/4 fitting on the filter outlet, a replacement gasket to seal the fitting against the DEF Dosing Unit and a SAE J2044 fitting on the inlet. It is ready to install and does not require any additional sealant, thread locker or Teflon tape. Tighten finger tight until the filter is seated against the Dosing Unit and then tighten to 15-17 lb-ft (20-23Nm).
    i. Note, the filter element inside the housing can also be replaced by separating the housing. CCC p/n: 1032986

	1. Do not add any additional sealant, thread locker or Teflon tape to the G-1/4 fitting. 2. Tighten the new fitting to 15-17 lb-ft (20-23Nm).

h. Reconnect the DEF supply hose to the DEF filter.
   i. Ensure the Locking Tab is in the UP position
   ii. Press the fitting onto the inlet of the DEF filter
   iii. Push down on the lock ring to lock it on the fitting
   iv. Test that the fitting is seated and locked by attempting to pull the fitting off the DEF filter

3. Replace the Coalescing Air Filter/Dryer filter element in the Air Pressure Regulator in the Dosing Panel (Figure below)

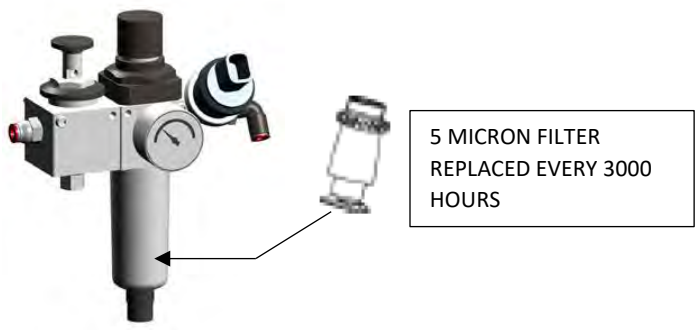

Figure 5: Air Pressure Regulator Coalescing Filter/Dryer

a. Ensure the air pressure is bled off the system and that the engine is off
b. Turn the condensate bowl ¼ turn counter clockwise
c. Remove the existing filter
d. Replace with new filter
e. Reinstall the condensate bowl
f. Repressurize the system and inspect for leaks

	Ensure air pressure is bled off the system before attempting to service the coalescing air filter element.

6. Every 6,000 Hours of Operations

1. In addition to the procedures for the 3,000 hour maintenance, the following items must be serviced at 6,000 hours of operation.
2. Replace the injection nozzle
   a. Ensure the engine is off, the exhaust system is cool and the engine cannot be started while servicing the injection nozzle.
   b. Locate the DEF Dosing Unit in the Dosing Cabinet
   c. Unscrew the outer hood of the Injection lance (Figure 6)

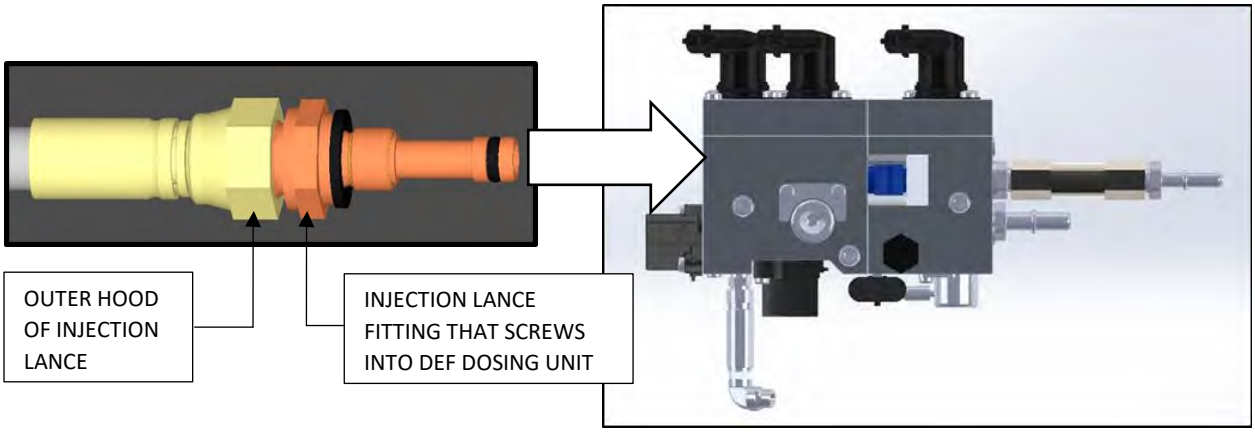

Figure 6: Injection Lance as it Screws into the DEF Dosing Unit

d. Unscrew the Injection Lance Fitting from the DEF Dosing Unit (Figure 6)
e. Pull the Injection Lance fitting from the DEF Dosing Unit and allow the hose to hang loose outside of the DEF Dosing Cabinet
f. Remove the 4 – bolts attaching the Injection Lance to the Reactor.
g. Remove Injection Lance from the Reactor.
h. Using the new gasket included with the new Injection Lance, reinstall the Injection Lance into the Reactor. The nozzle tip must be pointed with the direction of exhaust flow.

	IMPORTANT! The Injection Lance Nozzle Tip must be pointed with the exhaust flow direction!

i. Ensure the Gasket is installed on the end of the Injection Lance Fitting and lightly lubricate the O-Ring on the tip of the Injection Lance Fitting with a general purpose lubricant such as WD-40 (Figure 7).

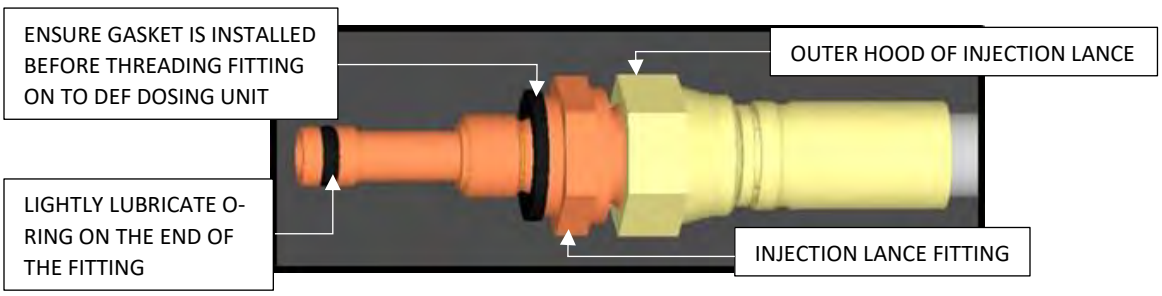

Figure 7: Injection Lance Fitting with O-Ring and Gasket

j. Find the center of DEF Dosing Unit with the end of the Injection Lance Fitting and press into place. Thread the fitting into the DEF Dosing Unit. Tighten to 10 lb-ft.
k. Thread Outer Fitting onto Injection Lance Fitting and tighten to 10 lb-ft.

	Ensure both the Injection Lance Fitting and the Outer Hood of the Injection Lance are tightened properly. Failure to tighten properly may result in air leaks, DEF leaks, system non-performance, regulatory non-compliance and increased maintenance.

3. Replace the NOx/NH3 Concentration Sensor

a. Ensure the engine is off and the exhaust system is cool to the touch before attempting to replace the NOx/NH3 Concentration Sensor.
b. Locate the NOx/NH3 Concentration Sensor ECU located on the side of the reactor see Drawing 703275, Zone E2, Sheet 1 included in the drawings section of the Owners and Operators Manual).
c. Unplug the NOx/NH3Concentration Sensor from the NOx/NH3 Concentration Sensor ECU extension cable. It is the rectangular plug, not the small round one (Figure below).

Figure 8: NOx/NH3 Concentration ECU and Sensor

d. Unscrew the NOx/NH3 Concentration Sensor from the reactor. The NOx/NH3 Concentration Sensor is located on the front of the reactor below the outlet pipe).
e. Apply Anti-Seize compound to the threads of the replacement NOx/NH3 Concentration Sensor and thread into the sensor location. Torque to 15lb-ft.

	IMPORTANT! Apply Anti-Seize compound to the threads of the NOx/NH3 Concentration Sensor. Failure to do so may prevent the sensor from being removed in the future and cause damage to the reactor.
	Do not get Anti-Seize compound on the sensing element. It may cause premature failure of the sensor. If Anti-Seize gets on the sensor, clean by applying a non-residue solvent to a rag and wipe the sensor element clean.

f. Route the wiring harness back to the NOx/NH3 Concentration Sensor ECU and plug into the ECU. Secure wiring harness to ensure it does not touch hot or rotating components.

7. Every 9,000 Hour Maintenance

1. In addition to carrying out the procedures in the 3,000 hour maintenance section, the following parts must be serviced. The DEF Filter does not need to be replaced. The DEF Dosing Unit is provided with a new DEF filter installed.
2. Replace the DEF Dosing Unit
    a. Ensure the engine is off and cool to the touch before replacing the DEF Dosing Unit.
    b. Remove the DEF Supply Hose from the end of the DEF Filter and the DEF Return fitting.
        i. Lift up on the Locking Tab of the SAE J2044 fitting to unlock the fitting
        ii. Press down on the Thumb Tab and pull the fitting off the fitting on the DEF filter and DEF return fitting (Figure below)

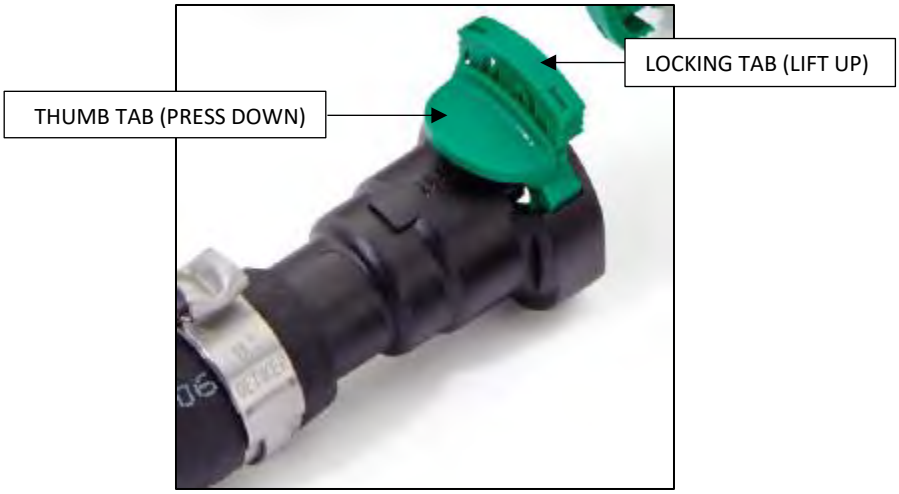

Figure 9: DEF Supply and Return Fitting

c. Unplug the DEF Dosing Unit Harness
d. Remove the ¼" air line
e. Remove Injection Lance from the DEF Dosing Unit.
f. Remove the 3 screws that hold the DEF Dosing Unit to the vibration isolators.
g. Install new DEF Dosing unit following the above steps
    i. Replace the O-ring at the tip of the injection lance and the Gasket at the base of injection lance fitting prior to reinstalling the injection lance into the DEF Dosing Unit.

⚠	You must replace the O-Ring at the tip of the Injection Lance and the Gasket at the base of the Injection Lance fitting prior to reinstalling the Injection Lance into the DEF Dosing Unit. Failure to do so may lead to leaking DEF, leaking compressed air, system under performance and regulatory non-compliance. Review Section 8.2.

3. Replace DEF Supply Pump
    a. Locate the DEF Supply pump.
    b. Remove the DEF Hoses from the Inlet and Outlet of the DEF Supply Pump.
    c. Unplug wiring harness from the DEF Supply Pump.
    d. Remove the 4 screws holding the DEF Supply Pump to the DEF Supply Pump Mounting Bracket.
    e. Reinstall following per the steps above.

8. Every 12,000 Hour Maintenance

The 12,000 Hour maintenance cycle is identical to the 6,000 hour maintenance procedure.

9. Every 15,000 Hour Maintenance

The 15,000 Hour maintenance cycle is identical to the 3,000 hour maintenance procedure.

10. Every 18,000 Hour Maintenance

1. The 18,000 hour maintenance cycle includes all items in the 9,000 hour maintenance as well as replacing the thermocouples, differential pressure transmitters, and SCR Catalyst.
2. Replace the Differential Pressure Transducer
    a. Locate the Junction Panel (see Drawing 703275, Zone E2, Sheet 1 included in the drawings section of the Owners and Operators Manual)
    b. Open the Junction Panel door. The differential pressure transmitter is located inside the Junction Panel and labeled PT10x.
    c. Remove the pressure hoses from the Push-To-Connect fittings by pressing down on the collar and pulling up on the hose.
    d. Remove the differential pressure transmitter wiring from the pressure transmitter. They should be labeled 24V and C8.
    e. Note the orientation of the sensor in the bracket to prevent mixing up the high and low pressure hoses when installing the new sensor.

	**IMPORTANT!** Note the orientation of the sensor prior to removing to prevent mixing up the high and low pressure hoses when installing the new sensor.

    f. Remove the Differential Pressure Transmitter from the bracket
    g. Remove the Push-To-Connect fittings from the sensor and install on the new sensor.

	Apply Teflon tape or anti-seize compound to the threads of the new pressure transducer to prevent thread galling over time.

    h. Install the new sensor into the bracket
    i. Install the high and low pressure hoses into the Push-To-Connect fittings (press the hose into the fitting)
        i. Rewire the 24V and C8 lines.
    j. Close the Junction Panel door and latch closed
3. Replace the Thermocouples (TE10x)
    a. Locate the yellow thermocouple connector (Figure 10) near the Control Cabinet and pull to unplug – TE10x.

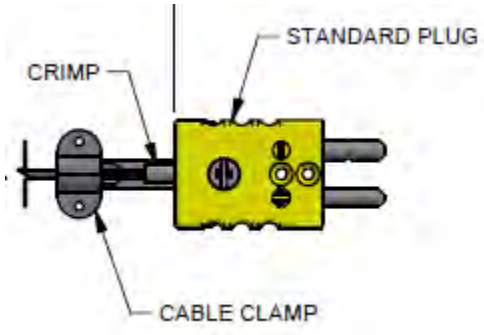

Figure 10: Thermocouple Connector

b. Unscrew the thermocouple from the Reactor
c. Apply anti-seize to the threads of the new thermocouple
d. Thread new thermocouple into the reactor

	Apply anti-seize compound to the threads of the new thermocouple to prevent thread galling over time.

e. Route harness back to connector on control panel and plug in.
f. Repeat for each thermocouple.

4. Replace the SCR Catalyst
   a. Ensure the engine is off, locked out and has not been running for at least 24 hours before attempting to replace the SCR catalyst. The SCR catalyst retains heat extremely well therefore has the potential to be hot for hours after the engine is shut off.

	Burn Warning! Ensure the engine is off, locked out and has not been running for at least 24 hours before attempting to replace the SCR catalyst. The SCR catalyst retains heat extremely well therefore has the potential to be hot for hours after the engine is shut off.

	Proper PPE must be worn during the SCR catalyst removal process. Please review your company policy regarding proper PPE. It is suggested that safety shoes, safety glasses, a dust mask and gloves (latex or work style) be worn when replacing the SCR Catalyst.

b. Locate the SCR catalyst access door hatch, see DWG 703275, Sheet 1.
c. Remove the Reactor insulation over access hatches.
d. Remove the hardware and open the access hatch. (Note: Gasket is not reusable and should be replaced).

	It is recommended that a dust mask or respirator be worn during this step. The insulation is a fiberglass type and the access door gasket is vermiculite impregnated fiberglass. Fibers may be shaken loose when working this step.

e. Loosen the hardware securing the SCR catalyst in place.

	Each SCR Catalyst weighs approximately 55lbs.

f. Remove the SCR catalyst through access hatches.
g. Re-Gasket SCR Catalyst Wall Face.
h. Install replacement SCR Catalysts. Each catalyst is the same therefore it does not matter which slot the catalyst is installed.
i. Torque first nut to 30 ft-lbs using a torque wrench or monitoring device.
j. While holding first nut from rotating torque the second/jam nut to 45 ft-lbs
k. Install new gasket onto access hatch seal faces.

l. Re-install the side access hatches.
m. Tighten exterior hardware to 45lb-ft

11. Lay-up Maintenance

Should the SCR system not be installed or not operated for an extended period of time (>1 month), take the following actions to ensure proper start-up.

1. Install Foreign Material Exclusion (FME) covers to inlet and outlet piping to the reactor as necessary. Ensure any ports where instrumentation is not installed are closed.

2. The DEF pump is a gear driven, positive displacement type pump. Lubricate gear internals by applying PTFE lubricant through the inlet and outlet ports of the pump. This will ensure proper lubrication during the dry priming cycle upon start-up.

3. DEF has a shelf life that is dependent upon temperature which could be as little as six months when stored above 120 F. Consult the specific DEF provider to understand storage requirements based on time and temperature conditions.

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Parts Manual

Holt Texas LTD.

Holt CAT Single Lance (3516E) SCR Systems

VPN 1040251

Published September 2022

• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

PROJECT NAME:		Single Lance			
PROJECT #:		1040157-CP-B7-157KG-3030_NA-NA-UZ-1	REV:	A	
DESCRIPTION:		Electrical Bill of Materials	DATE:	9/23/2022	
Qty	**Ref.**	**Description**	**Manufacturer**	**Manufacturer Part No.**	**CCC Part #**
Control Panel					
1	CB145	CB 15A 2P 1489 Series C-Curve AB	Allen-Bradley	1489-M2C150	1040149
1	CB150	CB 2A 1P 1492 Series C-Curve AB	Allen Bradley	1492-SPM1C020	1035679
1	CB155	CB 4A 1P 1492 Series C-Curve AB	Allen Bradley	1492-SPM1C040	1039560
1	CB159	CB 2A 1P 1492 Series C-Curve AB	Allen Bradley	1492-SPM1C020	1035679
1	CB207	CB 10A 1P 1492 Series C-Curve AB	Allen Bradley	1492-SPM1C100	1035680
1	CB223	CB 2A 1P 1492 Series C-Curve AB	Allen Bradley	1492-SPM1C020	1035679
1	CB235	CB 8A 1P 1492 Series D-Curve AB	Allen Bradley	1492-SP1D080	1011800
1	CR215	Relay 24VDC DPDT LED 8Amp IDEC	IDEC	RJ2S-CL-D24	1028528
1	CR215	Relay Base DPDT 8AMP	IDEC	SJ2S-05BW	1028530
1	CR353	Relay 24VDC DPDT LED 8Amp IDEC	IDEC	RJ2S-CL-D24	1028528
1	CR353	Relay Base DPDT 8AMP	IDEC	SJ2S-05BW	1028530
1	MCR231	Relay 24VDC DPDT LED 8Amp IDEC	IDEC	RJ2S-CL-D24	1028528
1	MCR231	Relay Base DPDT 8AMP	IDEC	SJ2S-05BW	1028530
1	DS143	Disconnect Non Fused 32Amp 3 Pole 600vac	Socemec	22003003-UL	1027554
1	DS143	Disconnect Handle S00 Nema 4/4x	Socemec	147D1111	1027556
1	DS143	Disconnect Handle Shaft S0 320mm	Socemec	14070532	1027557
1	ECU401	ECU Bracket	STT Emetec AB	102184-01	1026051
1	ECU401	ECU Connector	Allied Electronics	70231196	1026052
1	ECU401	ECU 57kg/hr 6ft whip -5 to 15V	STT Emetec AB	110058-00	1036227
1		Enclosure 30x30x8 SCE NEMA 4 Gray	SAGINAW Control and Engineering	SCE-30EL3008LP	1033211
1		Sub-Panel, Mounting 30x30	SAGINAW Control and Engineering	SCE-30P30	1001827
1	HMI223	HMI Color 7in touch 24vdc	Beijer Electronics Inc.	630001805	1030286

PROJECT NAME:		Single Lance			
PROJECT #:		1040157-CP-B7-157KG-3030_NA-NA-UZ-1	**REV:**	A	
DESCRIPTION:		Electrical Bill of Materials	**DATE:**	9/23/2022	
Qty	**Ref.**	**Description**	**Manufacturer**	**Manufacturer Part No.**	**CCC Part #**
1	HMI223	HMI Can Bus Module	Beijer Electronics Inc.	100-0193	1030287
1	HS231	Block Contact NCLB 10A AB	Allen Bradley	800F-MX01L	1000573
1	HS231	Legend Yellow Estop 40mm AB	Allen Bradley	800F-15YE112	1000587
1	HS231	Pushbutton Mushroom Head Red	Allen Bradley	800FP-MT44	1000607
1	HS231	Guard E-Stop Yellow 40mm AB	Allen Bradley	800F-A6PR5	1002260
1	PLC241	MODBUS TCP/UDP network adapter	Beijer Electronics Inc.	GN-9289	1031701
1	PLC252	Analog ThermoCouple Input Module - 4 points	Beijer Electronics Inc.	GT-3804	1031702
1	PS206	Power Supply 120V-24VDC 10A	Meanwell	SDR-240-24	1030088
1	U150	Receptacle Duplx GFCI 120VAC 15A Encl AB	Allen Bradley	1492-REC15G	1017322
1	UPS200	UPS, SDU850B	SolaHD	SDU850B	1039053

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

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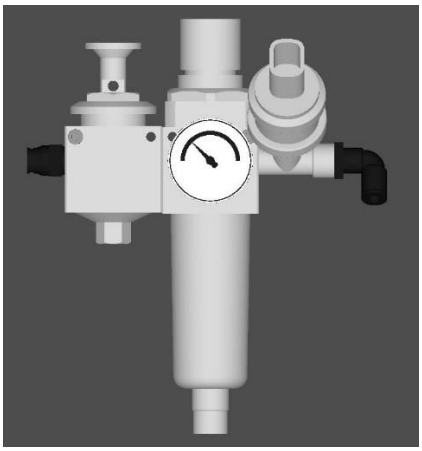
CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

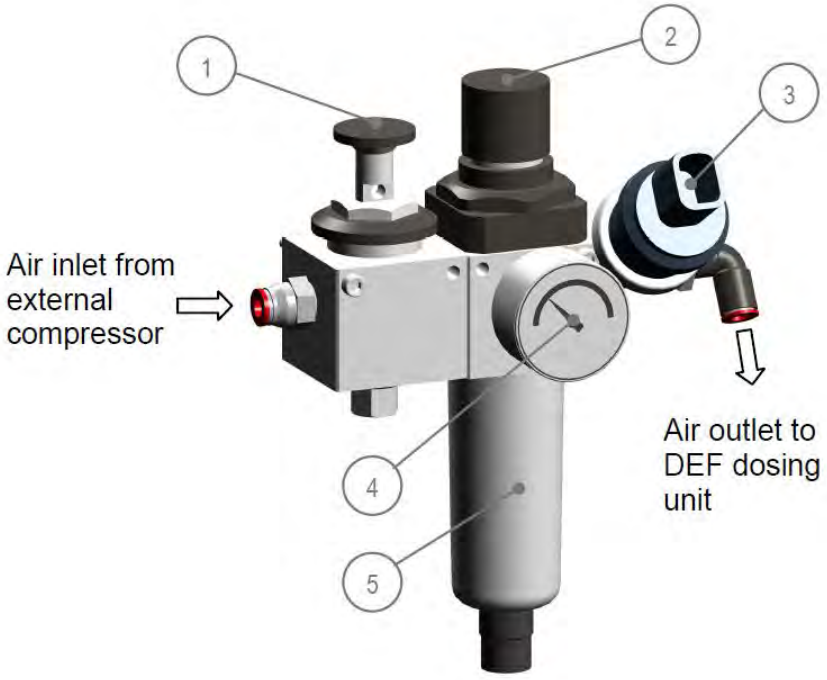
Datasheet

Compressed Air Regulator/Dryer



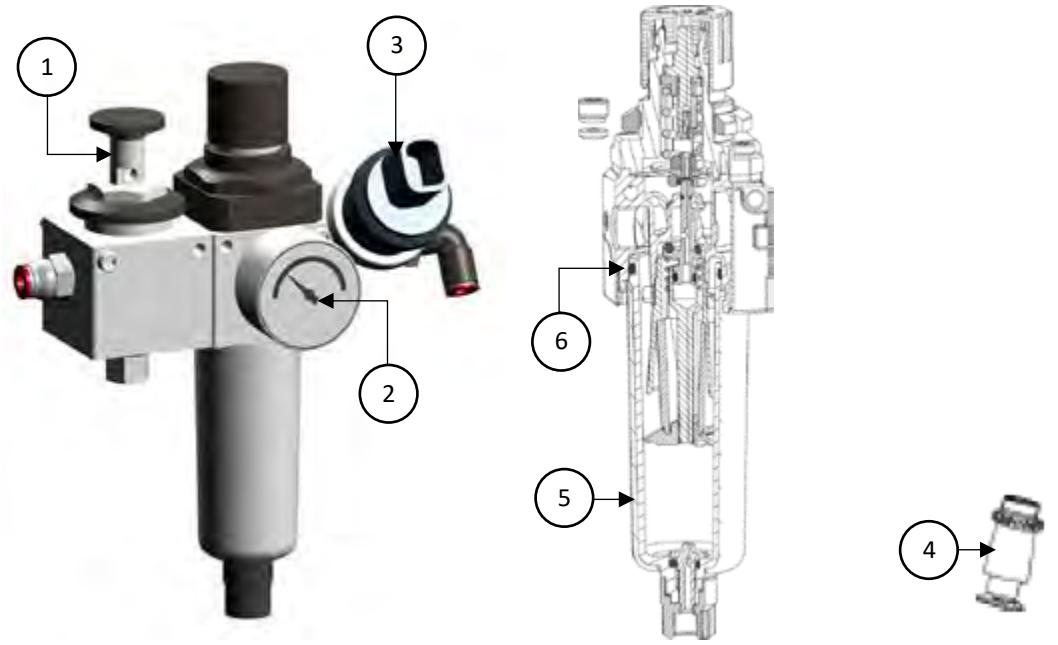
Published January 2019

Product Family		SCR Dosing System
Function		Compressed air regulator/dryer
Purpose		Regulate air pressure and dry air supply
Material		Brass, NBR, technopolymer
Mounting		Inside Dosing Cabinet with DEF dosing unit
Media		Compressed Air
Pressure	Inlet	Max 16bar
	Outlet	0.5 to 10bar
Filter	Pore Size	5µm
Drain		Automatic
Connection	Inlet	¼" OD Teflon or polyamide tube



Call Out	Description
1	Shut off valve
2	Pressure regulator
3	Pressure switch
4	Pressure gauge
5	Condensate trap

SPARE PARTS



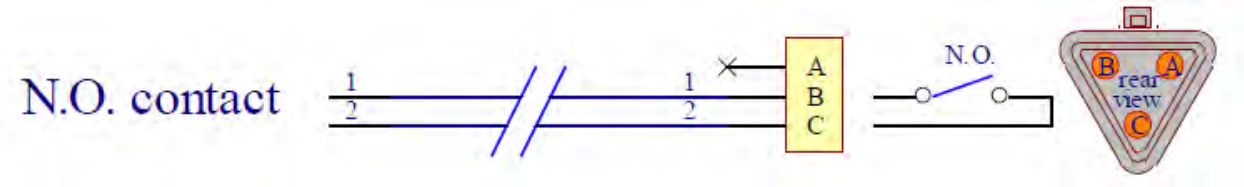
Item	Detail	P/N
1	Shut off valve	107357
2	Gauge	108859
3	Pressure switch	109578
4	Replacement Filter, 5µ	1028298
5	Bowl, complete with semi-auto drain	1028297
6	Standard Bowl O-Ring	1028299

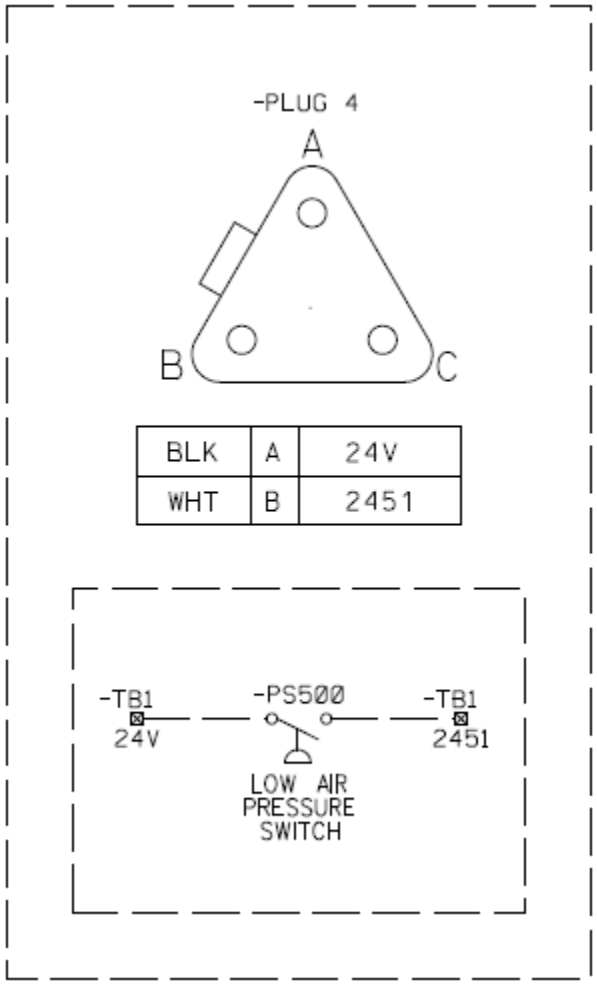
MECHANICAL INTERFACES

Description	Air Connection	Thread Pitch
Inlet	¼” OD Poly or Teflon, Push-to-Connect	¼” female NPT
Outlet	¼” OD Poly or Teflon, Push-to-Connect	N/A

ELECTRICAL INTERFACE

Pressure Switch





CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

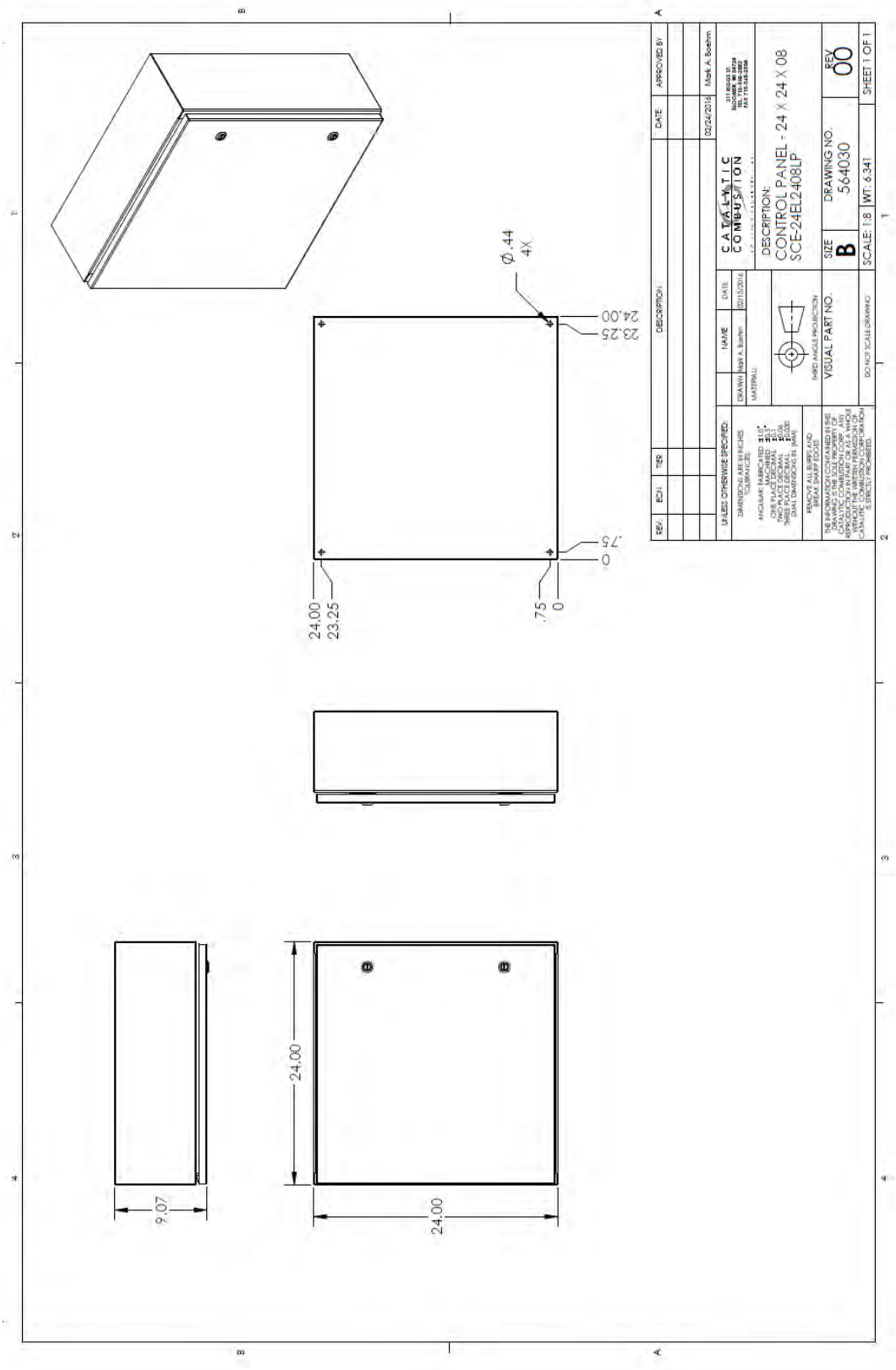
Selective Catalytic Reduction (SCR) System

Datasheet

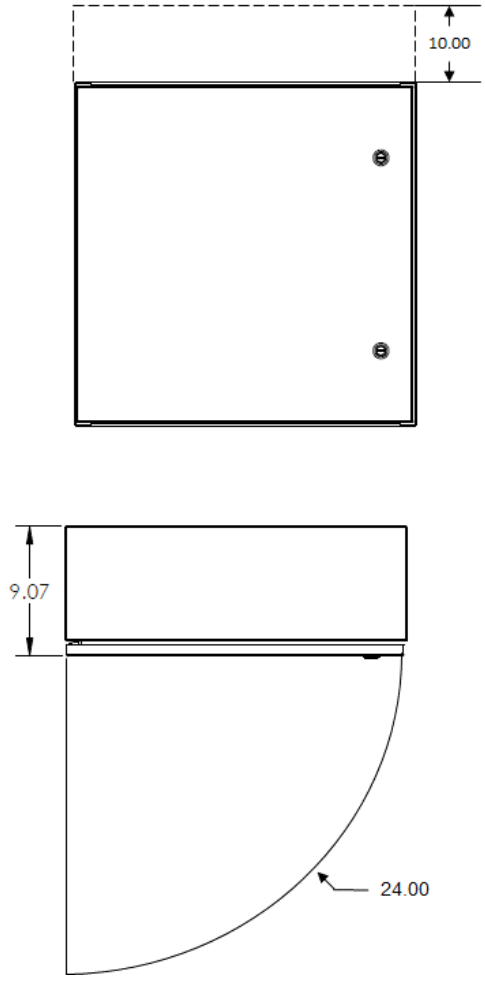
DEF Dosing System Control Panel with HMI

Published January 2019

Product Family		SCR Dosing System
Function		DEF Dosing Control Unit
Purpose		DEF Dosing System Control, 0.4l/h – 10l/h
Temperature	*Environment*	-20°C to +55°C (-4°f to +131°f)
	Storage	-25°C to +75°C (-13°f to +167°f)
Power	*Voltage*	24 VDC
	Nominal Current	11.25A (at 24 VDC)
Material	*Enclosure*	Stainless Steel
	Cable Glands	Nickle plated, steel
	Tube Fitting	Bulkhead, ¼" OD tube
Weight		32kg (70lbs)
Environmental Protection		IP65
Mounting	*Fixing*	Bolted, 4x 5/16 dia with isolation
	Location	Rear
Scope of Supply		Assembled component, no loose parts
Air Conditioning		None


Ø.44
4X
24.00
23.25
.75
0
24.00
23.25
.75
0
24.00
24.00
9.07
DESCRIPTION:
CONTROL PANEL - 24 X 24 X 08
SCE-24EL2408LP
DRAWING NO.
564030
SIZE
B
REV
00
SCALE: 1:8
WT: 6.341
SHEET 1 OF 1

REQUIRED MAINTENANCE SPACE

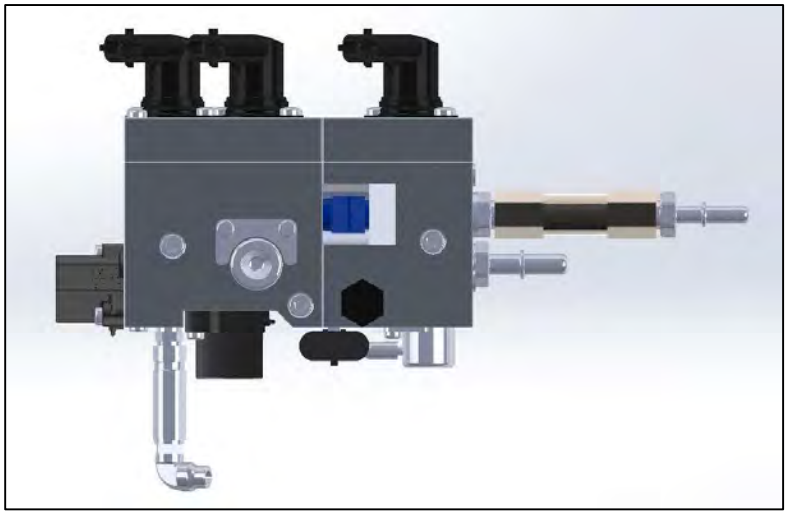


CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

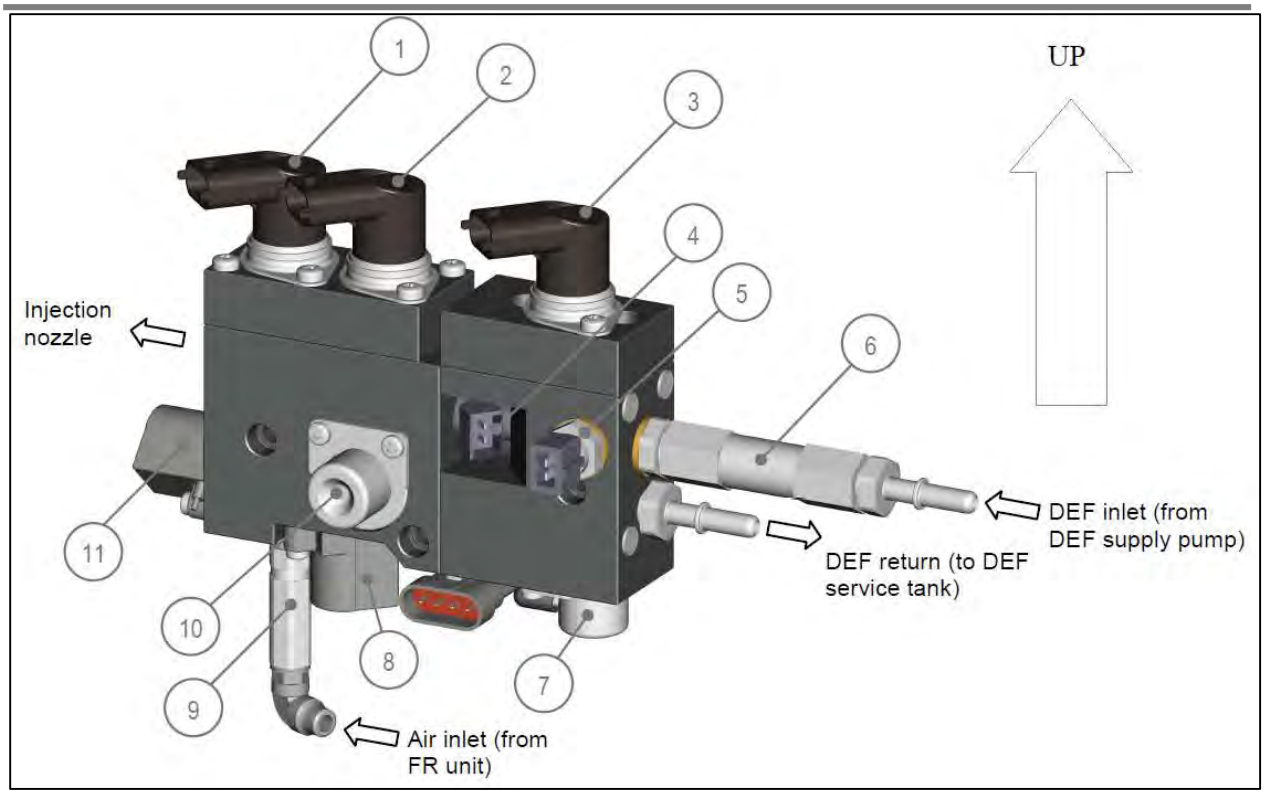
Datasheet

DEF Dosing Unit (DDU)



Published January 2019

Product Family		SCR Dosing System
Function		DEF Dosing Unit
Purpose		DEF Dosing control, 12kg/hr – 57kg/hr
Media	Reactant	Type: Diesel Exhaust Fluid (DEF), AUS 32.5
		Pressure: 5bar
		Quality: Per ISO22241 (32.5% Urea Conc.)
	Air	Consumption: 4cfm (nominal), 7cfm (peak)
		Pressure: 4.5bar (+/- 0.25bar)
		Quality: ISO8573-1:2010, Class 4.4.4
Materials	Housing	Anodized aluminum
Interfaces	Reactant	SAE J2044
	Air	Push-to-connect, ¼" Teflon or poly
	Electric	Deutsch
Supply	Power	20W (nominal), 25W (peak)
	Voltage	5 VDC, 12 VDC (FROM CONTROL CABINET)
Weight		1.7kg (4.0lbs)
Mounting	Interface	Via 3 vibration isolators
	Location	DEF Dosing Cabinet
Temperature	Environment	-40°C to +50°C (-40°f to +122°f)
	Storage	Same
	Media	Air: 0°C to +40°C (32°f to 104°f)
		Reactant: -5°C to +50°C (23°f to +122°f)
Environmental Protection		IP65
Scope of Supply		Assembled Part, no loose items

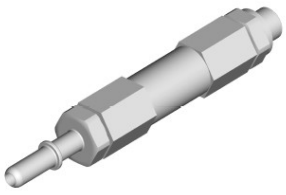


Position	Detail	Part Number
1	DEF Pressure Sensor	1028120
2	DEF Pressure Sensor	1028120
3	DEF Pressure Sensor	1028120
4	DEF Injector (NOT USER SERVICEABLE)	N/A
5	DEF Temperature Sensor	1028121
6	DEF Filter	1028126
7	DEF Pressure Regulator	1028123
8	Compressed Air Solenoid (Flush)	1028124
9	Compressed Air Check Valve	1028125
10	DEF Pressure damper	1028122
11	Compressed Air Solenoid (Atomization)	1028124

MAINTENANCE ITEM

DEF FILTER (ANNUAL): p/n 1028126

Complete with gasket and fittings.



MECHANICAL INTERFACES

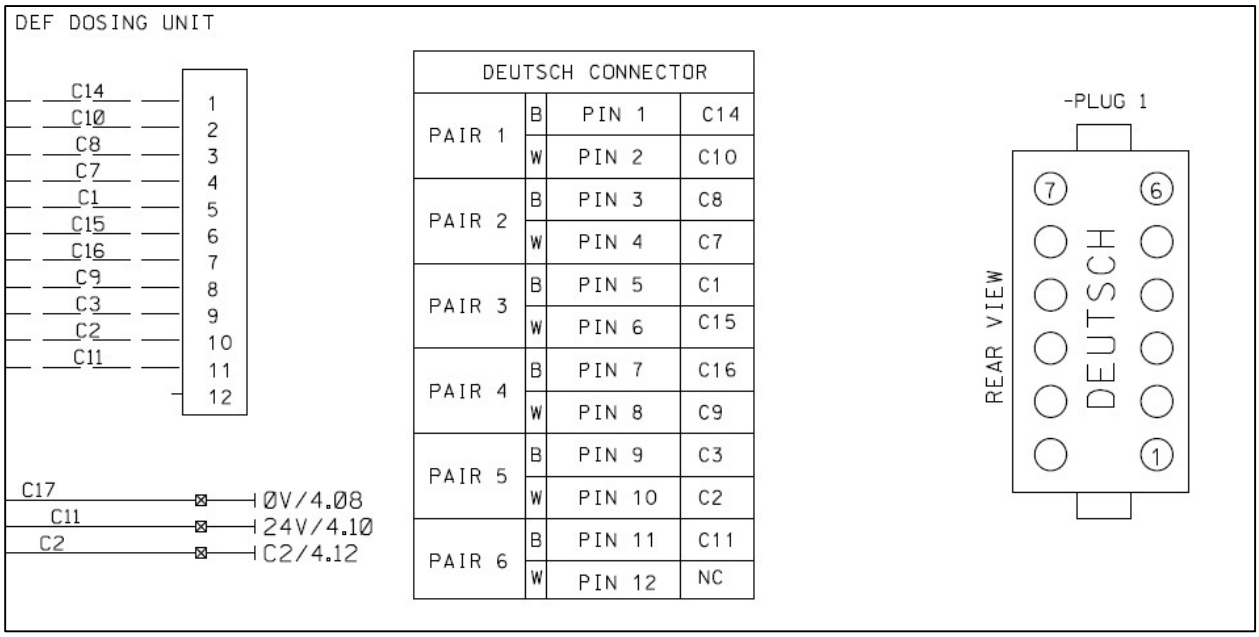
Detail	Liquid Sealing	Thread Pitch (DDU)
DEF Inlet from DEF Supply Pump	SAE J2044, 5/16” diameter	¼” NPT
DEF Return to Storage Tank	SAE J2044, 3/8” diameter	G-1/4
DEF/AIR to Injection Nozzle	***SPECIAL – Contact Catalytic Combustion with questions***	

Liquid sealing via Parker Safe Lock or Equivalent.

Description	Parker Safe Lock P/N	Photo
Straight End form: 5/16” Barb tail: 5/16”	**A614 A50 G06 02**	
Straight End Form: 3/8” Barb Tail: 3/8”	**A614 M53 08 02**	
90 Degree End form: 5/16” Barb tail: 5/16”	**A624 A50 D06 02**	
90 Degree End Form: 3/8” Barb tail: 3/8”	**A624 M53 08 02**	

HOSE AND CLAMPING EXAMPLE		
Description	**P/N**	**Photo**
Hose, 5/16” I.D., 7/16” O.D. PTFE with 304 SS Braid	**McMaster-Carr 52515K3**	
Hose, 3/8” I.D., 9/16” O.D.	**McMaster-Carr 52515K4**	

ELECTRICAL INTERFACE



DEUTSCH CONNECTOR			
PAIR 1	B	PIN 1	C14
	W	PIN 2	C10
PAIR 2	B	PIN 3	C8
	W	PIN 4	C7
PAIR 3	B	PIN 5	C1
	W	PIN 6	C15
PAIR 4	B	PIN 7	C16
	W	PIN 8	C9
PAIR 5	B	PIN 9	C3
	W	PIN 10	C2
PAIR 6	B	PIN 11	C11
	W	PIN 12	NC

CATALYTIC COMBUSTION

EMISSION TECHNOLOGIES

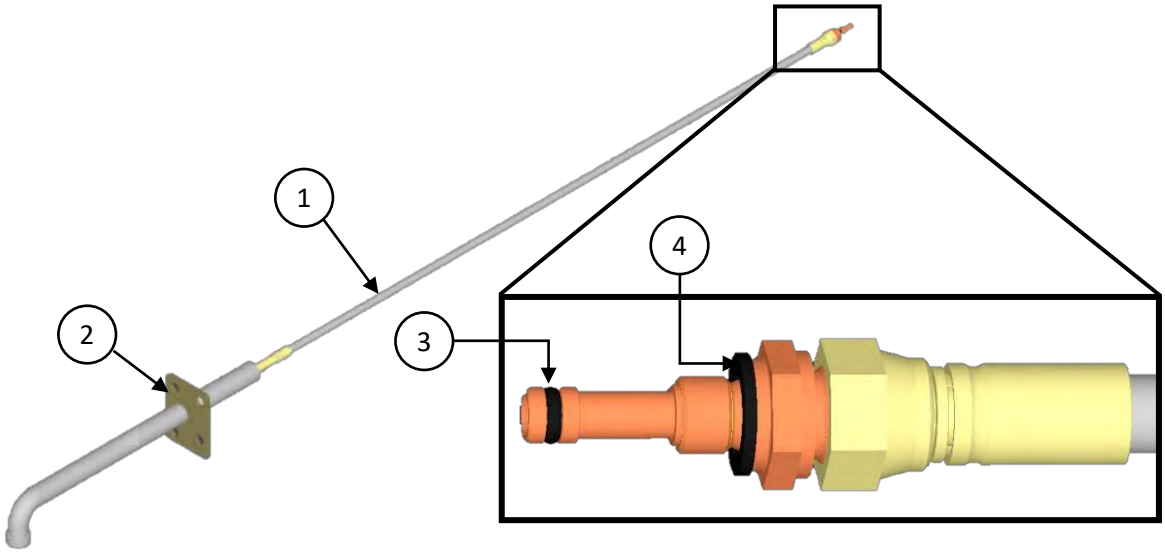
Selective Catalytic Reduction System

Datasheet

DEF Injection Lance

Document No.: INJ Rev. 0 Published January 2021

Product Family		SCR Dosing System, Stationary
Function		DEF Injector
Purpose		Inject DEF into exhaust stream
Media	Reactant	DEF (32.5% urea concentration) AUS 40 (40.0% urea concentration)
		Pressure, 5bar
		Quality per ISO22241 (DEF, 32.5% conc.) Quality per ISO18611 (AUS 40, 40% conc.
	Air	Consumption: 4cfm (nominal), 7cfm (flushing)
		Pressure: 4.5bar (+/- 0.25bar)
		Quality per ISO 8573-1:2010 Class 4:4:4
Materials	Body	Stainless steel, Teflon
	Part in contact with media	Stainless steel, Teflon
Connections	Reactant	Proprietary sealed design at DDU.
	Air	
Weight		3.4kg (7.5lbs)
Mounting		Flange mount, keyed for direction, gasketed
Temperature	Environment	-40°C to +260°C (-4°f to +500°f)
	Storage	-40°C to +75°C (-4°f to +167°f)
	Media	Reactant: -5°C to +50°C (23°f to +122°f)
		Air: -5°C to +75°C (23°f to +167°f)
Scope of Supply		Assembled component, no loose parts



Position	Detail	VPN
1	DEF Injector, Complete	1036226
2	Injector Flange Gasket	1026556
2	O-ring	1028149
3	Washer, gasket	1028150

MECHANICAL INTERFACES

Detail	Liquid Sealing	Thread Pitch
Connection to DDU	Via machined fit and O-ring	G-1/4

ELECTRICAL INTERFACE

None

CATALYTIC COMBUSTION

EMISSION TECHNOLOGIES

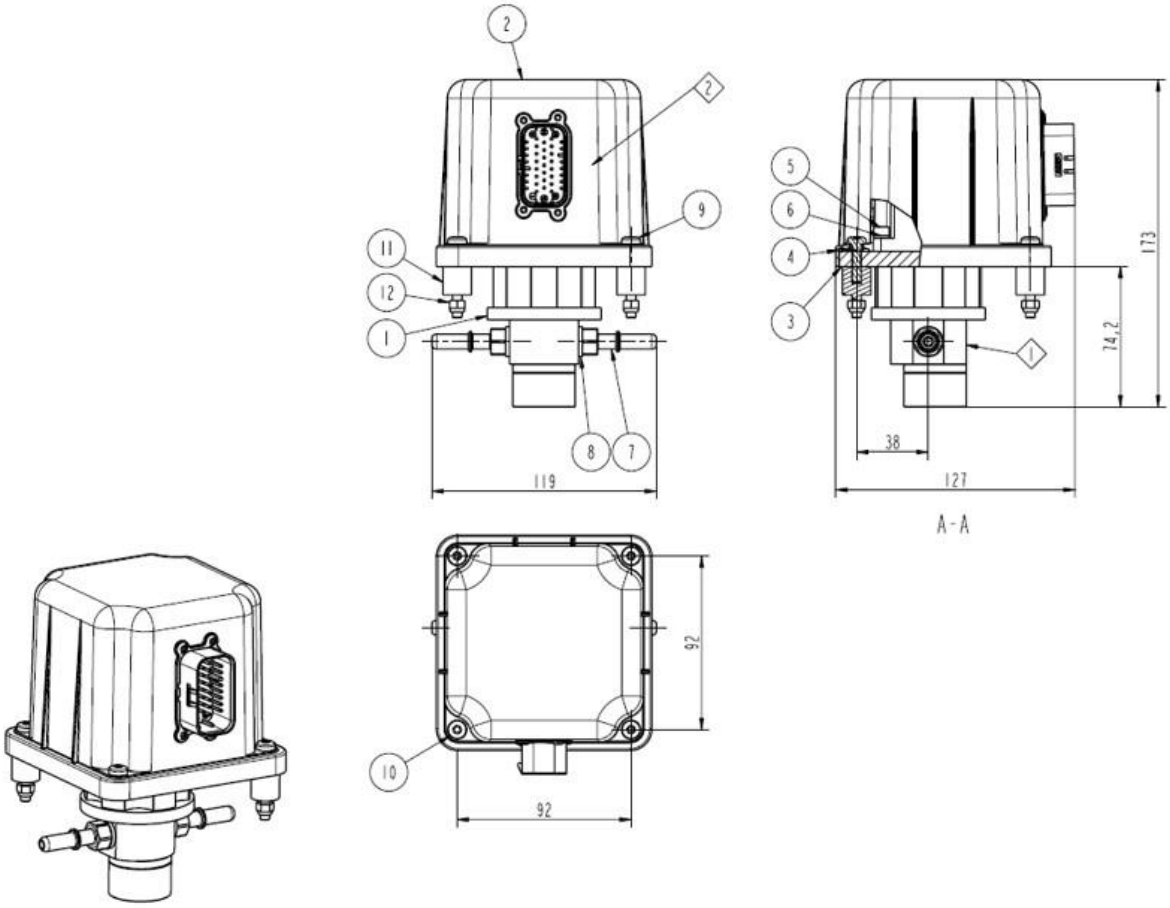
Selective Catalytic Reduction (SCR) System

Datasheet

DEF Supply Pump

Published: June 2018

Product Family		SCR Dosing System
Function		DEF Supply Pump
Purpose		DEF supply to DEF Dosing Unit
Media	Reactant	Diesel Exhaust Fluid (DEF)
	Quality	Per ISO22241 (32.5% urea solution) Per ISO18611 (40% urea solution)
Pressure	Pressure	5 bar (MAX)
	Suction Height	2m (6ft) (MAX)
Flow Rate	liters/hr (gal/hr)	75 (19.8) maximum
Temperature	Environment	-20°C to +50°C (-4°f to +122°f)
	Storage	-40°C to +75°C (-40°f to +167°f)
	Reactant	-5°C to +50°C (+23°f to +122°f)
Power	Watts	50W (nominal), 75W (peak)
	Supply	24VDC (supplied from DEF Dosing Control Unit)
Material	ECU	ABS, Aluminum, Copper
	Pump	Stainless steel
	Parts in contact with reactant	Stainless Steel
Weight		2.9kg (6.4lbs)
Degree of Protection		IP65
Mounting	Fixing	Via 4 vibration isolators
	Position	Vertical only, pump down
Scope of Supply		Assembled component, no loose parts

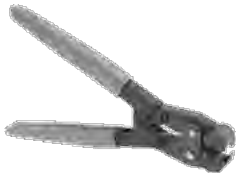


Position	Detail
1	DEF Pump (Marked with direction of flow)
2	DEF Pump, ECU
3	DEF Pump, Baseplate
4	Sealing Ring
5	Screw, MC6S 5x16 FZB
6	Washer spring, M5
7	Fitting, SAE J2044, 5/16”, G-1/8”
8	Washer, R1/8”, Tredo 12
9	Screw, MRT, 5x20, Torx, black
10	Screw, MRT, M5x10, Torx, Black
11	Vibration isolator
12	Nut, M5 with nylon lock ring

MECHANICAL INTERFACES

Detail	Liquid Sealing	Thread Pitch
DEF Inlet from DEF Storage Tank	SAE J2044, 5/16” diameter	G-1/8
DEF Outlet to DEF Dosing Unit (DDU)	SAE J2044, 5/16” diameter	G-1/8

Liquid sealing via Parker Safe Lock or Equivalent.

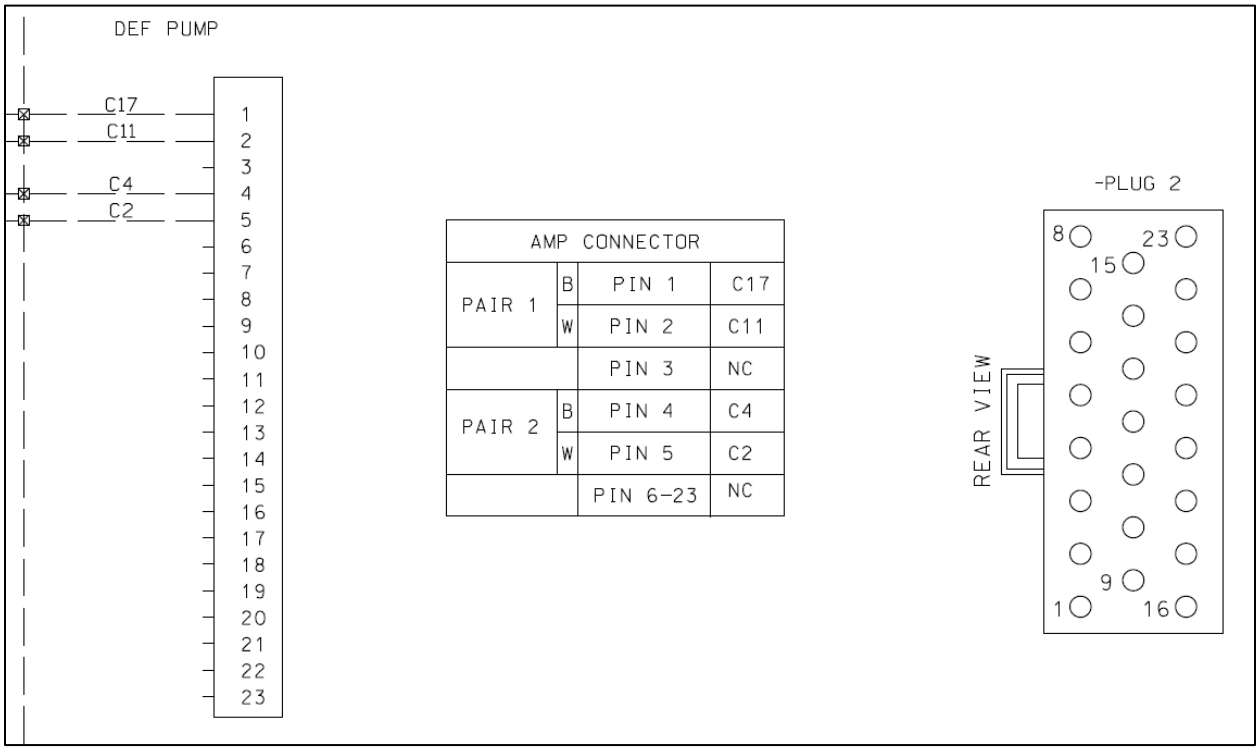
Description	Parker Safe Lock P/N	Photo
Straight End form: 5/16” Barb tail: 5/16”	**A614 A50 G06 02**	
90 Degree End form: 5/16” Barb tail: 5/16”	**A624 A50 D06 02**	
HOSE AND CLAMPING EXAMPLE		
Description	**P/N**	**Photo**
Hose, 5/16” I.D., 7/16” O.D. PTFE with 304 SS Braid	**McMaster-Carr 52515K3**	
Single pinch vibration resistant clamp (304SS), 13/32” to 31/64”	**McMaster-Carr 5435K14**	
Pinch Clamp Pliers	**McMaster-Carr 6541K69**	

MAINTENANCE ITEMS

None. Replace pump and/or ECU per Maintenance Schedule or upon demand. See Parts Manual.

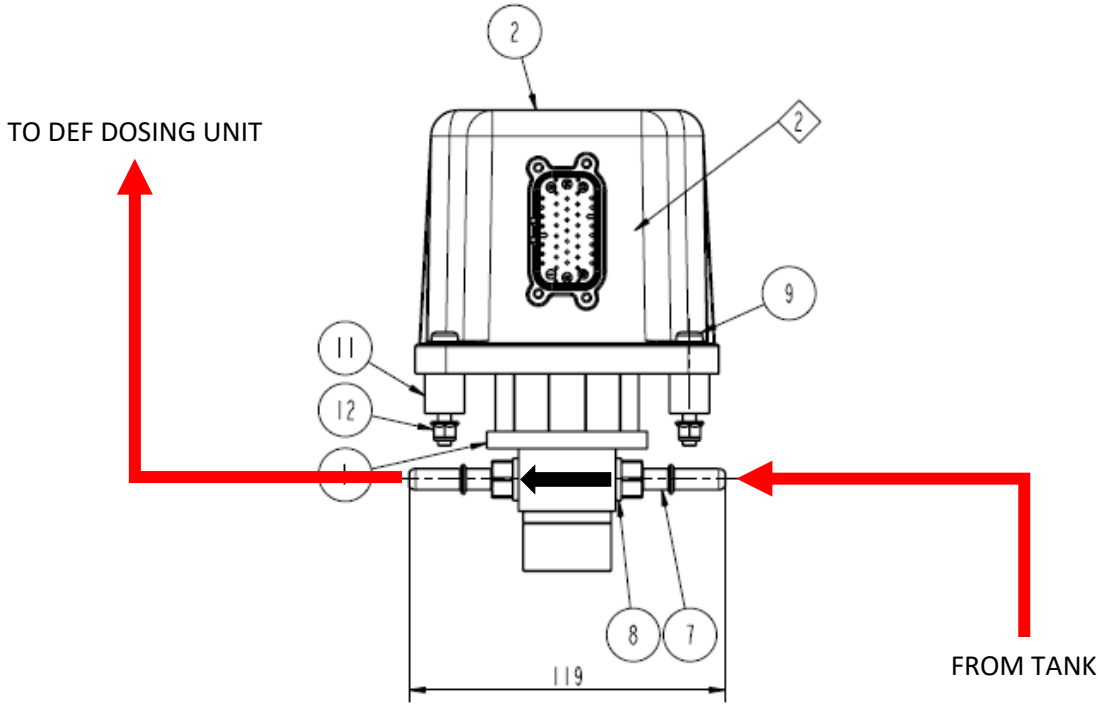
ELECTRICAL INTERFACE

Electrical interface is via an AMP style plug on the pump and terminal strip in the DEF Dosing Control Cabinet.



AMP CONNECTOR			
PAIR 1	B	PIN 1	C17
	W	PIN 2	C11
		PIN 3	NC
PAIR 2	B	PIN 4	C4
	W	PIN 5	C2
		PIN 6–23	NC

1. The pump is marked with a flow direction arrow. Please observe direction of flow through the pump.



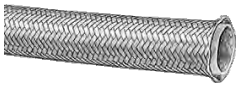
2. Liquid connections are made via fittings meeting the SAE J2044 standard. Male fittings are provided on the pump. Female fittings are NOT included with the system; however, they are widely available from Parker. They are available in a straight form or 90° form. Part numbers are shown below.

Description	***Parker Part Number***	
5/16” end form and hose barb, straight	A614A50G06 02	
5/16” end form and hose barb, 90°	A624A50D06 02	

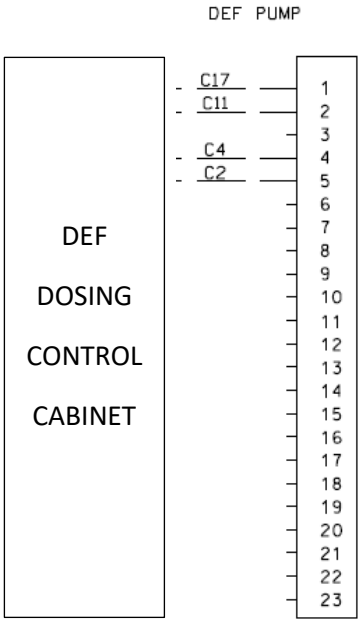
Catalytic Combustion recommends the use of tubing made with FEP Teflon for applications where the tube is protected from abrasion. PTFE or PFA Teflon hose protected by stainless steel braiding is suggested where the hose may be at risk of abrasion or routed near hot components.

5/16” I.D. hose is required.

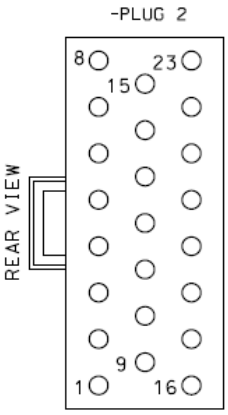
Single pinch or double pinch hose clamps are suggested instead of worm gear type clamps. Suggestions for hose and hose clamps are shown below.

Description	***McMaster-Carr Part Number***	
Teflon PTFE hose with 304 stainless steel braid, 5/16” ID, 7/16” OD	52515K3	
Single pinch, Tight-Seal Vibration resistant pinch clamp, 27/64” – 17/32”	52545K51	

3. Catalytic Combustion includes a wiring harness terminated with the correct AMP style connector on one end and striped bare wire on the other.
    a. The connector plugs into the pump
    b. The unterminated end is routed to the DEF Dosing Control Cabinet where the wires are inserted into the appropriate terminal strips



AMP CONNECTOR			
PAIR 1	B	PIN 1	C17
	W	PIN 2	C11
		PIN 3	NC
PAIR 2	B	PIN 4	C4
	W	PIN 5	C2
		PIN 6-23	NC



CATALYTIC COMBUSTION

EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Datasheet

Exhaust Pressure Transducer

Document No.: Differential Pressure

Published January 2019

Product Family	SCR Dosing System
Function	Exhaust Pressure Sensor
Purpose	Sense differential pressure across catalyst bed
Media	Wet exhaust gas
Accuracy	0.08% BSL linearity, hysteresis and repeatability combined
Operating Temperature	-45°C to 115°C (-20°F to 239°F)
Compensated Temperature Range	-29°C to +85°C (-20°F to 185°F)
Pressure Cycles	1 million, minimum
Long Term Stability	+/- 0.1%, full scale
Response Time	<1ms
Compliance	CE, EN61326-1: 2006 for industrial locations
Wetted Parts	316L stainless steel
Line/Static Pressure	35bar max applied to both sides simultaneously
Proof Pressure (Differential)	6.8bar
High side containment pressure	To 70bar
Pressure Ports	¼” male NPT
Electrical Termination	Cable
Output	4-20mA
Weight	350g

Position	Detail
1	PIT101 Low Pressure
2	PIT101 High Pressure

MECHANICAL INTERFACES

Detail	Liquid Sealing	Thread Pitch
Inlet and Outlet	N/A	¼" male NPT

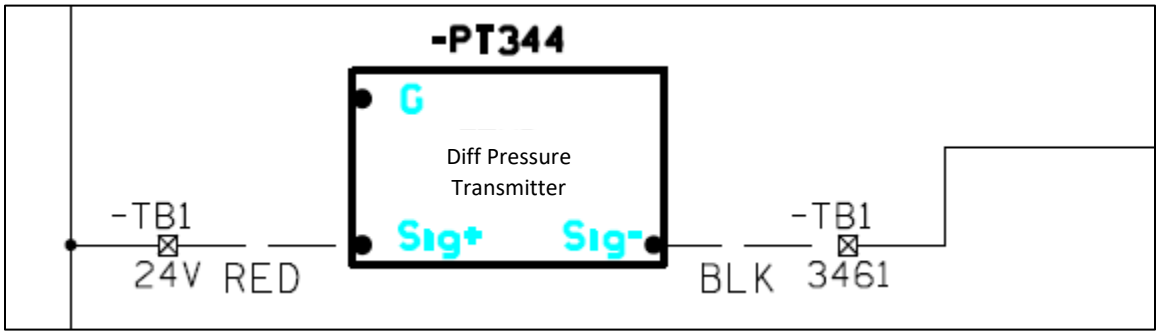
Supplied mounted to the Control Cabinet Door (internal) with two (2) ¼" push-to-connect tube fittings installed on sensor. Two (2) ¼" push-to-connect by ¼" NPT bulkhead fittings are installed in the Control Cabinet. JIC fittings enable connection of the exhaust hose to the bulkhead fitting.

¼" flexible poly tubing shipped loose inside the Control Cabinet to connect pressure transducer to bulkhead fitting. Customer responsible for plumbing tubing from PIT101 and PIT102 ports on reactor to bulkhead fittings. Stainless steel tubing (1/4" O.D.) suggested, however properly supported copper tubing is acceptable.

Flexible stainless tubing is acceptable.

ELECTRICAL INTERFACE

Delivered with 3ft pigtail and tinned wire. Pre-Installed in Control Cabinet by Catalytic Combustion. No external wiring required.

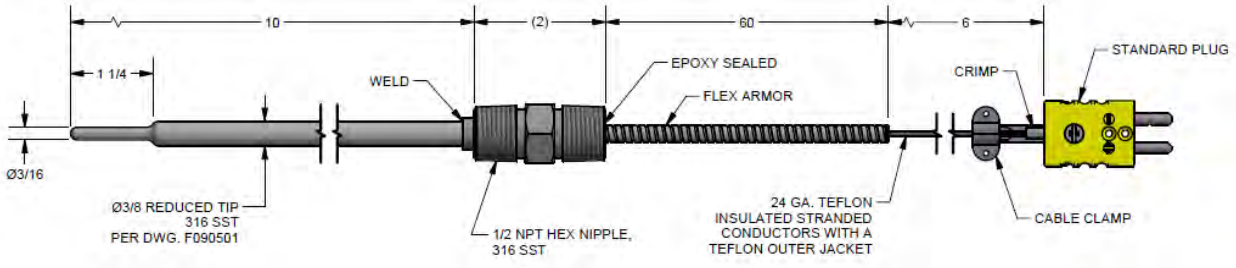


CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

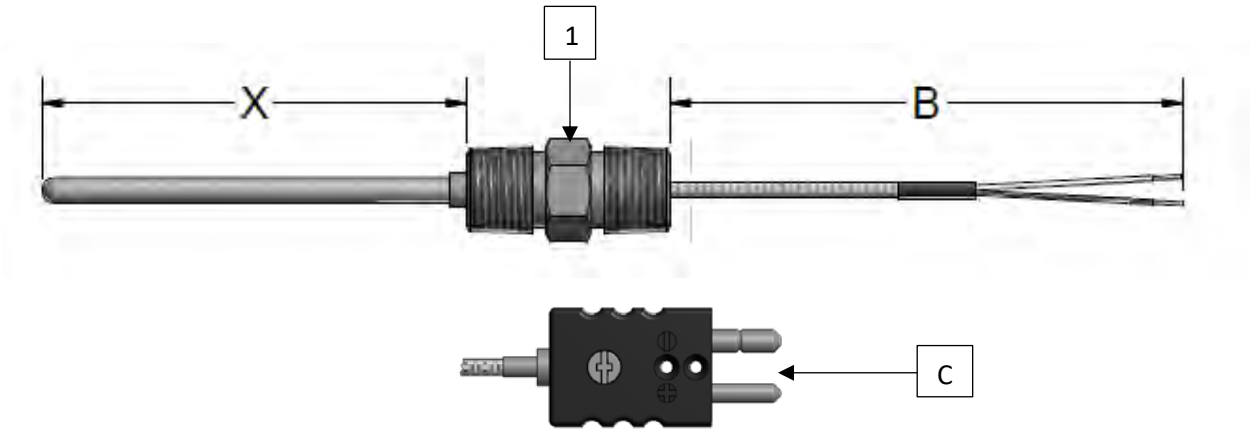
Datasheet

Exhaust Temperature Sensor



Published January 2019

Product Family		SCR Dosing System
Function		Exhaust Temperature Sensor
Purpose		Sense exhaust temperature
Media		Exhaust gas
Type		Type K thermocouple, ungrounded
Size	Probe	12” long, 3/8” diameter
	Interface	1/2” male NPT
	Termination	Male Type K Connector
	Length	60” OAL
Material	Sheath	316 SS
	Fill	MgO
	Insulation	Fluoropolymer, Flexible armor
	Conductor	Stranded

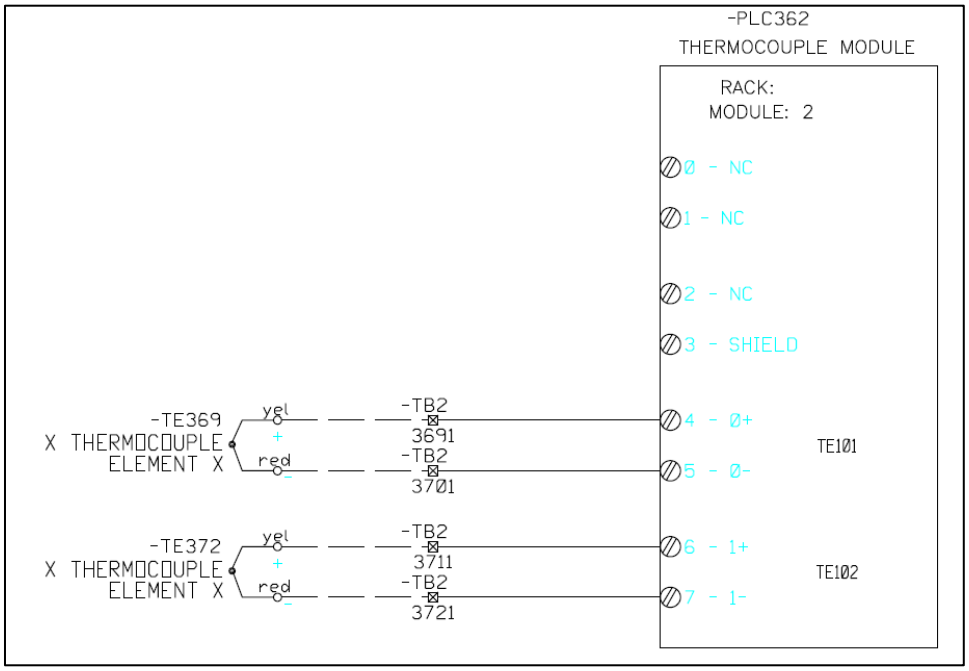


Position	Detail
X	12”, 3/8” diameter, reduced tip 3/16”
B	60 inches, armored
C	Type K Connector, male

MECHANICAL INTERFACES

Detail	Interface
1	½” Male NPT

ELECTRICAL INTERFACE



CATALYTIC COMBUSTION

EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Datasheet

NH3 Concentration Sensor and ECM

Published January 2019

Product Family		SCR Dosing System
Function		Sense exhaust outlet NH3 concentration
Purpose		Sense NH3 Concentration in exhaust gas
Media		Exhaust gas, diesel
Accuracy		+/- 5ppm (0-200ppm) +/-20ppm (200-1000ppm)
Response Time		< 1 second
Communication		CAN, high speed per ISO 11898
Environmental	Temperature (module)	-55°C to +125°C
	Temperature (sensor)	950°C continuous
	Sealing (module)	IP67
Dimensions	Module	145mm x 120mm x 40mm
	Sensor	1.5m (Interconnect cable)
		18mm x 1.5mm (mounting)
Power	Voltage	11 to 28 VDC (From Control Cabinet)
	Current	1.2A @ 12V (steady state) 4A @ 12V for 30s (start-up)

Position	Detail
1	NH3 Concentration Sensor
2	NH3 Concentration Sensor Electronic Control Module

MECHANICAL INTERFACES

Detail	Liquid Sealing	Thread Pitch
Sensor Mounting	N/A	18mm x 1.5mm

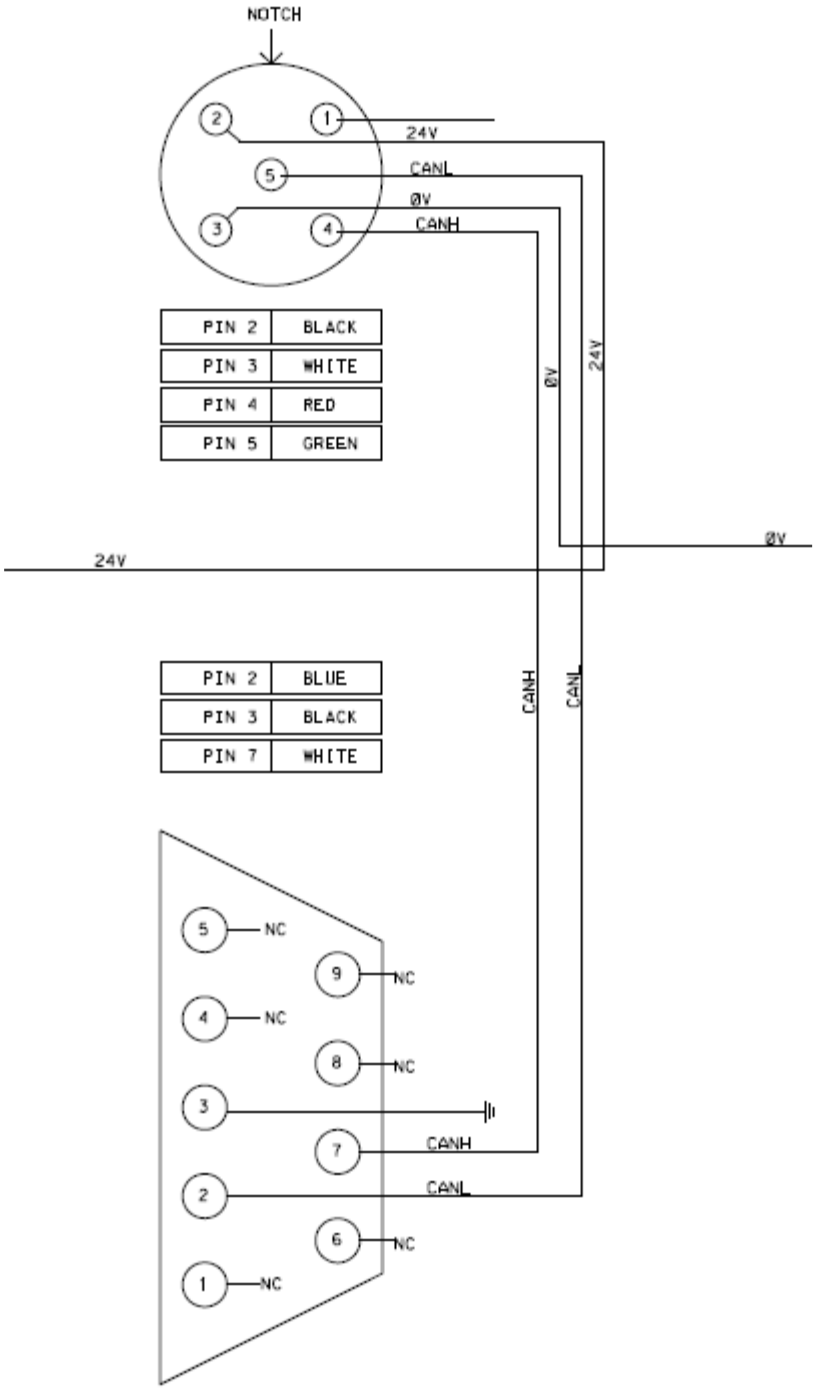
ELECTRICAL INTERFACE

Sensor delivered with 8inch pigtail to connect to wiring harness.

4.5-foot wiring harness connects Sensor to ECM.

Proprietary wiring harness connects NH3 Concentration ECM's to the Control Cabinet.

NH3 CONCENTRATION SENSOR ECM INTERCONNECT TO DOSING CONTROL CABINET


NOTCH
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CANL
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PIN 2 BLACK
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PIN 4 RED
PIN 5 GREEN
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24V
0V
CANH
CANL
PIN 2 BLUE
PIN 3 BLACK
PIN 7 WHITE
5 NC
9 NC
4 NC
8 NC
3
7 CANH
2 CANL
6 NC
1 NC

CATALYTIC COMBUSTION

EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Datasheet

NOx Concentration Sensor and ECM

Published January 2019

Product Family		SCR Dosing System
Function		Sense exhaust outlet NOx concentration
Purpose		Sense NOx Concentration in exhaust gas
Media		Exhaust gas, diesel
Accuracy		+/- 5ppm (0-200ppm) +/-20ppm (200-1000ppm)
Response Time		< 1 second
Communication		CAN, high speed per ISO 11898
Environmental	Temperature (module)	-55°C to +125°C
	Temperature (sensor)	950°C continuous
	Sealing (module)	IP67
Dimensions	Module	145mm x 120mm x 40mm
	Sensor	1.5m (Interconnect cable)
		18mm x 1.5mm (mounting)
Power	Voltage	11 to 28 VDC (From Control Cabinet)
	Current	1.2A @ 12V (steady state) 4A @ 12V for 30s (start-up)

Position	Detail
1	NOx Concentration Sensor
2	NOx Concentration Sensor Electronic Control Module

MECHANICAL INTERFACES

Detail	Liquid Sealing	Thread Pitch
Sensor Mounting	N/A	18mm x 1.5mm

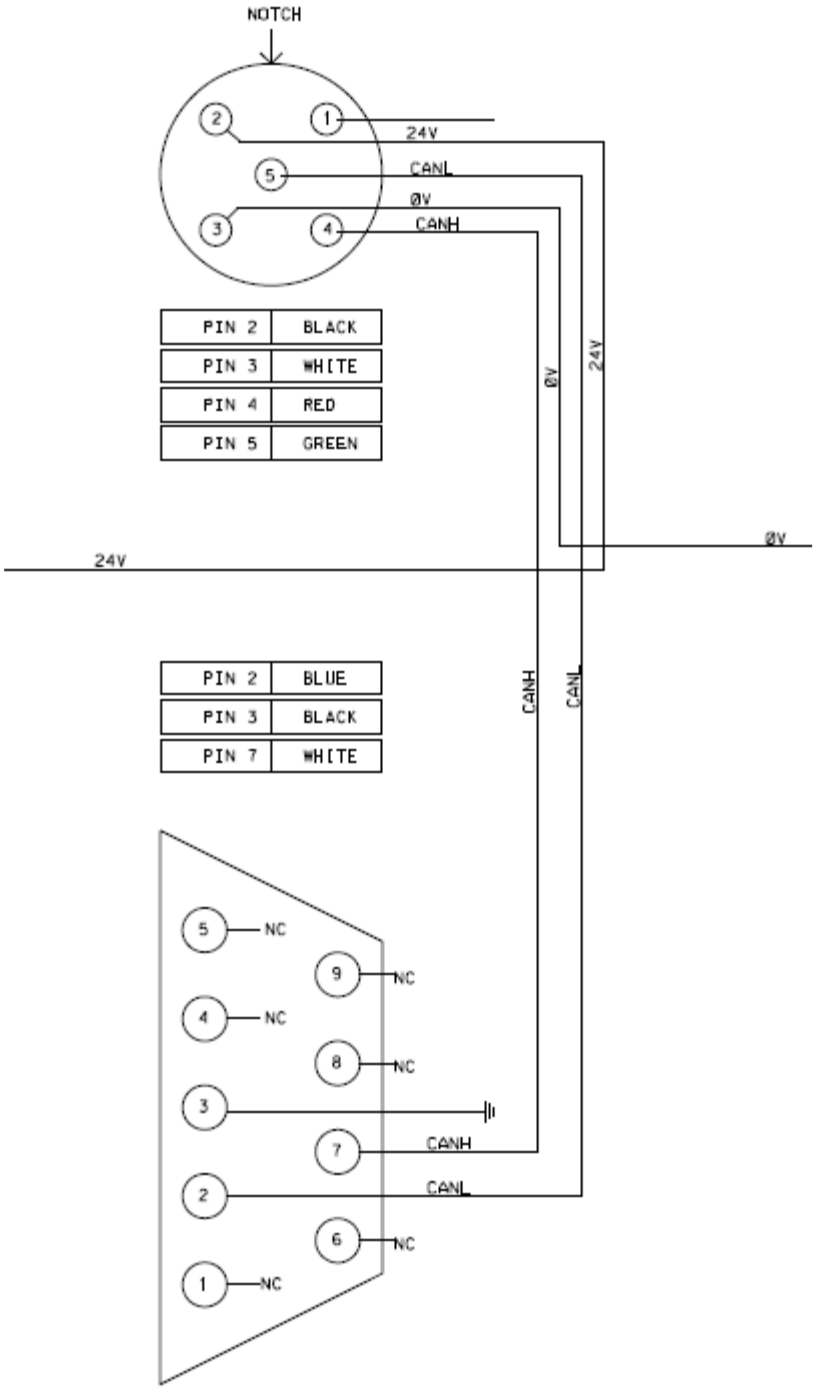
ELECTRICAL INTERFACE

Sensor delivered with 8inch pigtail to connect to wiring harness.

4.5-foot wiring harness connects Sensor to ECM.

Proprietary wiring harness connects NOx Concentration ECM's to the Control Cabinet.

NOx CONCENTRATION SENSOR ECM INTERCONNECT TO DOSING CONTROL CABINET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PIN 3 WHITE
PIN 4 RED
PIN 5 GREEN
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24V
24V
0V
CANH
CANL
PIN 2 BLUE
PIN 3 BLACK
PIN 7 WHITE
5 NC
9 NC
4 NC
8 NC
3
7 CANH
2 CANL
6 NC
1 NC

Specification

General

The Powerex Enclosed Scroll Air Compressor unit is designed to provide clean, dry air for industrial applications where the quality of the compressed air is critical. The standard unit is rated for a maximum of 115 PSIG. A higher pressure version (max. 145 PSIG) is also available. The unit is UL/CSA certified[1].

Air Compressor System

The package shall include one oil-less scroll air compressor, a 13 gal. tank, and associated equipment. The only field connections required will be system exhaust, power connection at the control panel, and condensate tank drain connection. All interconnecting piping and wiring shall be included and operationally tested prior to shipment. Single phase 3HP units require installation of an additional external 30 gal. tank and single phase 5HP units require installation of an additional external 60 gal. tank. Anti-corrosion tank lining is available. Package includes sound reducing enclosure.

Sound Reducing Enclosure

The system is constructed with an internal frame and steel base system with an individual vibration isolation mounted compressor module. The sound reducing enclosure has side access panels to allow service of the electrical controls. The enclosure has side cooling air intakes and all exhaust air leaves the enclosure from the right side.

Oilless Scroll Compressor Pump

Each compressor shall be belt driven oil-less rotary scroll single stage, air-cooled oil-less construction with absolutely no oil needed for operation. The rotary design shall not require any inlet or exhaust valves and shall be rated for 100% continuous duty. Direct drive compressors shall not be used. Tip seals shall be of a composite PTFE material and be rated for 10,000 hours operation. Compressor bearings shall be external to the air compression chamber and shall all be serviceable for extended compressor life. Bearing maintenance shall not be required until 10,000 run hours. Compressors with bearings that are not accessible for service have a limited life span and shall not be accepted. Compressors shall have an integral radial flow fan for cooling and shall not require any additional electric cooling fans. Each compressor shall have flexible connectors on discharge.

Each compressor pump shall be provided with an electric drive motor, discharge check valve, an air-cooled after-cooler, and a high discharge temperature shut down switch.

Motor

Each compressor shall be belt driven by a 1750 RPM, ODP, NEMA construction motor. Motors running at speeds higher than 1750 RPM shall not be acceptable. Three phase motors are EISA compliant and premium efficient.

[1] With the exception of 5 HP single phase units, which only have a UL508A listed control panel.

Air Receiver

The system shall include an internal 13 gallon ASME air receiver rated for 175 PSI MAWP. The tank shall be equipped with a safety relief valve and a manual or optional automatic electronic tank drain with manual override. The tank will also have corrosion resistant FDA approved material tank lining if that option is selected.

System Controls

The system shall include a control panel with lighted on/off switch magnetic starter overload protection, hour meter, and high temperature shutoff switch.

Inlet Filters

The system shall include a single inlet filter system. The inlet filter system shall be located on the compressor pump.

Optional Desiccant Air Dryer

Each twin-tower desiccant dryer shall be sized for the peak calculated system demand to provide a pressure dew point of 0oF. Dryer controls shall include a re-pressurization cycle to prevent shocking of the desiccant bed prior to switching towers. An integral purge saving control system shall be provided and shall suspend the purge air loss during periods of low demand. When the dryer is in purge control mode, the tower switching valves shall not operate, and only one desiccant tower shall be on-line. Dryers that continue to operate the switching valves on a fixed cycle, while in purge control mode shall not be acceptable. Desiccant dryer controls are to be powered from a separate supply, not through compressor controls.

Optional Refrigerant Air Dryer

The refrigerated air dryer is non-cycling, direct expansion type, using R-134 A refrigerant (CFC free). A hot gas by-pass system maintains a consistent temperature at all load conditions. Heat exchangers are made of copper tube construction and fully insulated. Dryers shall have power on and high temperature lights, internal 3-micron filter/separator with stainless steel bowl, and timed electric condensate drain. Refrigerated dryers are to be powered from a separate supply, not through the compressor controls.

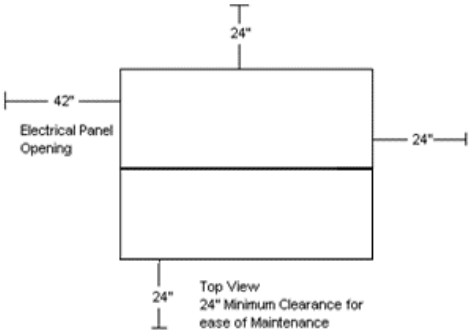
Optional Dewpoint Monitor

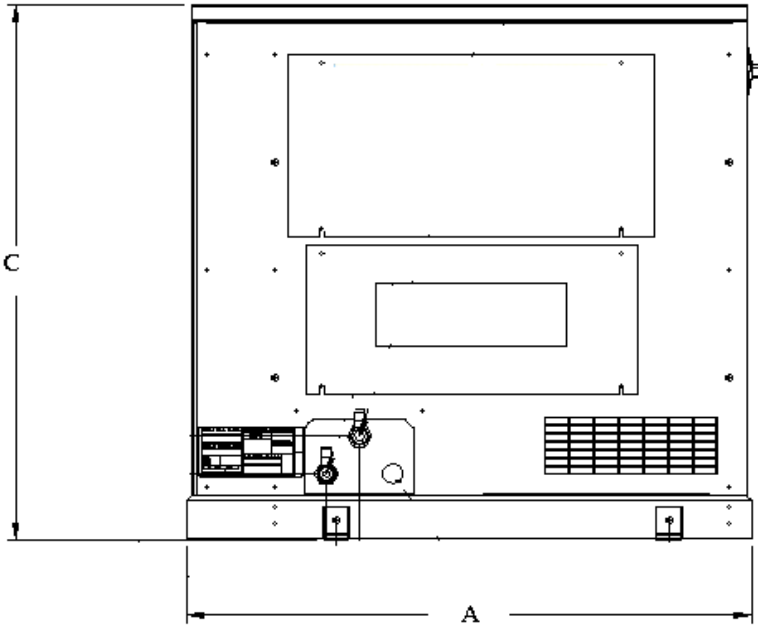
The system-integrated hygrometer shall be equipped with an LCD dew point display and high dew point alarm with dry contacts for remote monitoring. The sensor shall include an auto calibration feature to ensure the accuracy of the dew point measurement. Dew point monitor powered separately.

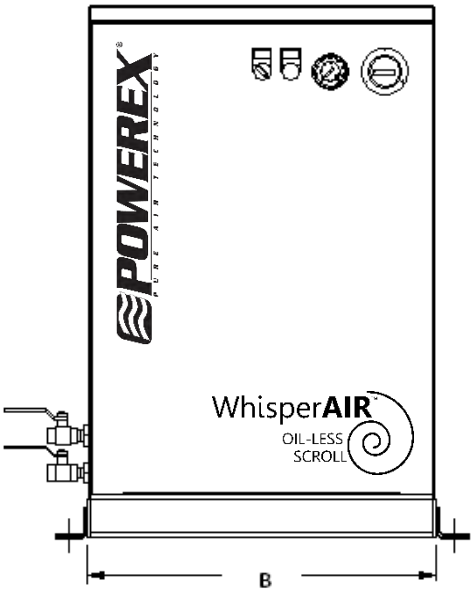
Optional Carbon Monoxide Monitor

The carbon monoxide (CO) monitor is provided in an enclosure with LCD display of CO concentrations. The monitor shall continuously display the CO content of the discharge air and shall provide audible and visual high CO alarms. High alarm is set at 10 ppm. Dry contacts are provided for remote monitoring of the high CO alarm. Carbon monoxide monitor powered separately.

Dimensions				
Model	Dim. A	Dim. B	Dim. C	Outlet
SES0308	34"	21"	33"	3/8"
SES1308	34"	21"	33"	3/8"
SES0508	34"	21"	33"	3/8"
SES1518	34"	21"	33"	3/8"







Enclosed Scroll Air Compressors										
Model[5]	HP[1]	SCFM @ 100 PSIG [5]	Maximum Pressure (PSIG)	Tank Size (gal)[6]	BTU/Hr	dB(A) Level	System F.L.A.			System Weight (lbs)
							208V	230V	460V	
SES0308	3	8.8	116	13	7,635	49	9.0	8.1	4.2	310
SES0308HP	3	7.1	145	13	7,635	49	9.0	8.1	4.2	310
SES1308	3	8.8	116	13	7,635	49	-	13	-	336
SES1308HP	3	7.1	145	13	7,635	49	-	13	-	336
SES0508	5	15.2	116	13	12,725	51	14.5	13.1	6.6	335
SES0508HP	5	12.5	145	13	12,725	51	14.5	13.1	6.6	335
SES1518	5	15.2	116	13	12,725	51		23.4	-	345
SES1518HP	5	12.5	145	13	12,725	51		23.4	-	345

Notes:

1 – Actual BHP is less than rated name plate. Contact Powerex for BHP rating.

2 – 3 Year Limited Warranty

3 – Single Phase 3HP units will require installation of an additional 30 gal. external tank and 5HP units will require the installation of an additional 60 gal. external tank.

4 – UL/CSA Certified with the exception of 5 HP single phase units, which only have a UL508A listed control panel.

5 – HP after a model number indicates high pressure model. SCFM for high pressure units are @ 145 PSIG.

6 – Tank is located inside the enclosure

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Process & Instrument Diagram

Holt Texas LTD.

Holt CAT Single Lance (3516E) SCR Systems

VPN 1040251

Published September 2022

• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

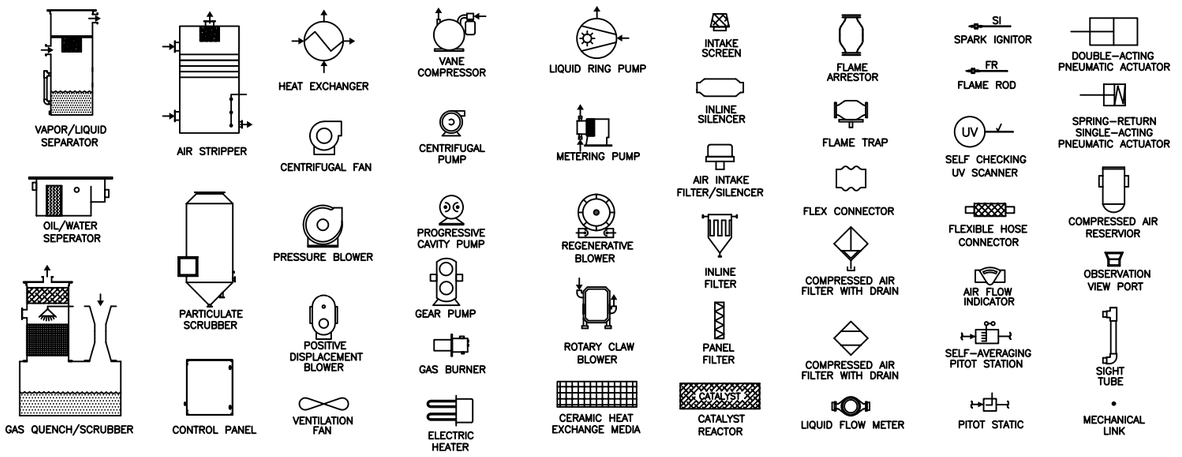
VALVES AND PIPING

- GLOBE
- BALL
- BUTTERFLY
- CHECK
- GATE
- ORIFICE METERING
- LUBRICATED PLUG
- VACUUM RELIEF
- PRESSURE RELIEF
- FORWARD PRESSURE REDUCING REGULATOR INTERNAL RELIEF
- BACK PRESSURE REGULATOR INTERNAL RELIEF
- PRESSURE REDUCING EXTERNAL PRESSURE
- PRESSURE REDUCING DIFFERENTIAL PRESSURE
- PRESSURE REDUCING VENTED
- 3 WAY
- REDUCER
- Y–STRAINER
- SAMPLE/TEST PORT
- FLANGE
- UNION
- ORFICE PLATE
- VALVE NORMALLY OPEN
- VALVE NORMALLY CLOSED

OPERATORS

- M 01 — MOTOR
- MV 01 — MOTORIZED VALVE
- PA 01 — PNEUMATIC ACTUATOR
- PV 01 — PNEUMATIC VALVE
- VFD 01 — VARIABLE FREQUENCY DRIVE
- SV 01 — SOLENOID VALVE
- MANUAL
- MV 01 — MANUAL VALVE

EQUIPMENT



TRANSDUCERS

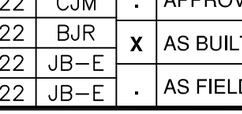
EXAMPLE:

FY I/P — CURRENT TO PNEUMATIC TRANSDUCER (MOUNTED BEHIND–THE–PANEL)

A	ANALOG
D	DIGITAL
E	VOLTAGE
F	FREQUENCY
I	CURRENT
P	PNEUMATIC
PF	PULSE FREQUENCY
PD	PULSE DURATION

INSTRUMENT IDENTIFICATION

BUBBLE SYMBOL



INSTRUMENT LOCATION SYMBOL

- FIELD MOUNTED INSTRUMENT
- PANEL MOUNTED INSTRUMENT
- BEHIND–THE–PANEL MOUNTED INSTRUMENT
- (GREEN) PILOT LIGHT/ALARM LIGHT (LIGHT COLOR)
- PROGRAMMABLE LOGIC CONTROLS

SPECIAL CASES

- HS 4 OO — ON AND OFF EVENT LIGHTS
- HS 4 OC — OPENED AND CLOSED POSITION LIGHTS
- HS 4 OC — OPENED AND CLOSED POSITION SWITCHES
- I — INTERLOCKS

LINE LEGEND

- PIPING
- PROCESS DUCTWORK
- COMPRESSED AIR
- PNEUMATIC SIGNAL
- ELECTRICAL SIGNAL OTHER
- ANALOG SIGNAL
- NON CONNECTING LINES
- CONNECTING LINES
- DATA LINK
- HOSE
- LINE SIZE 6 — FLOW DIRECTION
- OTHERS — CCC

PROCESS FLOW DIAGRAM LEGEND

- °F — TEMPERATURE DEGREES FAHRENHEIT
- SCFM — VAPOR FLOW STANDARD CUBIC FEET PER MINUTE
- PSIG — PRESSURE POUNDS PER SQUARE INCH GAGE
- PPM — CONCENTRATION PARTS PER MILLION
- GPM — WATER FLOW GALLONS PER MINUTE
- PROCESS NO.

TYPE, ACTION, OR CONTROL ABBREVIATIONS

AAH	ANALYTICAL ALARM HIGH
AAL	ANALYTICAL ALARM LOW
AC	ALTERNATING CURRENT
AE	ANALYTICAL ELEMENT
AI	ANALOG INPUT
AM	AUTO MANUAL
AO	ANALOG OUTPUT
AT	ANALYTICAL TRANSMITTER
B	BURNER
CV	CONTROL VALVE
DC	DIRECT CURRENT
DI	DIGITAL INPUT
DO	DIGITAL OUTPUT
DPI	DIFFERENTIAL PRESSURE INDICATOR
DPS	DIFFERENTIAL PRESSURE SWITCH
EH	ELECTRIC HEATER
ENET	ETHERNET
F	FAN
FAR	FORWARD AUTO REVERSE
FE	FLOW ELEMENT/SENSOR
FI	FLOW INDICATOR
FIR	FLOW INDICATING RECORDER
FIT	FLOW INDICATING TRANSMITTER
FS	FLOW SWITCH
HOA	HAND OFF AUTO
HS	HAND SWITCH
HV	HAND VALVE
LAH	LEVEL ALARM HIGH
LAL	LEVEL ALARM LOW
LEL	LOWER EXPLOSIVE LIMIT
LSH	LEVEL SWITCH HIGH
LSHH	LEVEL SWITCH HIGH HIGH
LSL	LEVEL SWITCH LOW
LSLL	LEVEL SWITCH LOW LOW
LT	LEVEL TRANSMITTER
M	MOTOR
MV	MOTORIZED VALVE
N	NOZZLE
NC	NORMALLY CLOSED
NO	NORMALLY OPENED
OC	OPEN–CLOSE
OCA	OPEN–CLOSE–AUTO
OO	ON–OFF
OOA	ON–OFF–AUTO
OOR	ON–OFF–REMOTE
P	PUMP
PAH	PRESSURE ALARM HIGH
PAL	PRESSURE ALARM LOW
PC	PRESSURE CONTROL
PCV	PRESSURE CONTROL VALVE
PI	PRESSURE INDICATOR
PIR	PRESSURE INDICATING RECORDER
PIS	PRESSURE INDICATING SWITCH
PIT	PRESSURE INDICATING TRANSMITTER
PLC	PROGRAMMABLE LOGIC CONTROLLER
PRV	PRESSURE RELIEF VALVE
PRX	PRESSURE RELIEF RUPTURE DISK
PS	PRESSURE SWITCH
PSH	PRESSURE SWITCH HIGH
PSL	PRESSURE SWITCH LOW
PT	PRESSURE TRANSMITTER
SR	SPRING RETURN
SS	START–STOP
SSOV	SAFETY SHUT OFF VALVE
SV	SOLENOID VALVE
TAH	TEMPERATURE ALARM HIGH
TAL	TEMPERATURE ALARM LOW
TCV	TEMPERATURE CONTROL VALVE
TE	TEMPERATURE ELEMENT
TI	TEMPERATURE INDICATOR
TIC	TEMPERATURE INDICATING CONTROLLER
TIR	TEMPERATURE INDICATING RECORDER
TIT	TEMPERATURE INDICATING TRANSMITTER
TS	TEMPERATURE SWITCH
TSH	TEMPERATURE SWITCH HIGH
TSL	TEMPERATURE SWITCH LOW
TT	TEMPERATURE TRANSMITTER
VFD	VARIABLE FREQUENCY DRIVE
VRV	VACUUM RELIEF VALVE
XCV	CHECK VALVE
XDA	DETONATION ARRESTOR
XFA	FLAME ARRESTOR
XFT	FLAME TRAP
XHE	HEAT EXCHANGER
XIF	INLET FILTER
XIS	INLET SCREEN
XJ	FLEX CONNECTOR/EXPANSION JOINT
XS	SILENCER
XSI	SPARK IGNITER
XUV	UV DETECTOR
XV	UNCLASSIFIED VALVE
YC	EVENT CLOSED
YI	EVENT INDICATOR
YO	EVENT OPEN
ZAC	POSITION ALARM CLOSED
ZAO	POSITION ALARM OPEN
ZS	POSITION SWITCH
ZSC	POSITION SWITCH CLOSED
ZSO	POSITION SWITCH OPEN
ZT	POSITION TRANSMITTER

NOTES

1. SPECIFICATIONS AND DIMENSIONS ARE SUBJECT TO CHANGE WITHOUT NOTIFICATION.
2. REFERENCE ANSI/ISA–S5.1 FOR SYMBOLS NOT SHOWN ON THIS LEGEND.
3. THIS IS A STANDARD LEGEND, THEREFORE, NOT ALL OF THIS INFORMATION MAY APPLY.
4. THESE SYMBOLS AND ABBREVIATIONS ARE SPECIFIC TO CATALYTIC COMBUSTION CORPORATION AND MAY DIFFER FROM ISA.

REV	DESCRIPTION	DATE	BY
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.			
.			
.			
03	UPDATED TO "AS–BUILT"	9/28/22	CJM
02	CHANGED NOMENCLATURE FOR PT102	8/17/22	BJR
01	UPDATED CUSTOMER SUBMITTAL	5/17/22	JB–E
00	INITIAL CUSTOMER SUBMITTAL	3/29/22	JB–E

	DRAWING STATUS:	DATE:	BY:
.	PRELIMINARY	.	.
.	FOR APPROVAL	.	.
.	APPROVED FOR FAB	.	.
X	AS BUILT	9/28/2022	CJM
.	AS FIELD MODIFIED	.	.

MATERIAL: SEE BOM

WEIGHT: N/A

TOLERANCES:
.X = 0.06
.XX = 0.03
.XXX = 0.015
∠ = 0.5°

THIRD ANGLE PROJECTION

INCH [mm]

CATALYTIC COMBUSTION EMISSION TECHNOLOGIES

Catalytic Combustion Corporation
311 Riggs Street
Bloomer, WI 54724

Telephone: 715–568–2882
Fax: 715–568–2884

www.catalyticcombustion.com

DATE: 03/29/2022

SCALE: NTS

DRAWN BY: JB–E

CHECKED BY: CM

CUSTOMER: HOLT CAT – ALIGNED ENERGY LLC
BLUE – SINGLE INJECTION

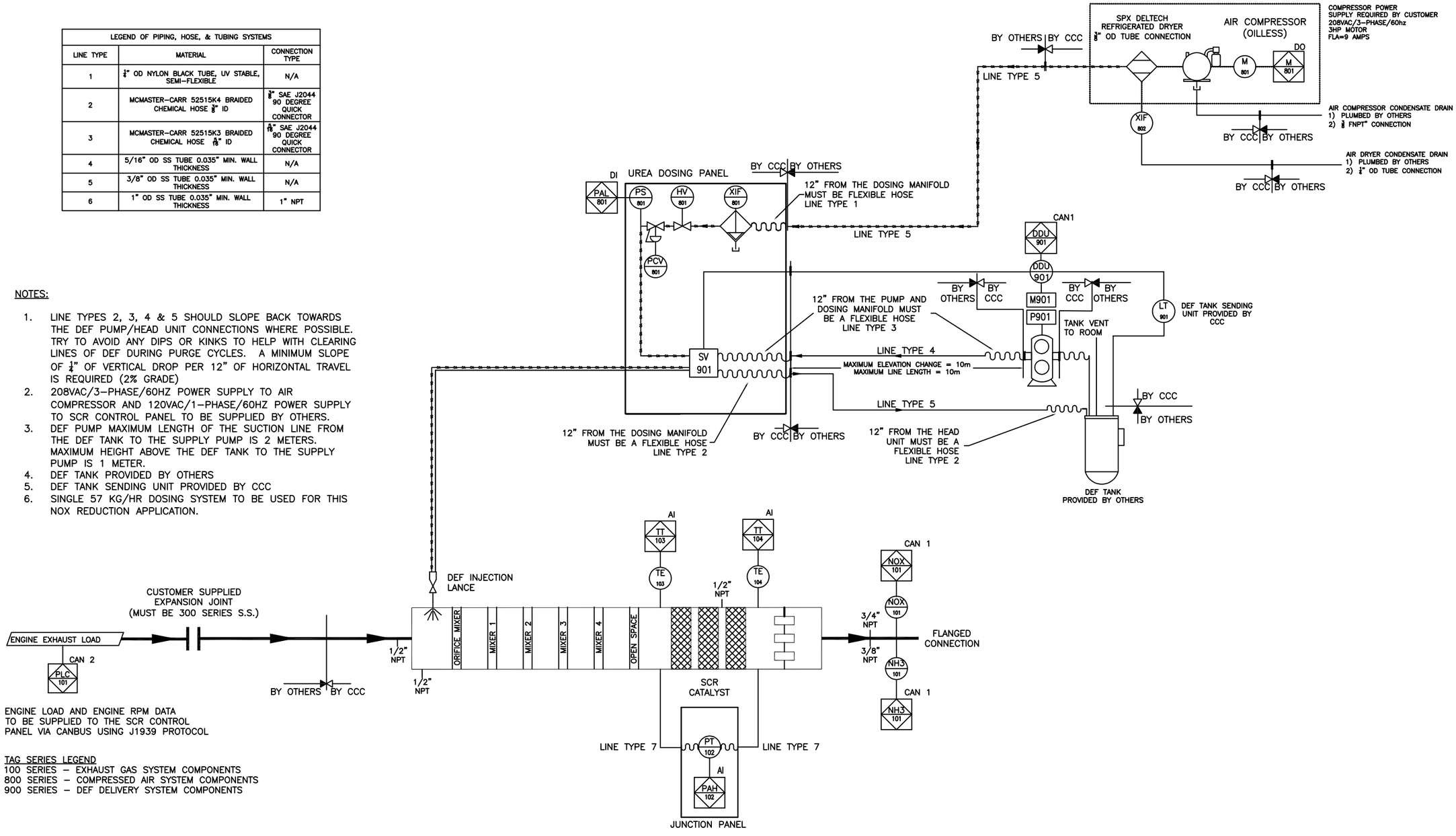
TITLE: SELECTIVE CATALYST REDUCTION SYSTEM
PROCESS & INSTRUMENTATION DIAGRAM

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
W0172978	500	03	B

LEGEND OF PIPING, HOSE, & TUBING SYSTEMS		
LINE TYPE	MATERIAL	CONNECTION TYPE
1	¼" OD NYLON BLACK TUBE, UV STABLE, SEMI-FLEXIBLE	N/A
2	MCMASTER-CARR 52515K4 BRAIDED CHEMICAL HOSE ⅜" ID	⅜" SAE J2044 90 DEGREE QUICK CONNECTOR
3	MCMASTER-CARR 52515K3 BRAIDED CHEMICAL HOSE ⅜" ID	⅜" SAE J2044 90 DEGREE QUICK CONNECTOR
4	5/16" OD SS TUBE 0.035" MIN. WALL THICKNESS	N/A
5	3/8" OD SS TUBE 0.035" MIN. WALL THICKNESS	N/A
6	1" OD SS TUBE 0.035" MIN. WALL THICKNESS	1" NPT

NOTES:

1. LINE TYPES 2, 3, 4 & 5 SHOULD SLOPE BACK TOWARDS THE DEF PUMP/HEAD UNIT CONNECTIONS WHERE POSSIBLE. TRY TO AVOID ANY DIPS OR KINKS TO HELP WITH CLEARING LINES OF DEF DURING PURGE CYCLES. A MINIMUM SLOPE OF ¼" OF VERTICAL DROP PER 12" OF HORIZONTAL TRAVEL IS REQUIRED (2% GRADE)
2. 208VAC/3-PHASE/60HZ POWER SUPPLY TO AIR COMPRESSOR AND 120VAC/1-PHASE/60HZ POWER SUPPLY TO SCR CONTROL PANEL TO BE SUPPLIED BY OTHERS.
3. DEF PUMP MAXIMUM LENGTH OF THE SUCTION LINE FROM THE DEF TANK TO THE SUPPLY PUMP IS 2 METERS. MAXIMUM HEIGHT ABOVE THE DEF TANK TO THE SUPPLY PUMP IS 1 METER.
4. DEF TANK PROVIDED BY OTHERS
5. DEF TANK SENDING UNIT PROVIDED BY CCC
6. SINGLE 57 KG/HR DOSING SYSTEM TO BE USED FOR THIS NOX REDUCTION APPLICATION.



TAG SERIES LEGEND
100 SERIES – EXHAUST GAS SYSTEM COMPONENTS
800 SERIES – COMPRESSED AIR SYSTEM COMPONENTS
900 SERIES – DEF DELIVERY SYSTEM COMPONENTS

REV	DESCRIPTION	DATE	BY
.			
.			
.			
.			
03	UPDATED TO "AS-BUILT"	9/28/22	CJM
02	CHANGED NOMENCLATURE FOR PT102	8/17/22	BJR
01	UPDATED CUSTOMER SUBMITTAL	5/17/22	JB-E
00	INITIAL CUSTOMER SUBMITTAL	3/29/22	JB-E

	DRAWING STATUS:	DATE:	BY:
.	PRELIMINARY	.	.
.	FOR APPROVAL	.	.
X	APPROVED FOR FAB	9/28/22	CJM
.	AS BUILT	.	.
.	AS FIELD MODIFIED	.	.

MATERIAL: SEE BOM

WEIGHT: N/A

TOLERANCES:
.X = 0.06
.XX = 0.03
.XXX = 0.015
∠ = 0.5°

THIRD ANGLE PROJECTION

INCH [mm]

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES
Catalytic Combustion Corporation
311 Riggs Street
Bloomer, WI 54724
Telephone: 715-568-2882
Fax: 715-568-2884
www.catalyticcombustion.com

DATE: 03/29/2022

SCALE: NTS

DRAWN BY: JB-E

CHECKED BY: CM

CUSTOMER: HOLT CAT – ALIGNED ENERGY LLC
BLUE – SINGLE INJECTION

TITLE: SINGLE LANCE SCR SYSTEM
PROCESS & INSTRUMENTATION DIAGRAM

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
W0172978	501	03	B

BILL OF MATERIALS – MECHANICAL

SHEET	DEVICE ID	CCC P/N	DESCRIPTION	QTY / SCR
501	TE 103 TE 104	1026482	THERMOCOUPLE K68U–012–05C–19HT–F3A060–4	2
501	PT 102	1035675	DIFFERENTIAL PRESSURE TRANSMITTER 0–50 IN W.C. ASHCROFT	1
501	NOX 101	1027235	NOX SENSOR	1
501	NOX 101	1027237	NOX SENSOR MODULE/ECU	1
501	NH3 101	1027236	NH3 SENSOR	1
501	NH3 101	1027238	NH3 SENSOR MODULE/ECU	1
501	SCR	1039367	FFCE RCC–1920F–02–20SC–SCR20 W/O LIFTING LUGS	27
N/A	N/A	1006777	GASKET VERMICULITE FIBERGLASS W/PRESSURE SENSITIVE ADHESIVE DROP WARP 3.0" WIDE X $\frac{1}{4}$" THICK	130 FT
N/A	N/A	1031617	GASKET VERMICULITE FIBERGLASS W/PRESSURE SENSITIVE ADHESIVE DROP WARP 1.5" WIDE X $\frac{1}{4}$" THICK (AMOUNT NEEDED WHEN CHANGING CATALYST)	30 FT

BILL OF MATERIALS – MECHANICAL

SHEET	DEVICE ID	CCC P/N	DESCRIPTION	QTY / SCR
501	M801	1036652	AIR COMPRESSOR, POWEREX, MODEL SES0308, 8 CFM, 208VAC 3PH	1
501	N/A	1039726	SPX DELTECH 5–10CFM REFRIGERATED DRYER	1
501	PS801, HV801, XIF 801, PCV801	1026054	STT EMTEC AIR PRESSURE REGULATOR, FILTER, & SWITCH REGULATOR	1
501	SV901	1036225	STT EMTEC, DOSING MANIFOLD, 57 KG/HR	1
501	M901, P901	1036224	STT EMTEC DEF PUMP ASSY, 57 KG/HR	1
501	N/A	1036226	STT EMTEC DEF INJECTION LANCE, 57KG/HR	1
N/A	N/A	1032959	FILTER DEF 40 MICRON (INSIDE DAY TANK)	1
501	LT901	1030877	GEMS UCL–510 ULTRASONIC LEVEL TRANSMITTER	1

REV	DESCRIPTION	DATE	BY
.			
.			
.			
.			
03	UPDATED TO "AS–BUILT"	9/28/22	CJM
02	CHANGED NOMENCLATURE FOR PT102	8/17/22	BJR
01	UPDATED CUSTOMER SUBMITTAL	5/17/22	JB–E
00	INITIAL CUSTOMER SUBMITTAL	3/29/22	JB–E

	DRAWING STATUS:	DATE:	BY:
.	PRELIMINARY	.	.
.	FOR APPROVAL	.	.
X	APPROVED FOR FAB	9/28/22	CJM
.	AS BUILT	.	.
.	AS FIELD MODIFIED	.	.

MATERIAL: SEE BOM

WEIGHT: N/A

TOLERANCES:
.X = 0.06
.XX = 0.03
.XXX = 0.015
∠ = 0.5°

CATALYTIC COMBUSTION EMISSION TECHNOLOGIES

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THIRD ANGLE PROJECTION

INCH [mm]

DATE: 03/29/2022

SCALE: NTS

DRAWN BY: JB–E

CHECKED BY: CM

CUSTOMER: HOLT CAT – ALIGNED ENERGY LLC
BLUE – SINGLE INJECTION

TITLE: SINGLE LANCE SCR SYSTEM
PROCESS & INSTRUMENTATION DIAGRAM

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
WO172978	502	03	B

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Troubleshooting Guide

Holt Texas LTD.

Holt CAT Single Lance (3516E) SCR Systems

VPN 1040251

Published September 2022

• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

ISO 9001 Certified
Verisys Registrars®

Integrity | Service | Excellence

Catalytic Combustion Corporation introduced cutting edge technology in 1950 with the development of the first ever US patented catalyst to destroy VOCs (Volatile Organic Compounds). Since that time, the company has expanded into the design and supply of catalysts and emission control system for a wide variety of industries. The Selective Catalytic Reduction System installed on this engine represents the most advanced and least maintenance intensive system enabling compliance with US EPA and MARPOL IMO 3 regulations.

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1. General Information

Alarms are grouped into one of three categories:

1. **Critical Alarm:** Critical alarms will shut down the engine and are communicated locally on the HMI. Critical alarms include:
    a. SCR Inlet temperature high
    b. SCR outlet temperature high
    c. E-Stop engaged
2. **Pre-Alarm:** Pre-alarms will not shut down the engine, however may disable the SCR system. Pre-Alarm conditions include:
    a. Engine Communication loss
    b. TE10x signal fail
    c. NOx10x or NH3-10x sensor fault
    d. NOx10x or NH3-10x communication fault
    e. Dosing Fault, Air Flow
    f. Dosing Fault, DEF Flow
    g. Dosing Fault, DEF pressure
    h. Dosing Fault, Injection Nozzle blocked
3. **Global Alarm:** Global alarms will not shut down the engine, however may disable the SCR system. Global alarm conditions include:
    a. SCR (PT102) differential pressure signal fail
    b. SCR (PT102) differential pressure high
    c. Dosing ECU communication loss
    d. Loss of air pressure
    e. DEF Level in Day Tank critically low
    f. Dosing Fault, System frozen
    g. Dosing fault, Control unit
    h. Dosing Fault, system voltage
    i. Dosing Fault, PT9x1.1 DEF pressure signal fail
    j. Dosing Fault, PT9x1.2 Injection pressure signal fail
    k. Dosing Fault, PT9x1.3 Air pressure signal fail
    l. Dosing Fault, Failure to dose
    m. Dosing Fault, Air Flow shutdown
    n. Dosing Fault, DEF flow shutdown
    o. Dosing Fault, DEF pressure shutdown
    p. Dosing Fault, Dosing nozzle blocked

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Items listed as “Not User Serviceable” indicate that these items must be serviced by Catalytic Combustion Corporation only.

2. Troubleshooting Guide

Alarm	Probable Cause	Remedy
TE10x Signal Fail	Failure of thermocouple TE10x	Test thermocouple TE10x and replace if necessary
PT10x D/P Signal Fail	Failure of pressure transducer PT10x	Test pressure transducer PT10x and replace if necessary
NOx10x Sensor Fault	NOx wiring loose/broken NOx sensor failure ECU failure	Check sensor wiring Check/replace NOx sensor Check/replace ECU
NH310x Sensor Fault	NOx wiring loose/broken NOx sensor failure ECU failure	Check sensor wiring Check/replace NOx sensor Check/replace ECU
NOx10x Comms loss	NOx wiring loose/broken NOx sensor failure ECU failure	Check sensor wiring Check/replace NOx sensor Check/replace ECU
NH310x Comms loss	NOx wiring loose/broken NOx sensor failure ECU failure	Check sensor wiring Check/replace NOx sensor Check/replace ECU
Dosing ECU Comm Loss		Not user serviceable
SCR High Temperature (outlet)	Improper engine operation	Investigate per engine manufactures guidelines
SCR High Temperature (inlet)	Improper engine operation	Investigate per engine manufactures guidelines
Catalyst High Differential Pressure	Catalyst clogged by PM Failure of pressure transducer Clogged sensing lines	Check exhaust mixer and SCR chamber for deposits Test pressure transducer and replace if necessary Check sensor hoses for water/soot
Loss of Air Pressure	Loss of supply air to air regulator Clogged air filter Failed pressure transducer PS8x1	Verify air pressure on gauge at air regulator, investigate loss of air per engine manufactures guidelines Replace Not user serviceable. Replace air regulator and set

DEF Level Low (Day Tank)	Low fluid level	Fill Day Tank
DEF Critical Low (Day Tank)	Low fluid level	Fill Day Tank
Day Tank Level Sensor Fail	Failure of level transducer LT901	Test level transducer LT901
Dosing Fault, Air Flow	Loss of air pressure Improper injection nozzle operation	Investigate per "Loss of Air Pressure" above
Dosing Fault, DEF Flow	Improper pump operation	Not user serviceable
Dosing Fault, DEF Pressure (SV901.1)	Improper pump operation	Not user serviceable
Dosing Fault, Nozzle Blocked		Not user serviceable
Dosing Fault, System Frozen	System temperature below -8°C	Not user serviceable
Dosing Fault, Control Unit		Not user serviceable
Dosing Fault, Supply Voltage	Unstable bus voltage	Investigate per engine manufactures guidelines
DEF Pressure Signal Fail	PT9x1.1	Not user serviceable
Injection Pressure Signal Fail	PT9x1.2	Not user serviceable
Nozzle Air Pressure Sensor Fail	PT9x1.3	Not user serviceable
Failure to Dose		Not user serviceable
Dosing Airflow Shutdown		Not user serviceable
Dosing DEF Flow Shutdown		Not user serviceable
Dosing DEF Pressure Shutdown	PT9x1.1	Not user serviceable
Dosing Nozzle Blocked Shutdown		Not user serviceable

** Above table is a general troubleshooting guideline for CCC's SCR system not unit specific. **

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CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Safety Data Sheets

Holt Texas LTD.

Holt CAT Single Lance (3516E) SCR Systems

VPN 1040251

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SAFETY DATA SHEET

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

CCC SCR Catalyst D on Metallic Foil Substrate, for SCR Applications

Date SDS Revised: Rev A, June 2019 *Date SDS reviewed:* Rev A, June 2019

SECTION 1 — CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Identifier:	CCC SCR D Catalyst on Metallic Foil Substrate, for SCR Applications
Product Use:	SCR NOx reduction process, on exhaust of reciprocating engines, Gas Turbines and Chemical processes.
Manufacturer's Name	Catalytic Combustion Corporation
Street Address	311 Riggs Street
City, State, Zip Code	Bloomer, WI 54724
Telephone Number:	715-568-2882
Fax Number:	715-568-2884
Emergency Phone Number:	715-568-2882
Date SDS Revised:	June 2019 REV A
Date SDS Prepared:	November 2016

SECTION 2 — COMPOSITION/INFORMATION ON INGREDIENTS

Note:

This product is HAZARDOUS. This section refers only to dust or fumes which may be generated under conditions other than normal handling or use.

Hazardous Ingredients *(specific)*	**CAS Number**	**Concentration**
Divanadium pentoxide	1314-62-1	< .6% W/W

SECTION 3 — HAZARDS IDENTIFICATION

No adverse health effects would be expected during normal handling of this product. Health effects should be considered if this product is further worked, such as cutting, grinding, or crushing.

Routes of Entry: ☒ Skin Contact ☒Eye Contact ☒ Inhalation ☐ Skin Absorption ☒ Ingestion

	Hazard Category	Signal Word	Hazard Statement	Pictograms
Inhalation Hazard	4	Warning	When dusting occurs, the dust is classed as a hazardous dust and should be treated accordingly. Use NIOSH respirator, and collect loose dust with Vacuum Cleaner, with HEP filters	
Germ Cell mutagenicity	2	Warning	When dusting occurs, the dust is classed as a hazardous dust and should be treated accordingly. Use NIOSH respirator, and collect loose dust with Vacuum Cleaner, with HEP filters.	
Reproductive Toxicity	2	Warning	When dusting occurs, the dust is classed as a hazardous dust and should be treated accordingly. Use NIOSH respirator, and collect loose dust with Vacuum Cleaner, with HEP filters.	
Specific target organ toxicity, repeated exposure	1	Warning	When dusting occurs, the dust is classed as a hazardous dust and should be treated accordingly. Use NIOSH respirator, and collect loose dust with Vacuum Cleaner, with HEP filters.	
Acute aquatic toxicity	3	Warning	When dusting occurs, the dust is classed as a hazardous dust and should be treated accordingly. Use NIOSH respirator, and collect loose dust with Vacuum Cleaner, with HEP filters.	

Signs / Symptoms of Short-Term Exposure:

Inhalation	May cause irritation to the nose, throat and respiratory tract.
Eye Contact	May cause irritation and conjunctivitis
Skin Contact	May cause dehydration and irritation
Ingestion	None known

Hazard statements:

H332 Harmful if Inhaled.
H341 Suspected of causing genetic defects.
H361d Suspected of damaging the unborn child.
H372 Causes damage to organs though prolonged or repeated exposure.
H412 Harmful to aquatic life with long lasting effects.

Precautionary statements:

Prevention:
P201 Obtain Special instructions before use or handling this product.
P202 Do not handle until all safety precautions have been read and understood.
P260 Do not breathe dust/ fume/ gas/ mist/ vapors/ spray.
P264 Wash skin thoroughly after handling.
P270 Do not drink, eat or smoke when using, handling this product.
P271 Use only outdoors or in a well-ventilated area.
P273 Avoid release to the environment.
P280 Wear protective gloves/ protective clothing/ eye protection/ face protection.

Response:
P304 + P340 +P312 If dust inhaled: Remove person to fresh air and keep comfortable for breathing. Call a Poison Center if you feel unwell.
P308 + P313 If exposed or concerned: Get medical advice/ attention.

Storage:
P405 Store locked up.

Disposal:
P501 Dispose of contents/ container to an approved waste disposal plant.

Additional Labelling
The following percentage of the mixture consists of ingredient(s) with unknown acute toxicity: 4.99%

Other hazards
None known.

SECTION 4 — FIRST AID MEASURES

General advice	Show this Safety Data Sheet to the doctor in attendance. Remove victim to fresh air. Do not leave the victim unattended.
If Inhaled	Call a physician or poison control center immediately.
In case of skin contact	If on clothes, remove clothes. Cover wound with sterile dressing.
In case of eye contact	Remove contact lenses. Flush eyes with water, as a precaution. Protect unharmed eye. Keep eye wide open while rinsing. If eye irritation persists, consult a specialist.
If swallowed	Keep respiratory tract clear. Do not give milk or alcoholic beverages. Never give anything by mouth to an unconscious person. If symptoms persist, call a physician.
Most important symptoms and effects, both acute and delayed	None known.

SECTION 5 – FIRE AND EXPLOSION HAZARDS

Suitable extinguishing media:	Not combustible. Do not inhale dust.
Unsuitable extinguishing media:	High volume water jet.
Specific hazards during fire-fighting:	Do not allow run-off from fire-fighting to enter drains or water streams.
Hazardous combustion products:	Metal Oxides.
Further information:	Collect contaminated fire extinguishing water separately. This must not be discharged into drains. Fire residues and contaminated fire extinguishing water must be disposed in accordance with local regulations.
Special protective equipment for firefighters:	Use self-contained breathing apparatus in the danger area. Use protective clothing.

SECTION 6 — ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures:	Use personal protective equipment.
Environmental precautions:	Prevent product from entering drains. Prevent leakage or spillage if safe to do so. It the product contaminates rivers and lakes or drains, inform respective authorities.
Methods and materials for containment and cleaning up:	Pick up and transfer to properly labelled containers.

SECTION 7 — HANDLING AND STORAGE

Advice on protection against fire and explosion:	Normal measures for preventive fire protection.
Advice on safe handling:	Do not inhale dust. Avoid contact with skin and eyes. For personal protection see section 8. Smoking, eating and drinking shall be prohibited in the application area.
Conditions for safe storage:	Keep container tightly closed in a dry and well-ventilated place.
Material to avoid:	No Material to be especially mentioned.
Further information on storage stability:	Keep in dry place.

SECTION 8 — EXPOSURE CONTROL / PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value Type (forms of exposure)	Control Parameters / Permissible concentration	Basis
Divanadium pentoxide	1314-62-1	TWA (Inhalable fraction)	.05 mg/m³ (Vanadium)	ACGIH
		C (Fumes)	.05 mg/m³ (V_2O_5)	OSHA Z-1
		C (Respirable dust)	.05 mg/m³ (V_2O_5)	OSHA Z-1
		TWA (Respirable dust fraction)	.05 mg/m³ (V_2O_5)	OSHA P0
		TWA (Fumes)	.05 mg/m³ (V_2O_5)	OSHA P0
		C (Dust)	.05 mg/m³ (Vanadium)	NIOSH REL
		C (Fumes)	.05 mg/m³ (Vanadium)	NIOSH REL
		8 hour time weighted average	.02 mg/m³ (V_2O_5)	OSHA / TWA

Respiratory Protection: Wear a NIOSH – approved Respirator, Particulates type.

Ventilation Local exhaust to TLV

Protective Gloves Natural rubber, neoprene or nitrile are acceptable. Thickness .9 mm
Break through time > 480 min.

Eye Protection Safety glasses / goggles

Other Protective Clothing If dusts are generated, coveralls and NIOSH respirator

Work/Hygienic Practices If dusts are generated, wash skin and/or eyes in running water and remove to fresh air.

SECTION 9 — PHYSICAL AND CHEMICAL PROPERTIES

Physical State	Solid, like a thin steel foil, micro-corrugated.
Odor and Appearance	No odor, pale green coated metallic foil with wash coat.
Melting Point	1,400°C
Flash Point	Not applicable
Vapor Density (air = 1)	Not applicable
Decomposition Temperature	More than 1,000°C
Evaporation Rate (butyl acetate = 1)	Not applicable
Boiling Point (° C)	Not applicable
Freezing Point (° C)	Not applicable
Flammability (Solid, Gas)	Not classified as a flammability hazard
Coefficient of Water/Oil Distribution	Not applicable
Solubility in Water	Insoluble

SECTION 10 – STABILITY AND REACTIVITY

Stability	Stable.
Conditions to Avoid	None known.
Incompatible	None known.
Hazardous Decomposition Products	Will not occur if stored and applied as directed.
Hazardous Polymerization	Will not occur.

SECTION 11 — TOXICOLOGICAL INFORMATION

Acute Toxicity

Components:

Divanadium pentoxide:

Acute oral toxicity:	LD50 - rat, orally: 400 mg/kg.
Acute inhalation toxicity:	LC50 - rat, inhaled: 4.3 mg/liter.
Acute dermal toxicity:	Assessment: No data available.

IARC	Divanadium pentoxide	1314-62-1
OSHA	No components of this product present at levels greater than or equal to 0.1% is on OSHA list of regulated carcinogens.	
NTP	No components of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.	

STOT- single exposure

Components:

Divanadium pentoxide:

Target Organs: Respiratory Tract.

Assessment: May cause respiratory irritation.

STOT- repeated exposure

Components:

Divanadium pentoxide:

Assessment: Caused damage to respiratory organs through prolonged or repeated exposure.

Germ Cell mutagenicity

No information available. Product contains ingredient (divanadium pentoxide) that is hazardous to reproductive.

Carcinogenicity

No information available.

Reproductive toxicity

No information available. Product contains ingredient (divanadium pentoxide) that is hazardous to reproductive.

SECTION 12 – ECOLOGICAL INFORMATION

Ecotoxicity

Components:

Divanadium pentoxide:

Toxicity to fish:	LC50 (Oncorhyncus mykiss (rainbow trout)): 5.2 mg/l Exposure time: 96h Remarks: Fresh water
Toxicity to daphnia and other aquatic invertebrates:	EC50 (Daphnia magna (water flea)): 1.52 mg/l Exposure time: 48h Remarks: Fresh Water
Toxicity to fish (Chronic toxicity):	NOEC (Pimephales promelas (fathead minnow)): .12 mg/l Exposure time: 28 Days Remarks: Fresh Water
Ozone-Depletion Potential:	Regulation: 40 CFR Protection of Environment; Part 82 Protection of Stratospheric Ozone-CAA Section 602 Class I substances. Remarks: This product neither contains, nor was manufactured with a Class I or Class II ODS as defined by the U.S. clean Air act Section 60 (40CFR 82, Subpt. A, App.A+B)
Additional ecological information:	Harmful to aquatic life with long lasting effects.

SECTION 13 — DISPOSAL CONSIDERATIONS

Disposal Methods.

Waste from residues:	The product shall not be allowed to enter drains, water streams or the soil. Do not contaminate ponds, waterways or ditches with chemical or used container. Send to a licensed waste management company. Dispose of as hazardous waste in compliance with local and national regulations.
Contaminated packaging:	Empty remaining contents. Dispose of as unused product. Do not re-use empty containers.

SECTION 14 — TRANSPORT INFORMATION

International Regulations

UNRTDG
Not regulated as a dangerous good

IATA-DGR
Not regulated as a dangerous good

IMDG-Code
Not regulated as a dangerous good

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC code
Not applicable for product as supplied

National Regulations

49 CFR – DOT
Not regulated as a dangerous good

Special precautions for user
Not applicable

SECTION 15 — REGULATORY INFORMATION

EPCRA – Emergency Planning and Community Right-to-Know Act

CERCLA Reportable Quantity

Components	CAS-No.	Component RQ (lbs)	Calculated product RQ (lbs)
Divanadium pentoxide	1314-62-1	1000	Read note A
Note A: Calculated product RQ can exceed reasonably attainable upper limit			

SARA 304 Extremely Hazardous Substances Reportable Quantity

Components	CAS-No.	Component RQ (lbs)	Calculated product RQ (lbs)
Divanadium pentoxide	1314-62-1	1000	Read note A
Note A: Calculated product RQ can exceed reasonably attainable upper limit			

SARA 302 Extremely Hazardous Substances Threshold Planning Quantity

Components	CAS-No.	Component TPQ (lbs)
Divanadium pentoxide	1314-62-1	10000
Divanadium pentoxide	1314-62-1	100

SARA 311/312 Hazards:	Acute toxicity (any route of exposure)
	Germ cell mutagenicity
	Reproductive toxicity
	Specific target organ toxicity (single or repeated exposure)
SARA 313:	The following components are subject to reporting levels established by SARA Title III, Section 313:
	Divanadium pentoxide 1314-62-1 >= 1 - 5%

Clean Air Act

This product neither contains, nor was manufactured with a Class I or Class II ODS as defined by the U.S. Clean Air Act Section 602 (40 CFR 82, Subpart. A, App.A+B).

This Product does not contain any hazardous air pollutants (HAP), as defined by the U.S. Clean Air Act Section 112 (40 CFR 61).

This product does not contain any chemicals listed under the U.S Clean Air Act Section 112® for Accidental Release Preventions (40 CFR 68.130, Subpart F).

This product does not contain any chemicals listed under the U.S. Clean Air Act Section 111 SOCMI Intermediate or Final VOC's (40 CFR 60.489).

Clean Water Act

The following Hazardous Substances are listed under the U.S. Clean Water Act, Section 311, Table 116.4A:

Divanadium pentoxide 1314-62-1 4.99%

The following Hazardous Substances are listed under the U.S. Clean Water Act, Section 31, Table 117.3:

Divanadium pentoxide 1314-62-1 4.99%

This product does not contain any toxic pollutants listed under the U.S. Clean Water Act, Section 307.

US States Regulations

Massachusetts Right to Know

Components	CAS-No.
Divanadium pentoxide	1314-62-1

Pennsylvania Right to Know

Components	CAS-No.
Divanadium pentoxide	1314-62-1

California Prop 65.

Warning: This product can expose you to chemicals including divanadium pentoxide which is/are known to the State of California to cause cancer.

For more information go to www.P65Warnings.ca.gov.

California List of Hazardous Substances

Components	CAS-No.
Divanadium pentoxide	1314-62-1

California Permissible Exposure Limits for Chemical Contaminants

Components	CAS-No.
Divanadium pentoxide	1314-62-1

The components of this products are reported in the following inventories:

CH INV	On the inventory, or in compliance with the inventory.
DSL	All components of this products are on the Canadian DSL.
AICS	On the inventory, or in compliance with the inventory.
NZIoC	Not in compliance with the inventory.
ENCS	Not in compliance with the inventory.
ISHL	Not in compliance with the inventory.
KECI	On the inventory, or in compliance with the inventory.
PICCS	On the inventory, or in compliance with the inventory.
IECSC	On the inventory, or in compliance with the inventory.
TCSI	On the inventory, or in compliance with the inventory.
TSCA	ON TSCA inventory.

TSCA List

No substances are subject to a Significant New Use rule.

No substances are subject to TSCA 12(b) export notification requirements.

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

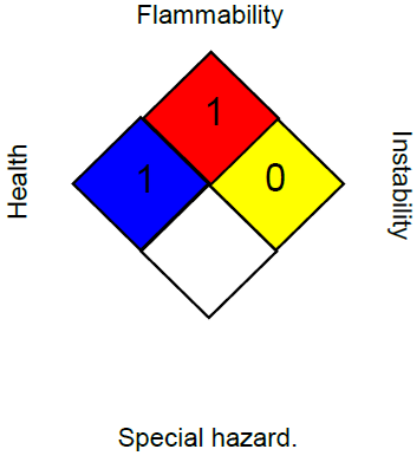
CCC SCR Catalyst D on Metallic Foil Substrate, for SCR Applications

Date SDS Revised: Rev A, June 2019 *Date SDS reviewed:* Rev A, June 2019

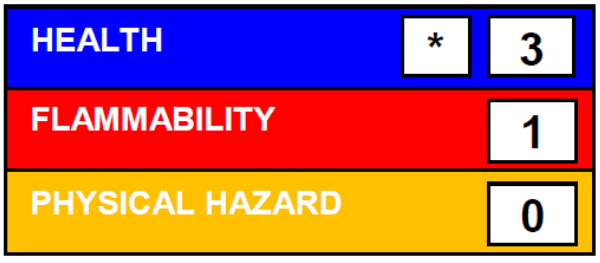
SECTION 16 — OTHER INFORMATION

Further information

NFPA:



HMIS® IV:



HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks. The "*" represents a chronic hazard, while the "/" represents the absence of a chronic hazard.

Full Text of other abbreviations

ACGIH	USA. ACGIH Threshold Limit Values (TLV)
NIOSH REL	USA. NIOSH Recommended Exposure Limits
OSHA P0	USA. OSHA - TABLE Z-1 Limits for Air Contaminants 1910.1000
OSHA Z-1	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
OSHA Z-3	USA. Occupational Exposure Limits (OSHA) - Table Z-3 Mineral Dusts
ACGIH/ TWA	8-hour, time – weighted average
ACGIH/ STEL	Short-term exposure limit
NIOSH REL / TWA	Time – weighted average concentration for up to a 10-hour workday during a 40-hour workweek
NIOSH REL / ST	STEL-15-minute TWA exposure that should not be exceeded at any time during a workday
NIOSH REL / C	Ceiling value not to be exceeded at any time
OSHA P0 / TWA	8-hour time weighted average
OSHA P0 / STEL	Short-term exposure limit
OSHA Z-1 / TWA	8-hour time weighted average
OSHA Z-1 / C	Ceiling
OSHA Z-3 / TWA	8-hour time weighted average

AICS - Australian Inventory of Chemical Substances; ASTM - American Society for the Testing of Materials; bw – Body weight; CERCLA - Comprehensive Environmental Response, Compensation and Liability Act; CMR - Carcinogen, Mutagen or Reproductive Toxicant; DIN - Standard of the German Institute for Standardization; DOT - Department of Transport; DSL - Domestic Substances List (Canada); ECx - Loading rate associated with x% response; EmS - Emergency Schedule; ENCS - Existing and New Chemical Substances (Japan); ErCx - Concentration associated with x% growth rate response; ERG - Emergency Response Guide; GHS - Globally Harmonized System; GLP - Good Laboratory Practice; HMIS - Hazardous Materials Identification System; IARC - International Agency for research on Cancer; IATA - International Air transport Association; IBC - International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk; IC50 – Half maximum inhibitory concentration; ICAO – International Aviation Organization; IECSC - Inventory of existing Chemical Substances in China; IMDG - International Maritime Dangerous Goods; IMO - International Maritime Organization; ISHL - Industrial and Safety Health Law (Japan); ISO - International Organization for Standardization; KECI - Korea Existing Chemicals Inventory; LC50 - Lethal concentration to 50% of test population (Median Lethal Dose); MARPOL - International Convention for the prevention of Pollution from Ships; MSHA - Mine Safety and Health Administration; n.o.s. - Not Otherwise Specified; NFPA - National Fire Protection Association; NO(A)EC - No Observable (Adverse) Effect Concentration; NO(A)EL - No Observable (Adverse) Effect Level; NOELR - No Observable Effect Loading Rate; NTP - National Toxicology Program; NZIoC - New Zealand Inventory of Chemicals; OECD - Organization for Economic Cooperation and Development; OPPTS - Office of the Chemical Safety and Pollution Prevention; PBT - Persistent Bio-Accumulative and Toxic substance; PICCS - Philippines Inventory of Chemicals and Chemical Substances; (Q)SAR - (Quantitative) Structure Activity Relationship; RCRA - Resources Conservation and Recovery Act; REACH - Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorization and Restriction of Chemicals; RQ - Reportable Quantity; SADT - Self- Accelerating Decomposition Temperature; SARA - Superfund Amendment and Reauthorization Act; SDS - Safety Data Sheet; TCSI - Taiwan Chemical Substance Inventory; TSCA - Toxic Substances Control Act (United States); UN - United nations; UNRTDG - United nations Recommendations on the transport of Dangerous Goods; vPvB – Very Persistent and Very Bio-Accumulative.

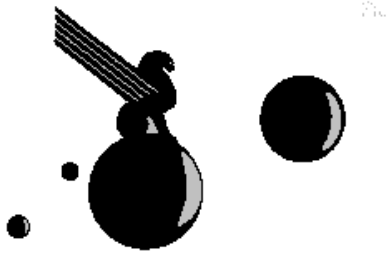
Revision date 06/06/2019

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

US
DrP

***Note**:*

The information in this Safety Data Sheet should be provided to all who use, handle, store, transport or are otherwise exposed to this product. CCC believes the information in this document to be reliable and up to date as of the publication, but makes no guarantee that it is.



Initial Preparation Date: ***3/30/09***
Last Revision Date: ***4/2/09***
Effective Date: ***12/11/09***

MATERIAL SAFETY DATA SHEET

PRODUCT IDENTITY: BlueDEF™ DIESEL EXHAUST FLUID

1. CHEMICAL PRODUCT & COMPANY INFORMATION

OLD WORLD INDUSTRIES, INC.
4065 COMMERCIAL AVENUE
NORTHBROOK, ILLINOIS 60062
PHONE: 847-559-2000
EMERGENCY PHONE: 1-800-424-9300 (CHEMTREC)

2. COMPOSITION / INFORMATION ON INGREDIENTS

No hazardous components identified per 29 CFR 1910.1200.

			TLV (ACGIH)	
Material	***CAS#***	***% by Wt.***	***STEL***	***TWA***
Urea	57-13-6	32 – 33	Not established	10 mg/m^3 (AIHA WEEL)

NOTE: State, local or other agencies or advisory groups may have established more stringent limits. Consult an industrial hygienist or similar professional, or your local agencies, for further information.

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

Avoid contact with eyes, skin and clothing. Wash thoroughly after handling.

Lowest Known LD50 (Oral): Not known

Lowest Known LD50 (Skin): Not known

Carcinogency: Not identified as a carcinogen

National Toxicology Program: Not identified as a carcinogen

International Agency for Research on Cancer: Not identified as a carcinogen

OSHA: Not identified as a carcinogen

HAZARD RATING SYSTEM

NPFA: HEALTH: 1 **FLAMMABILITY:** 0 **REACTIVITY:** 0
HMIS: HEALTH: 1 **FLAMMABILITY:** 0 **REACTIVITY:** 0 **PERSONAL PROTECTION:**

KEY: 0 - Minimal 1 - Slight 2 - Moderate 3 – Serious 4 - Severe

POTENTIAL HEALTH EFFECTS

Eye: Contact may cause mild eye irritation, including stinging, watering and redness.

Skin: Contact may cause mild skin irritation, including redness and burning. No harmful effects from skin absorption have been reported.

Inhalation (Breathing): No information available. Studies by other exposure routes suggest a low degree of toxicity by inhalation.

Ingestion (Swallowing): No harmful effects reported from ingestion.

Cancer: Inadequate evidence available to evaluate the cancer hazard of this material.

Target Organs: No data available.

Developmental: Inadequate evidence available for this material.

Pre-Existing Medical Conditions: None known.

4. FIRST AID MEASURES
Ensure physician has access to this MSDS.

Routes of Entry: Inhalation, Skin, Ingestion

Signs and Symptoms of Exposure: Effects of overexposure may include irritation of the nose, throat and digestive tract, headaches, coughing, nausea, vomiting and transient disorientation.

TREATMENT

Eyes: If irritation or redness develops, move victim away from exposure and into fresh air. Flush eyes with clean water. If symptoms persist, seek medical attention.

Skin: Remove contaminated shoes and clothing and cleanse affected area(s) thoroughly by washing with mild soap and water. If irritation or redness develops and persists, seek medical attention.

Inhalation: If respiratory difficulties develop, move victim away from source of exposure and into fresh air. If symptoms persist, seek medical attention. If victim is not breathing, clear airway and immediately begin artificial respiration. If breathing difficulties develop, oxygen should be administered by qualified personnel. Seek immediate medical attention.

Ingestion: Do NOT induce vomiting. First aid is not normally required; however, if swallowed and symptoms develop, seek medical attention.

Notes to Physician: None.

5. FIRE FIGHTING MEASURES

FIRE & EXPLOSION HAZARD DATA

Flammable Properties

Flash Point:	None to boiling
Method Used:	

Flammability Limits - % of vapor concentration at which product can ignite in presence of spark.

LEL:	No data
UEL:	No data

Hazardous Combustion Products: Closed containers exposed to extreme heat can rupture due to pressure building. Carbon oxides, nitrogen oxides, ammonia, biuret, cyanuric acid and other irritating fumes and smoke.

Extinguishing Media: Use extinguishing agent suitable for type of surrounding fire.

Fire Fighting Instructions: Isolate immediate hazard area and keep unauthorized personnel out. Stop spill / release if it can be done with minimal risk. Move undamaged containers from immediate hazard area if it can be done with minimal risk. Water spray may be useful in minimizing or dispersing vapors. Cool equipment exposed to fire with water, if it can be done with minimal risk.

Protective Equipment For Fire Fighters: For fires beyond the incipient stage, emergency responders in the immediate hazard area should wear bunker gear. When the potential chemical hazard is unknown, in enclosed or

confined spaces, or when explicitly required by DOT, a self-contained breathing apparatus should be worn. In addition, wear other appropriate protective equipment as conditions warrant. (See Section 8.)

6. ACCIDENTAL RELEASE MEASURES

Protect People: Wear appropriate protective equipment, including respiratory protection, as conditions warrant. (See Section 8.)

Protect the Environment: To prevent spilled material from entering sewers, storm drains or natural watercourses, contain material with a dike or with appropriate absorbent materials such as sand, clay, soil or commercially available absorbent. Place reclaimed liquid and absorbent into recovery or salvage drums for disposal. Refer to Section 13 for appropriate disposal.

Cleanup: Stop the source of the release if it can be done without risk. Immediately isolate the hazard area and restrict access to authorized personnel only.

7. HANDLING AND STORAGE

Handling: Do not enter confined spaces such as tanks or pits without following proper entry procedures such as ASTM D-4276 and 29CFR 1910.146. The use of appropriate respiratory protection is advised when concentrations exceed any established exposure limits. (See Sections 2 and 8.) Wash thoroughly after handling. Do not wear contaminated clothing or shoes. Use good personal hygiene practice.

Storage: Keep container(s) tightly closed. Do not heat or contact with strong oxidizers. Use and store this material in cool, dry, well-ventilated areas. Do not store at temperatures below 40º F. Store only in approved containers. Keep away from any incompatible material. (See Section 10.) Protect container(s) against physical damage.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Respiratory Protection: Respiratory protection is not usually required. If significant spray or mist occurs, wear a NIOSH approved or equivalent dust respirator.

Skin Protection: The use of gloves impermeable to the specific material handled is advised to prevent skin contact, possible irritation and absorption. (See glove manufacturer for information on permeability.)

Eye Protection: Approved eye protection to safeguard against potential eye contact, irritation or injury is recommended. Depending on conditions of use, a face shield may be necessary.

Engineering Controls: If current ventilation practices are not adequate to minimize exposure, additional ventilation or exhaust systems may be required.

Other Protective Equipment: A source of clean water should be available in the work area for flushing eyes and skin. Impervious clothing should be worn as needed.

9. PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point:	>212º F
Crystallization Point:	12º F
Pounds/Gallon:	9.09
Specific Gravity (Water =1):	1.09
Vapor Pressure (mm of Hg):	Not applicable
Vapor Density (Air=1):	0.6 H20, >1
Water Solubility:	100%
Appearance:	Colorless, clear liquid
Odor:	None to slight ammonia
Evaporation Rate:	<1

10. STABILITY & REACTIVITY DATA

Stability: Stable under normal conditions of storage and handling.

Conditions to Avoid: None known.

Incompatibility (Materials to Avoid): Avoid contact with strong oxidizing agents such as chlorine (bleach), peroxides, chromates, nitric acid, perchlorates, concentrated oxygen or permanganates. Contact can generate heat, fires, explosions and release toxic fumes.

Hazardous Decomposition Products: If involved in a fire, oxides of carbon and nitrogen may be generated; exposure to heat may generate ammonia fumes.

Hazardous Polymerization: Will not occur.

11. TOXICOLOGICAL INFORMATION

No definitive information available on carcinogenicity, mutagenicity, target organs or developmental toxicity.

Toxicological data: There is no available data for the product itself, only for the ingredients. See below for individual ingredient acute toxicity data.

Ingredients	LC_{50} (4 hr) Inh, rat	LD_{50}	
		Oral	Dermal
Urea	N/Av	8471 mg/kg (rat)	8200 mg/kg (rabbit)

12. ECOLOGICAL INFORMATION

No data available.

13. DISPOSAL CONSIDERATIONS

This material, if discarded as produced, is not a RCRA “listed” or “characteristic” hazardous waste. Use resulting in chemical or physical change or contamination may subject it to regulation as a hazardous waste. Along with properly characterizing all waste materials, consult state and local regulations regarding the proper disposal of this material.

If this product becomes a waste, it does not meet the criteria of a hazardous waste as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261, since it does not have the characteristics of Subpart C, nor is it listed under Subpart D. As a non-hazardous liquid waste, it should be solidified with stabilizing agents such as sand, fly ash, or clay absorbent, so that no free liquid remains before disposal to an industrial waste landfill.

RCRA # Not listed

14. TRANSPORT INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION (DOT): NOT CONTROLLED UNDER DOT.

Proper Shipping Name:	Labels Required:
Hazard Class:	Placard:
UN Identification:	Exemption:
Packing Group:	Reportable Quantity:

ICAO/IATA: NOT CONTROLLED UNDER ICAO/IATA.

Proper Shipping Name:	Labels Required:
Hazard Class:	Placard:
UN Identification:	Exemption:
Packing Group:	Reportable Quantity:

IMDG: NOT CONTROLLED UNER IMDG.

Proper Shipping Name:	Labels Required:
Hazard Class:	Placard:
UN Identification:	Exemption:
Packing Group:	Reportable Quantity:

15. REGULATORY INFORMATION

Sara Title III: This material contains the following chemicals subject to the reporting requirements of SARA 313 and 40 CFR 372: **None**

California Proposition 65: This material contains the following chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm, and are subject to the requirements of California Proposition 65 (CA Health & Safety Code Section 25249.5): **None known**

EPA (CERCLA) Reportable Quantity: **None**

Canadian Regulations:

WHMIS Information: This product is not a WHMIS controlled product in Canada. Refer elsewhere in the MSDS for specific warnings and safe handling information. Refer to the employer's workplace education program. All ingredients appear on the Domestic Substances List (DSL).

16. OTHER INFORMATION

Contact: Thomas Cholke **Phone**: (847) 559-2225

Old World Industries, Inc. makes no warranty, representation or guarantee as to the accuracy, sufficiency or completeness of the material set forth herein. It is the user's responsibility to determine the safety, toxicity and suitability of his own use, handling and disposal of this product. Since actual use by others is beyond our control, no warranty, expressed or implied, is made by Old World Industries, Inc. as to the effects of such use, the results to be obtained or the safety and toxicity of this product, nor does Old World Industries, Inc. assume liability arising out of the use by others of this product referred to herein. The data in this MSDS relates only to the specific material designated herein and does not relate to use in combination with any other material or in any process.

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Wiring Schematic

Holt Texas LTD.

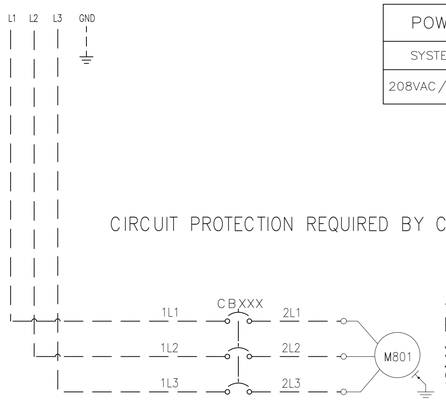
Holt CAT Single Lance (3516E) SCR Systems

VPN 1040251

Published September 2022

• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

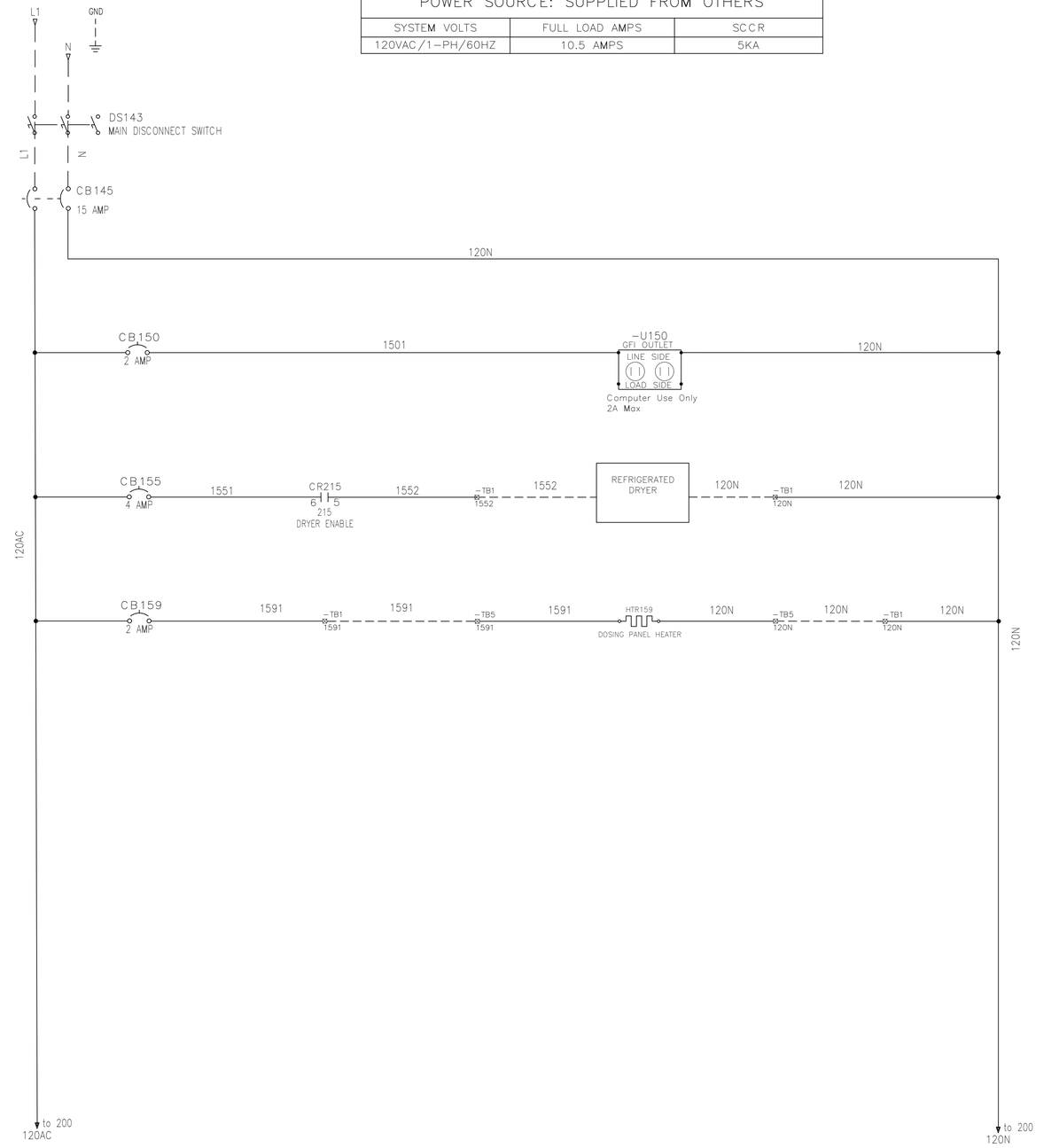
POWER SOURCE: SUPPLIED FROM OTHERS		
SYSTEM VOLTS	FULL LOAD AMPS	SCCR
208VAC/3-PH/60HZ	9 AMPS FLA	5KA



CIRCUIT PROTECTION REQUIRED BY CUSTOMER

-M801
POWEREX SES 0308 AIR COMPRESSOR
3 HP
208VAC/3PH/60HZ
9 AMPS FLA

POWER SOURCE: SUPPLIED FROM OTHERS		
SYSTEM VOLTS	FULL LOAD AMPS	SCCR
120VAC/1-PH/60HZ	10.5 AMPS	5KA



————	DENOTES INTERNAL WIRING
— — — —	DENOTES FIELD WIRING

REV.	DESCRIPTION	DATE	BY
00	INITIAL CREATION	3/29/2022	J.B-E
01	UPDATED CUSTOMER SUBMITTAL	5/17/2022	J.B-E
02	APPROVED FOR FAB	8/18/2022	CJY
A	AS BUILT	9/23/2022	CJY
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	DRAWING STATUS:	DATE:	BY:
	PRELIMINARY		
X	FOR APPROVAL	5/17/2022	J.B-E
X	APPROVED FOR FAB	8/18/2022	CJY
X	AS BUILT	9/23/2022	CJY
	AS FIELD MODIFIED		

MATERIAL: SEE BOM
WEIGHT: N/A
TOLERANCES: .X = 0.06, .XX = 0.03, .XXX = 0.015, ∠ = 0.5°
THIRD ANGLE PROJECTION
INCH [mm]

CATALYTIC COMBUSTION EMISSION TECHNOLOGIES

Catalytic Combustion Corporation
311 Riggs Street
Bloomer, WI 54724
Telephone: 715-568-2882
Fax: 715-568-2884
www.catalyticcombustion.com

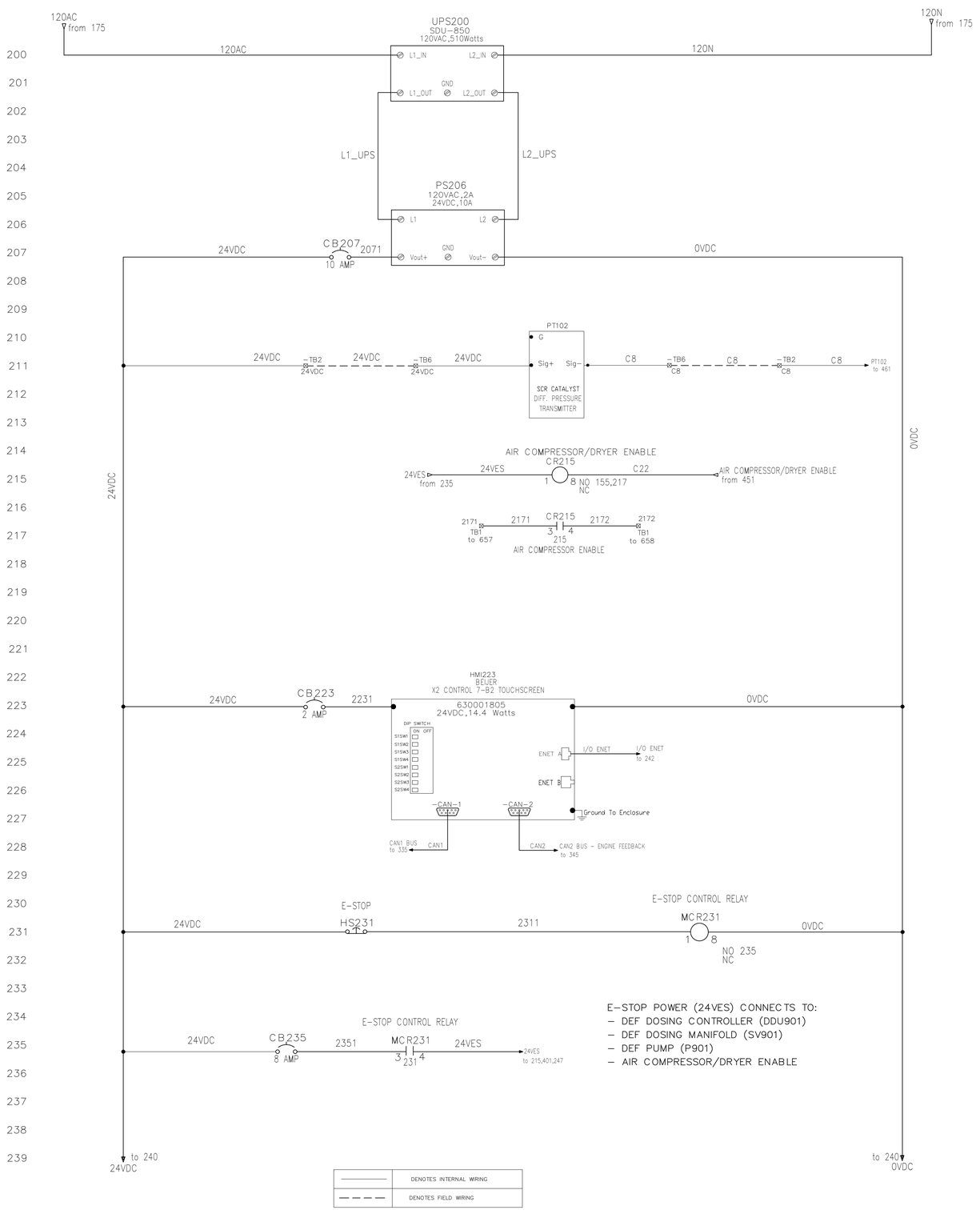
DO NOT SCALE THIS DRAWING

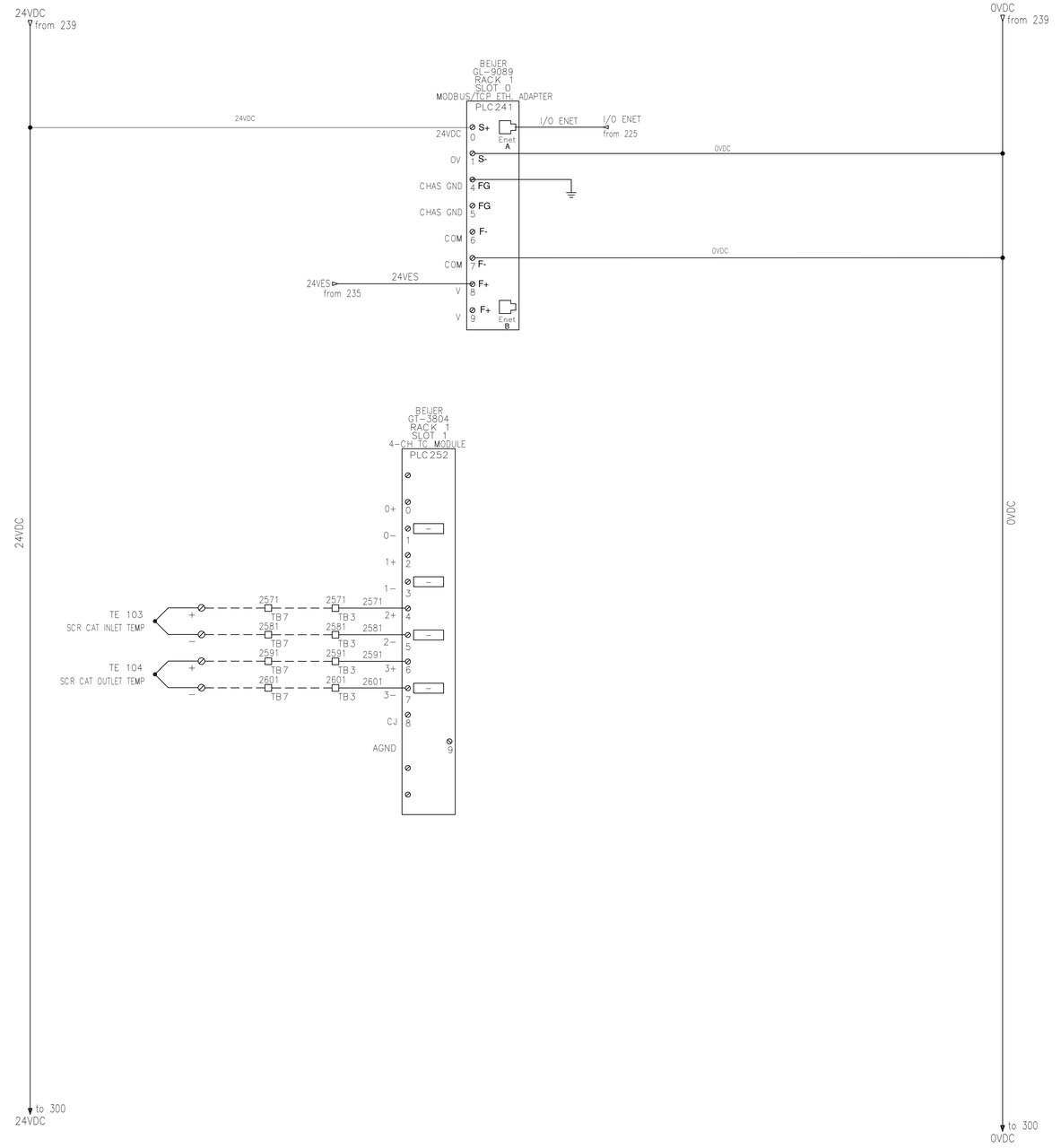
DATE: 08/18/2022
SCALE: NTS
DRAWN BY: CJY
CHECKED BY: BR

CUSTOMER: PN-1040157
CP-B7-157KG-3030-NA-NA-UZ-1

TITLE: SELECTIVE CATALYST REDUCTION SYSTEM
ELECTRICAL SCHEMATICS

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
SCR-SINGLE	301	A	D





REV	DESCRIPTION	DATE	BY
00	INITIAL CREATION	3/29/2022	J.B-E
01	UPDATED CUSTOMER SUBMITTAL	5/17/2022	J.B-E
02	APPROVED FOR FAB	8/18/2022	CJY
A	AS BUILT	9/23/2022	CJY
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	DRAWING STATUS:	DATE:	BY:
.	PRELIMINARY		
X	FOR APPROVAL	5/17/2022	J.B-E
X	APPROVED FOR FAB	8/18/2022	CJY
X	AS BUILT	9/23/2022	CJY
.	AS FIELD MODIFIED		

MATERIAL: SEE BOM
WEIGHT: N/A
TOLERANCES:
.X = 0.06
.XX = 0.03
.XXX = 0.015
∠ = 0.5°
THIRD ANGLE PROJECTION
INCH [mm]

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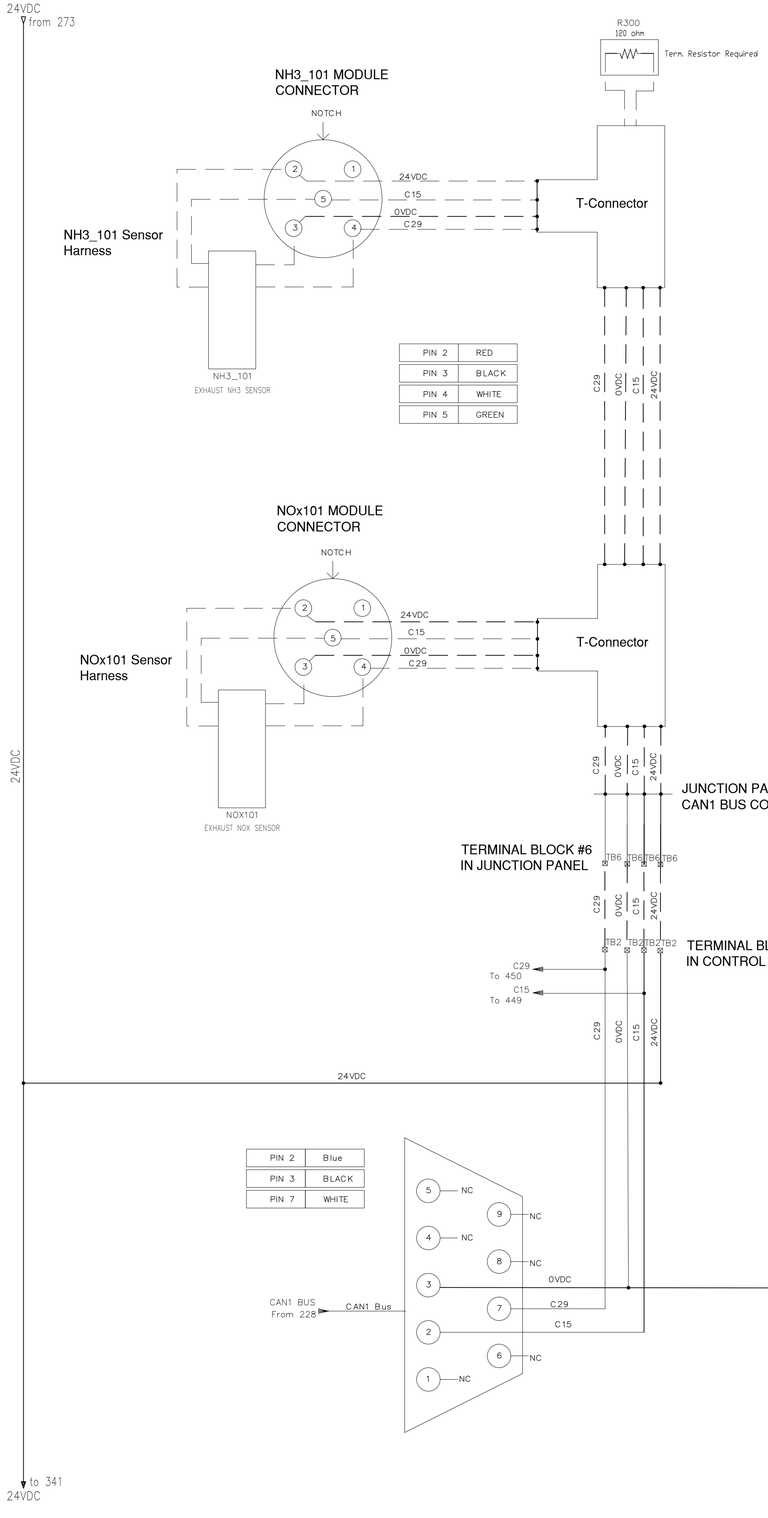
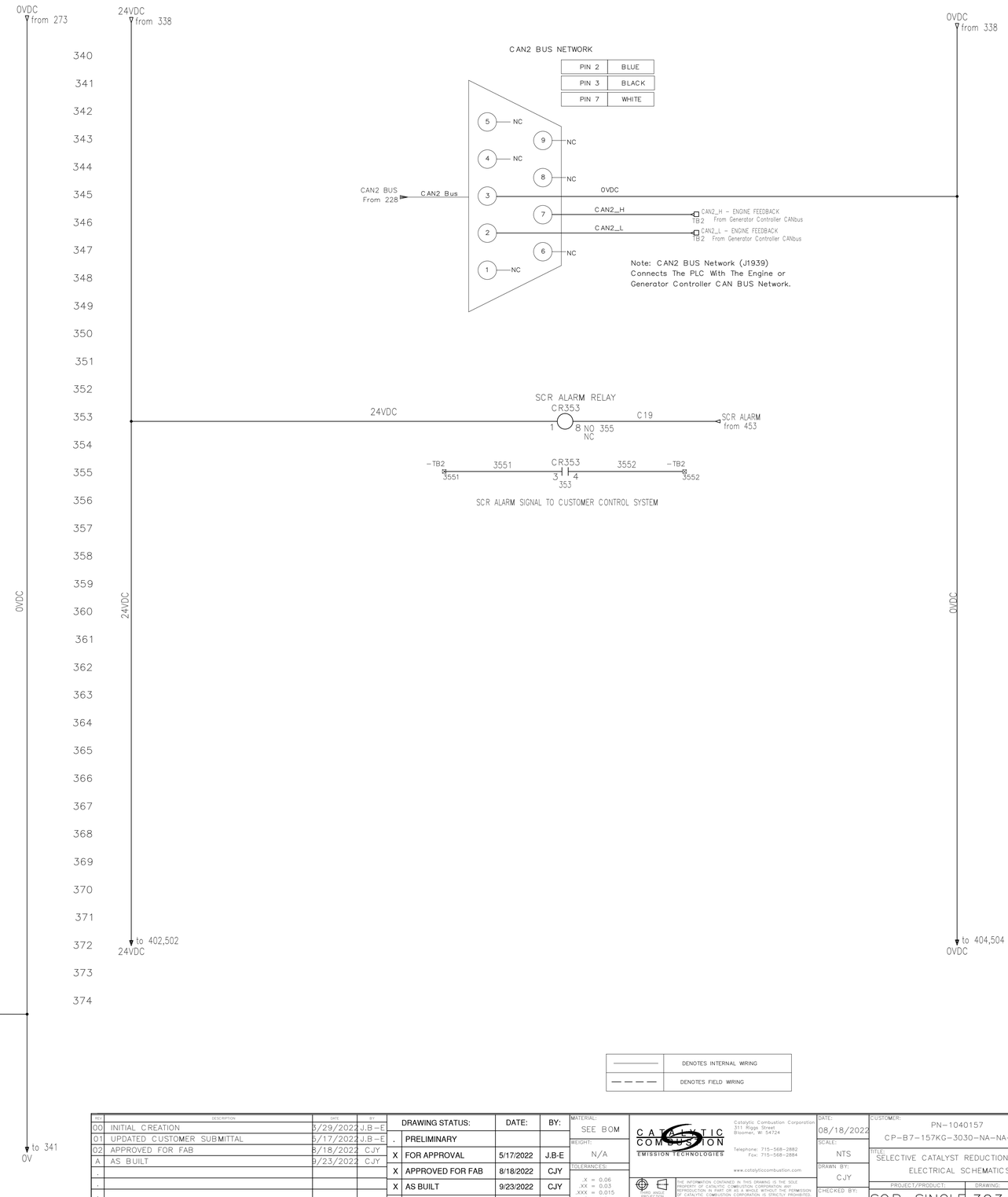
DATE: 08/18/2022
SCALE: NTS
DRAWN BY: CJY
CHECKED BY: BR

CUSTOMER: PN-1040157
CP-B7-157KG-3030-NA-NA-UZ-1
TITLE: SELECTIVE CATALYST REDUCTION SYSTEM ELECTRICAL SCHEMATICS

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
SCR-SINGLE	302	A	D





———	DENOTES INTERNAL WIRING
— — — —	DENOTES FIELD WIRING

REV	DESCRIPTION	DATE	BY
00	INITIAL CREATION	5/29/2022	J.B-E
01	UPDATED CUSTOMER SUBMITTAL	6/17/2022	J.B-E
02	APPROVED FOR FAB	8/18/2022	CJY
A	AS BUILT	9/23/2022	CJY
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DRAWING STATUS:		DATE:	BY:
.	PRELIMINARY		
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X	APPROVED FOR FAB	8/18/2022	CJY
X	AS BUILT	9/23/2022	CJY
.	AS FIELD MODIFIED		

MATERIAL: SEE BOM
WEIGHT: N/A
TOLERANCES:
.X = 0.06
.XX = 0.03
.XXX = 0.015
∠ = 0.5°

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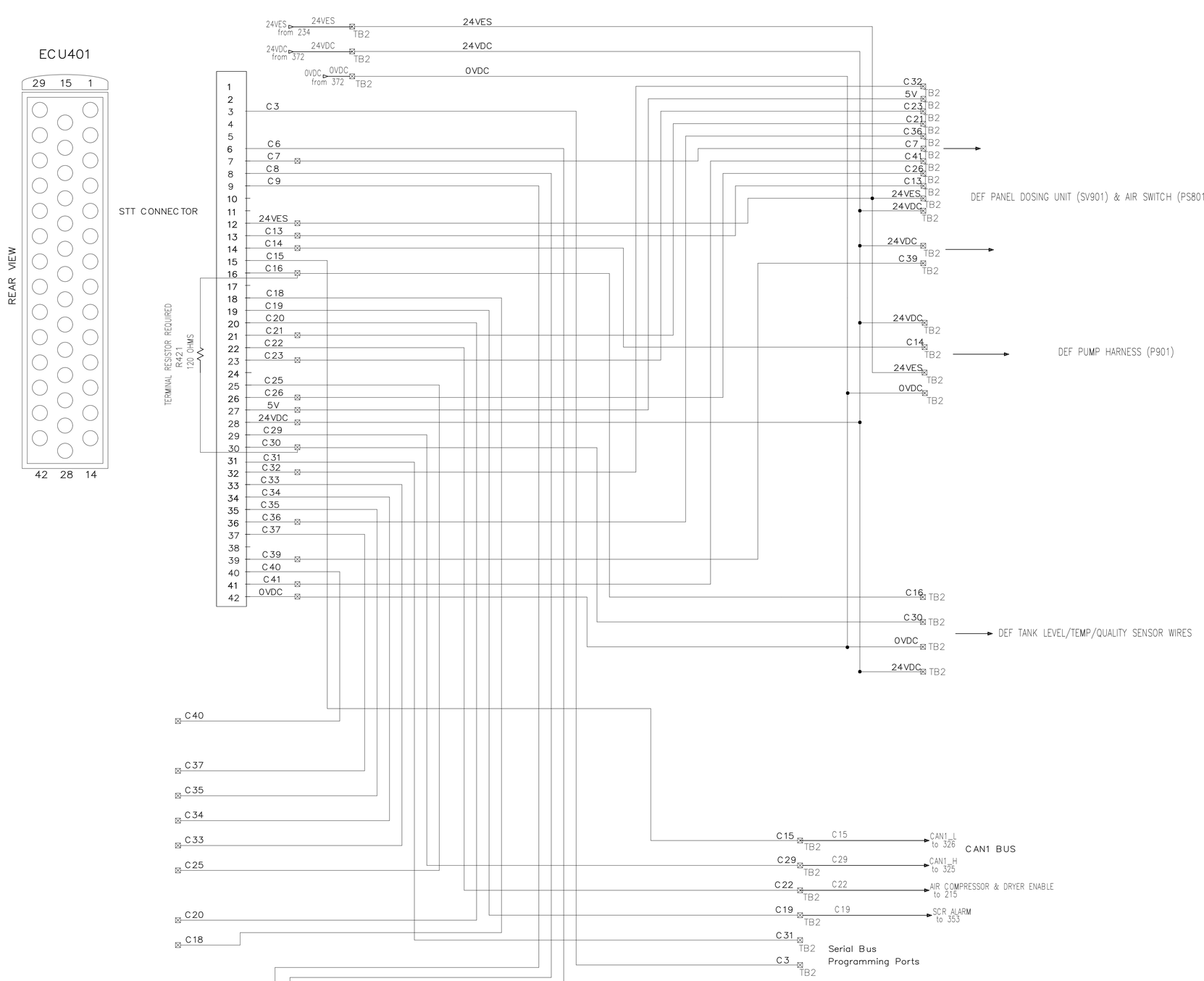
DATE:	08/18/2022
SCALE:	NTS
DRAWN BY:	CJY
CHECKED BY:	BR

CUSTOMER: PN-1040157
CP-B7-157KG-3030-NA-NA-UZ-1

TITLE: SELECTIVE CATALYST REDUCTION SYSTEM
ELECTRICAL SCHEMATICS

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
SCR-SINGLE	303	A	D



Wire #	Signal	Wire Color	Description
C3	TXD	BLUE	Prog. Port
C6	AIN1−	BLUE	SPARE
C7	PAIR	BLUE	PT901.3
C8	AIN5	BLUE	PT102
C9	AIN8	BLUE	SPARE
24VES	DIG2	BLUE	HS231 (E−Stop)
C13	AIR	BLUE	SV901.2
C14	PRPM	BLUE	P901
C15	CAN1_L	BLUE	CAN1_L
C16	CAN1.1_L	BLUE	CAN1.1_L
C18	AIN10	BLUE	SPARE
C19	ACT5	BLUE	SCR ALARM
C20	AIN2+	BLUE	SPARE
C21	PDEF1	BLUE	PT901.1
C22	ACT6	BLUE	M801
C23	TDEF1	BLUE	TE901.1
C25	DIG3	BLUE	SPARE
C26	FLUSH	BLUE	SV901.1
5V	5VDC	BLUE	5VDC
24VDC	VDDS	BLUE	24VDC
C29	CAN1_H	BLUE	CAN1_H
C30	CAN1.1_H	BLUE	CAN1.1_H
C31	RXD	BLUE	Prog. Port
C32	0VDC	BLUE	0VDC
C33	AIN11	BLUE	SPARE
C34	AIN1+	BLUE	SPARE
C35	AIN2−	BLUE	SPARE
C36	PDEF2	BLUE	PT901.2
C37	AIN6	BLUE	SPARE
C39	DIG1	BLUE	PS801
C40	DIG4	BLUE	SPARE
C41	INJ	BLUE	SV901.3
0VDC	VSS	WHT/BLU	0VDC

———	DENOTES INTERNAL WIRING
— — — —	DENOTES FIELD WIRING

REV	DESCRIPTION	DATE	BY
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.	AS FIELD MODIFIED		

MATERIAL: SEE BOM
WEIGHT: N/A
TOLERANCES: .X = 0.06, .XX = 0.03, .XXX = 0.015, ∠ = 0.5°
THIRD ANGLE PROJECTION
INCH [mm]

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EMISSION TECHNOLOGIES
Catalytic Combustion Corporation
311 Riggs Street
Bloomer, WI 54724
Telephone: 715-568-2882
Fax: 715-568-2884
www.catalyticcombustion.com

DATE: 08/18/2022
SCALE: NTS
DRAWN BY: CJY
CHECKED BY: BR

CUSTOMER: PN−1040157
CP−B7−157KG−3030−NA−NA−UZ−1

TITLE: SELECTIVE CATALYST REDUCTION SYSTEM ELECTRICAL SCHEMATICS

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
SCR−SINGLE	304	A	D

———————	DENOTES CCC RESPONSIBLE WIRING
- - - - - - - -	DENOTES WIRING RESPONSIBLE BY OTHERS

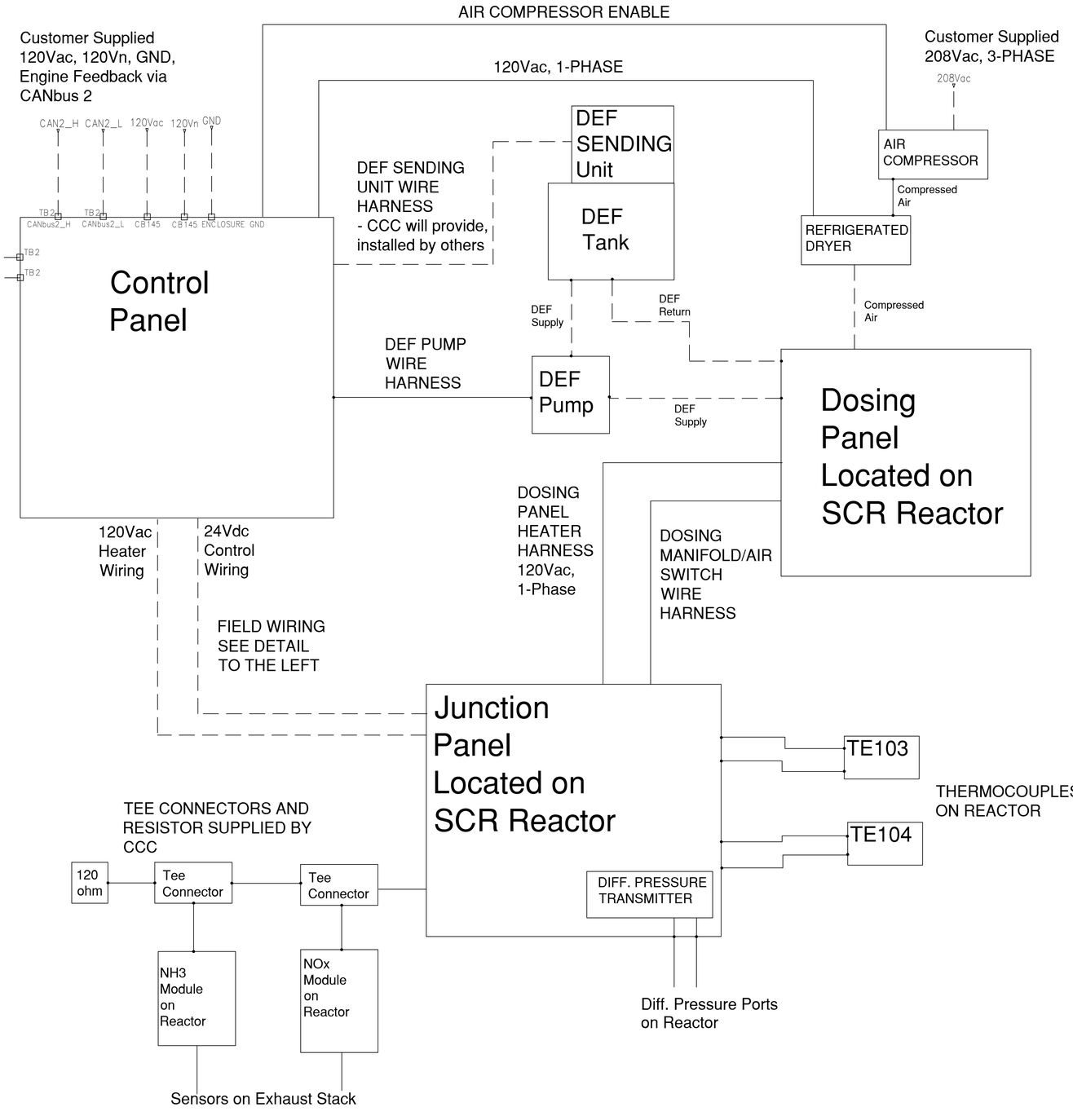
Interconnect Wiring

CONTROL PANEL — JUNCTION PANEL

TB3	2571	TYPE-K EXTENSION WIRE, 20AWG	TB7
TB3	2581		TB7
TB3	2591	TYPE-K EXTENSION WIRE, 20AWG	TB7
TB3	2601		TB7
TB2	C29	CANbus1, TWISTED PAIR, 20AWG	TB6
TB2	C15		TB6
TB2	24VDC	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	24VES	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	5V	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	0V	WHITE w/ BLUE STRIPE, 18 AWG, THHN, STRANDED	TB6
TB2	C7	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C13	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C21	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C23	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C26	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C32	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C36	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C37	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C39	BLUE, 18 AWG, THHN, STRANDED	TB6
TB2	C41	BLUE, 18 AWG, THHN, STRANDED	TB6

120VAC Wiring

TB1	1591	RED, 18 AWG, THHN, STRANDED	TB5
TB1	120N	WHITE, 18 AWG, THHN, STRANDED	TB5



REV	DESCRIPTION	DATE	BY
00	INITIAL CREATION	5/29/2022	J.B-E
01	UPDATED CUSTOMER SUBMITTAL	5/17/2022	J.B-E
02	APPROVED FOR FAB	8/18/2022	CJY
A	AS BUILT	9/23/2022	CJY

	DRAWING STATUS:	DATE:	BY:
.	PRELIMINARY		
X	FOR APPROVAL	5/17/2022	J.B-E
X	APPROVED FOR FAB	8/18/2022	CJY
X	AS BUILT	9/23/2022	CJY
.	AS FIELD MODIFIED		

MATERIAL: SEE BOM
WEIGHT: N/A
TOLERANCES: .X = 0.06, .XX = 0.03, .XXX = 0.015, ∠ = 0.5°

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES
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www.catalyticcombustion.com

ISO 9001 REGISTERED
INCH [mm]
DO NOT SCALE THIS DRAWING

DATE: 08/18/2022
SCALE: NTS
DRAWN BY: CJY
CHECKED BY: BR

CUSTOMER: PN-1040157
CP-B7-157KG-3030-NA-NA-UZ-1
TITLE: SELECTIVE CATALYST REDUCTION SYSTEM
ELECTRICAL SCHEMATICS

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
SCR-SINGLE	305	A	D

Junction Panel

Dosing Panel

C32
5V
C23
C21
C36
C7
C41
C26
C13
24VES
24VDC

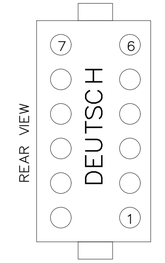
DOSING MANIFOLD AND AIR PRESSURE SWITCH WIRES

C32 → 1 / 1
5V → 2 / 2
C23 → 3 / 3
C21 → 4 / 4
C36 → 5 / 5
C7 → 6 / 6
C41 → 7 / 7
C26 → 8 / 8
C13 → 9 / 9
24VES → 10 / 10
24VDC → 11 / 11
12 / 12

SV901
DEF DOSING UNIT

DEUTSCH CONNECTOR			
PAIR 1	B	PIN 1	C32
	W	PIN 2	5V
PAIR 2	B	PIN 3	C23
	W	PIN 4	C21
PAIR 3	B	PIN 5	C36
	W	PIN 6	C7
PAIR 4	B	PIN 7	C41
	W	PIN 8	C26
PAIR 5	B	PIN 9	C13
	W	PIN 10	24VES
PAIR 6	B	PIN 11	24VDC
	W	PIN 12	NA

–PLUG 1

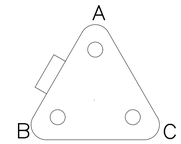


24VDC → A / A
C39 → B / B
C → C

PS801
AIR PRESSURE SWITCH

DEUTSCH CONNECTOR			
PAIR 7	B	PIN B	24VDC
	W	PIN C	C39

–PLUG 2

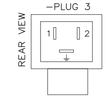


DOSING PANEL HEATER HARNESS

1591 → 1 / 1
120N → 2 / 2

SQR. DIN CONNECTOR			
	R	PIN 1	1591
	W	PIN 2	120N

–PLUG 3



Control Panel

0V
24VDC
C14
24VES

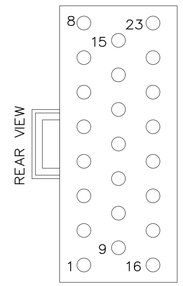
UREA PUMP WIRES

0V → 1 / 1
24VDC → 2 / 2
C14 → 3 / 4
24VES → 4 / 5
5 / 6..
6.. / ..23
..23

M901
P901
DEF. PUMP

AMP CONNECTOR			
PAIR 1	B	PIN 1	0V
	W	PIN 2	24VDC
		PIN 3	NA
PAIR 2	B	PIN 4	C14
	W	PIN 5	24VES
		PIN 6–23	NA

–PLUG 4



C16
C30
0V
24VDC

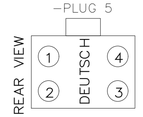
UREA TANK SENSOR WIRES

C16 → 1 / 1
C30 → 2 / 2
0V → 3 / 3
24VDC → 4 / 4

LT901
DEF LEVEL SENSOR

DEUTSCH CONNECTOR			
PAIR 1	B	PIN 1	C16
	W	PIN 2	C30
PAIR 2	B	PIN 3	0V
	W	PIN 4	24VDC

–PLUG 5



2171 → Wire 101
2172 → Wire 001

M801
Air Compressor Enable
Remove Start/Stop Switch and wire nut wires 2171 and 2172 to wires 101 & 001

1552 → Brown
120N → White
Refrigerated Dryer

Remove green power switch and wire nut brown & white wire together. Wire nut black wire by itself.

REV	DESCRIPTION	DATE	BY
00	INITIAL CREATION	5/29/2022	J.B-E
01	UPDATED CUSTOMER SUBMITTAL	5/17/2022	J.B-E
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A	AS BUILT	9/23/2022	CJY
.			
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	DRAWING STATUS:	DATE:	BY:
.	PRELIMINARY		
X	FOR APPROVAL	5/17/2022	J.B-E
X	APPROVED FOR FAB	8/18/2022	CJY
X	AS BUILT	9/23/2022	CJY
.	AS FIELD MODIFIED		

MATERIAL: SEE BOM
WEIGHT: N/A
TOLERANCES: .X = 0.06, .XX = 0.03, .XXX = 0.015, ∠ = 0.5°
THIRD ANGLE PROJECTION
INCH [mm]

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES
Catalytic Combustion Corporation
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Bloomer, WI 54724
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DATE: 08/18/2022
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CUSTOMER: PN-1040157
CP-B7-157KG-3030-NA-NA-UZ-1
TITLE: SELECTIVE CATALYST REDUCTION SYSTEM ELECTRICAL SCHEMATICS

PROJECT/PRODUCT:	DRAWING:	REV:	SIZE:
SCR-SINGLE	306	A	D

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

General Arrangement Drawings

Holt Texas LTD.

Holt CAT Single Lance (3516E) SCR Systems

VPN 1040251

Published September 2022

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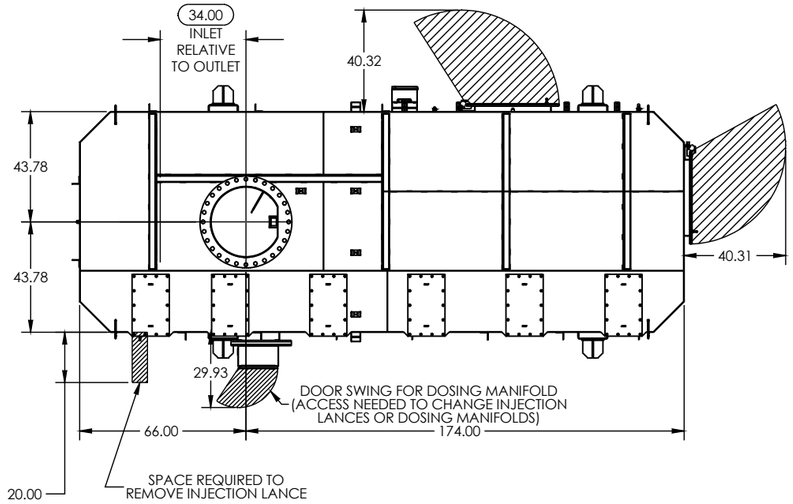
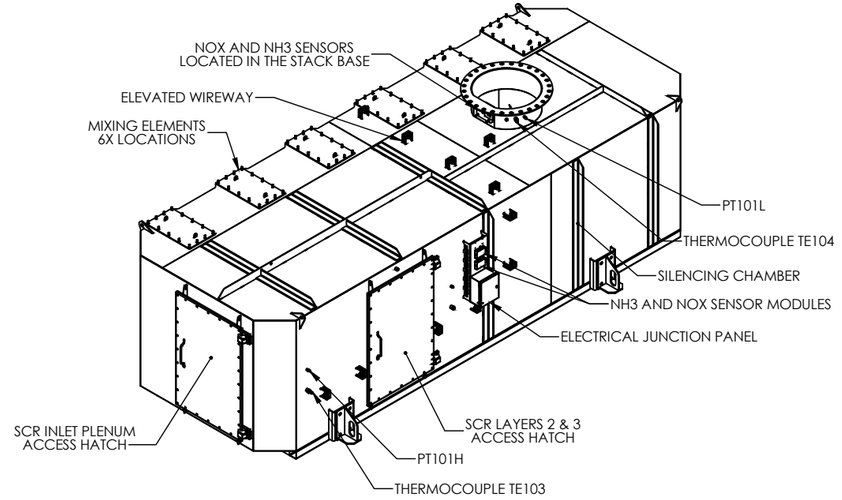
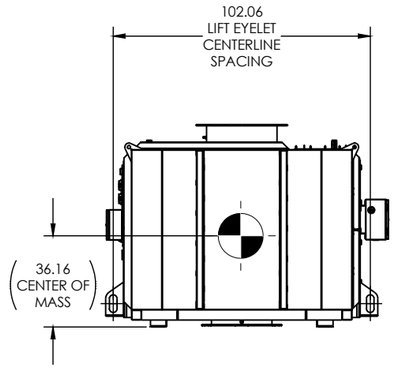
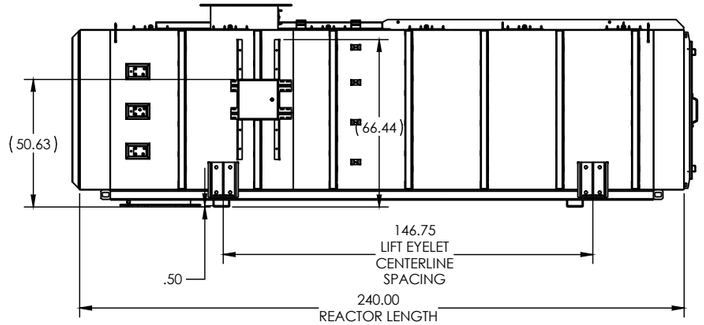
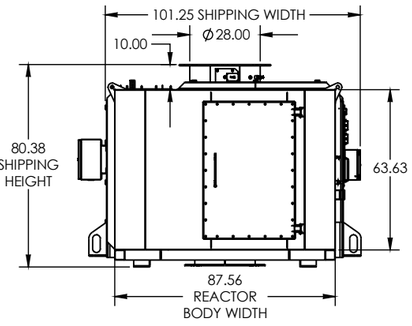
www.catalyticcombustion.com

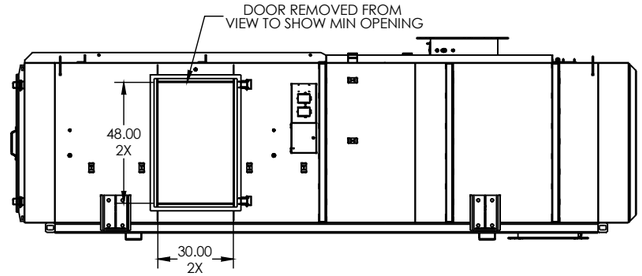


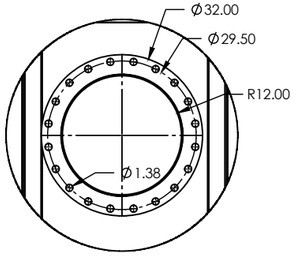




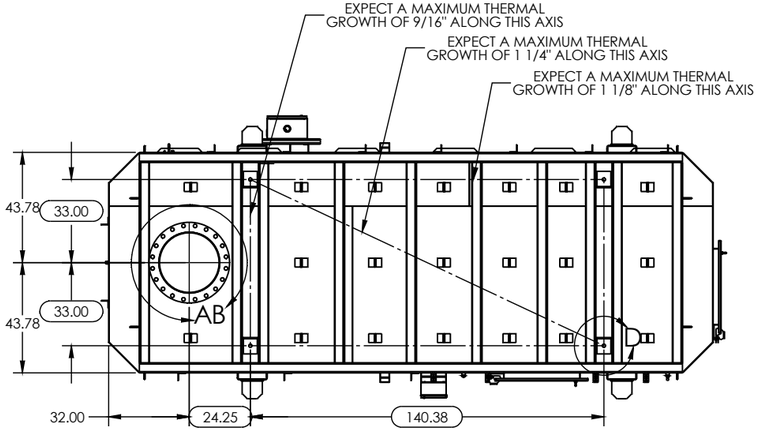


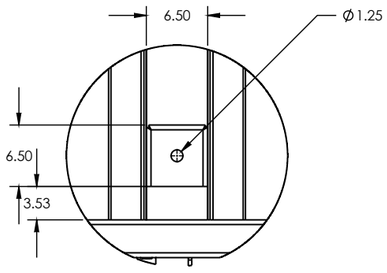




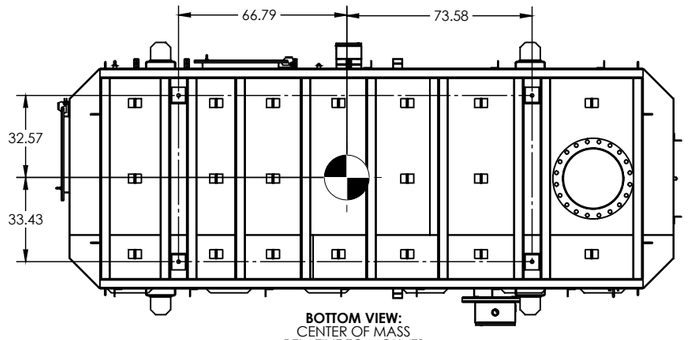


DETAIL AB
SCALE 1 : 15
INLET DETAIL





DETAIL D
SCALE 1 : 8
4X PLACES



BOTTOM VIEW:
CENTER OF MASS
RELATIVE TO MOUNTS

NOTES:

1) APPROXIMATE WEIGHT: 13,800 LBS

2) EXTERIOR WILL BE COVERED WITH FABRIC INSULATION BLANKET. INSULATION OUTER COVER WILL BE GRAY WITH SS FASTENERS.

3) SCR BODY CONSTRUCTION IS 3/16" 304 SS PANELS.

4) ALLOW 5" FROM THE OUTSIDE FACES TO CLOSEST OBSTRUCTION.

REV.	ECN	TIER	DESCRIPTION	DATE	APPROVED BY
03	N/A	1	UPDATED MODEL TO BE STANDALONE SINGLE INJECTION CONFIGURATION	07/19/2022	jbartlett
A	N/A	2	RELEASED TO PRODUCTION	07/19/2022	jbartlett
B					

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGULAR: FABRICATED ±1.0°
MACHINED ±0.5°
ONE PLACE DECIMAL ±0.1
TWO PLACE DECIMAL ±0.06
THREE PLACE DECIMAL ±0.030
DUAL DIMENSIONS IN. (MM)
REMOVE ALL BURRS AND
BREAK SHARP EDGES

	NAME	DATE
DRAWN:	cmalls	03/31/2022
MATERIAL:		

THIRD ANGLE PROJECTION

DO NOT SCALE DRAWING

CATALYTIC COMBUSTION
311 RIGGS ST.
RICHMOND, WI 53124
TEL: 715-568-2882
FAX: 715-568-2884

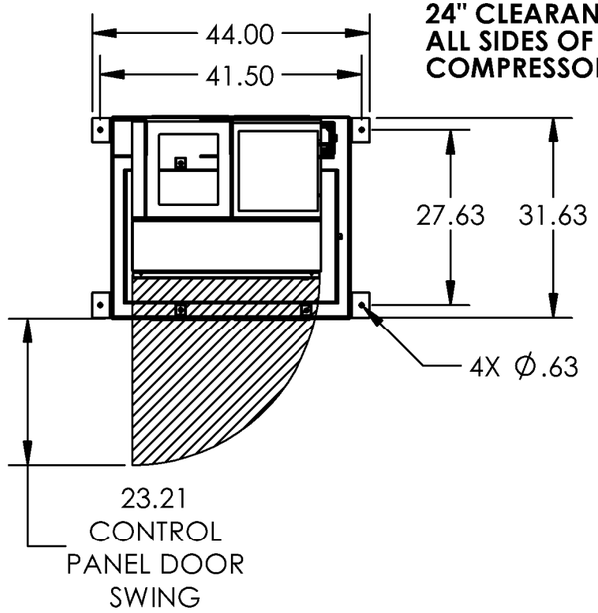
DESCRIPTION:
SCR-S-TIER IV-S24S28-3R3C3L-SCR+SIL-HOLT 3.1 MW-01

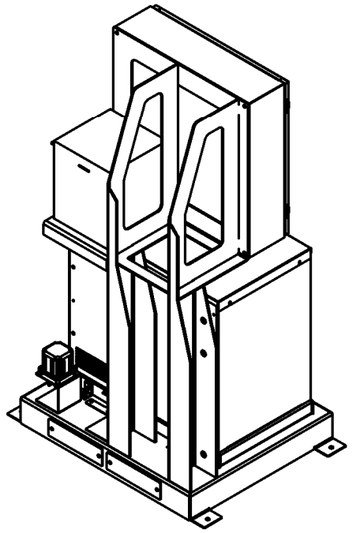
VISUAL PART NO.
1040201

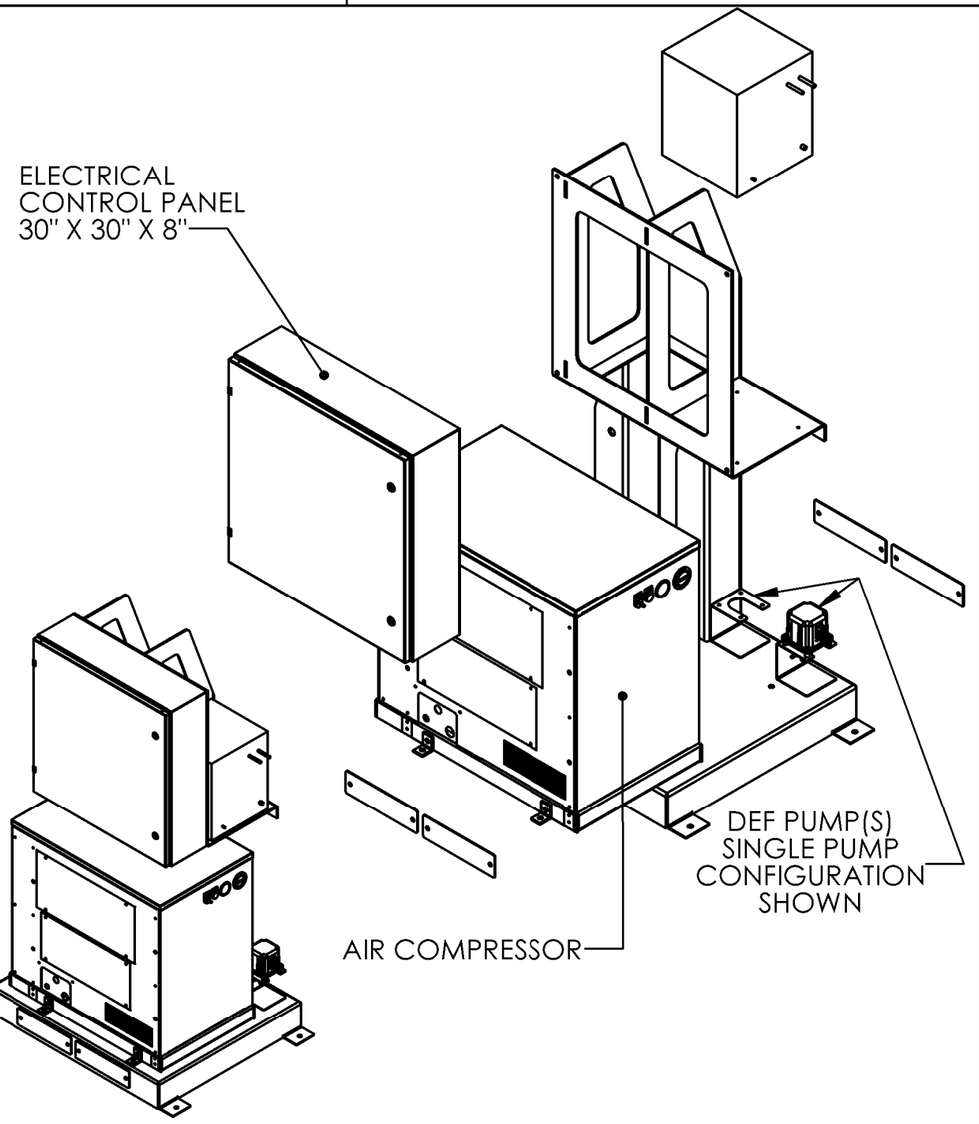
SIZE D | DRAWING NO. 703275 | REV B

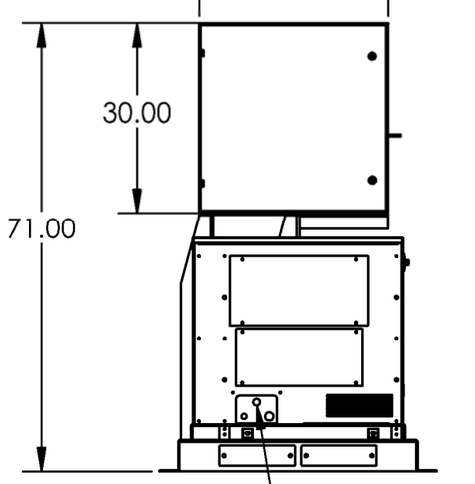
SCALE: 1:30 WT: SHEET 1 OF 6

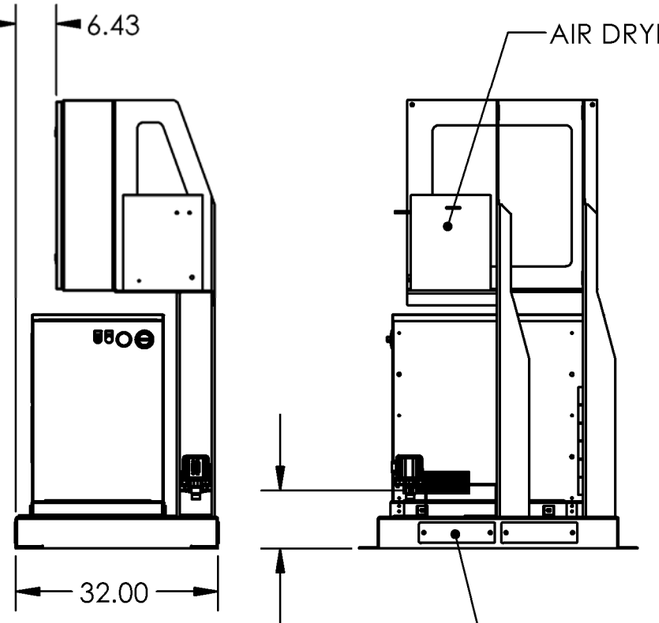
NOTE:
24" CLEARANCE REQUIRED ON ALL SIDES OF SKID FOR COMPRESSOR MAINTENANCE.











DEF PUMP LIMITATIONS:
-MOUNTING: MAX 1.0M ABOVE TOP OF DEF TANK
-MAX 2.0M SUCTION LINE LENGTH FROM DEF TANK TO PUMP
-MAX 10.0M PRESSURE LINE LENGTH VERTICAL OR HORIZONTAL BETWEEN PUMP AND DOSING MANIFOLD

REV.	ECN	TIER	DESCRIPTION	DATE	APPROVED BY
A	N/A	2	RELEASED TO PRODUCTION	02/02/2022	lszura
B	N/A	3	4X MOUNT HOLES UPDATED FOR 3/8" HARDWARE	06/02/2022	blewan
C	N/A	3	ADDED CONFIGURATION FOR DUAL PUMPS	07/07/2022	lszura

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGULAR: FABRICATED ±1.0°
MACHINED ±0.5°
ONE PLACE DECIMAL ±0.1
TWO PLACE DECIMAL ±0.06
THREE PLACE DECIMAL ±0.030
DUAL DIMENSIONS IN. {MM}

REMOVE ALL BURRS AND BREAK SHARP EDGES

	NAME	DATE
DRAWN	cccintern	01/07/2022

MATERIAL:

THIRD ANGLE PROJECTION

VISUAL PART NO.
SEE TABLE

DO NOT SCALE DRAWING

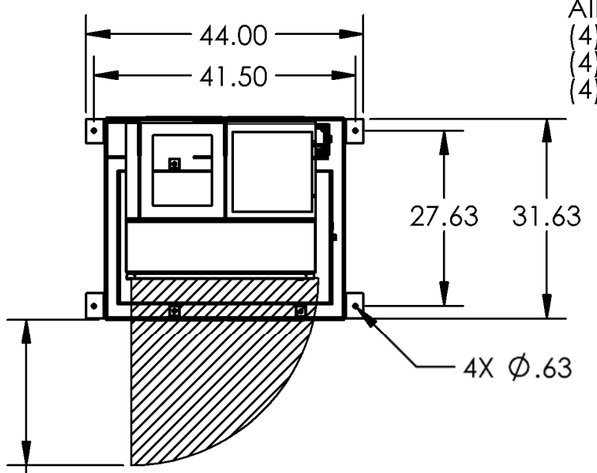
CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES
311 RIGGS ST.
BLOOMER, WI 54724
TEL. 715-568-2882
FAX 715-568-2884

DESCRIPTION:
Aux Skid Assy - 30x30 Controls - Compressor - Single or Dual Pumps - Type 01

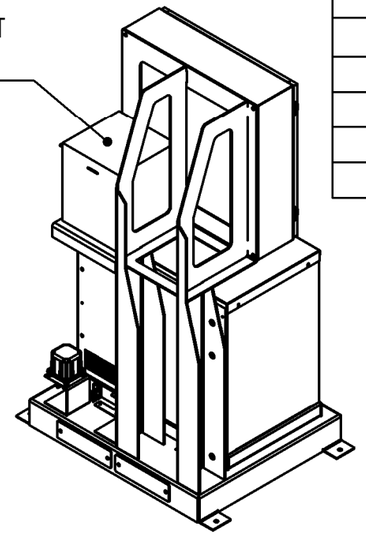
SIZE	DRAWING NO.	REV
B	701455	C

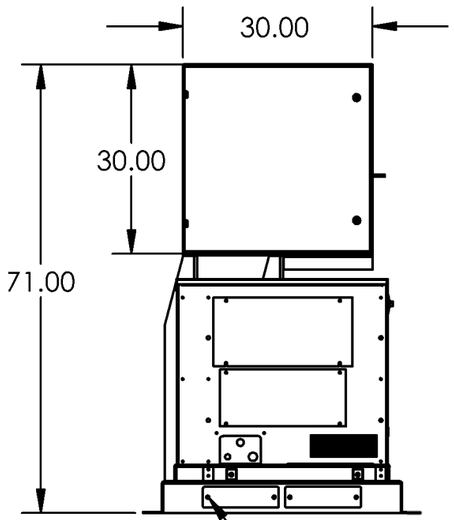
SCALE: 1:24 WT: SHEET 1 OF 2

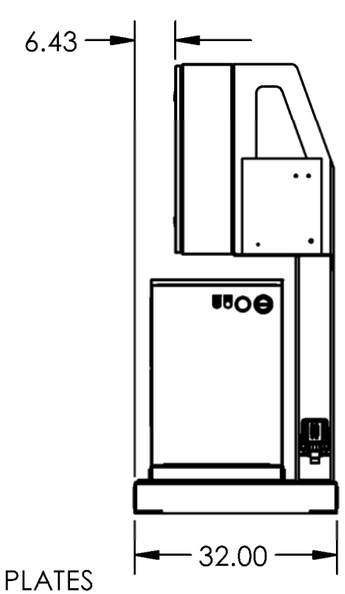
ITEM NO.	DRAWING NUMBER	REVISION	CONFIGURATION	VISUAL P/N	DESCRIPTION	MATERIAL	WEIGHT	QTY.
1	701457	D	Default	N/A	COMPRESSOR SKID FRAME WELDMENT		286.72	1
2	586623	D	Outboard Anchor Pads Shown	SEE TABLE	AIR COMPRESSOR POWEREX SES 0308		17.616	1
3	588338	D	Default	(SEE TABLE)	Deltech Air Cooler/Dryer (HG10/HG15)		86.052	1
4	608690	B	Default	1033211	SAGINAW ENCLOSURE - 30X30X8 SCE-30EL3008LP		13.154	1
5	593488	B	Default	1036890	SKID COVER PLATE 3.25" X 12.0" - BOLT-ON	ASTM A36 Steel	1.471	4
6	571926	B	Default	SEE TABLE	DEF PUMP ASSY - STT EMTEC			1

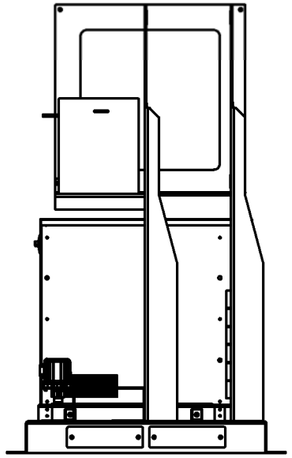


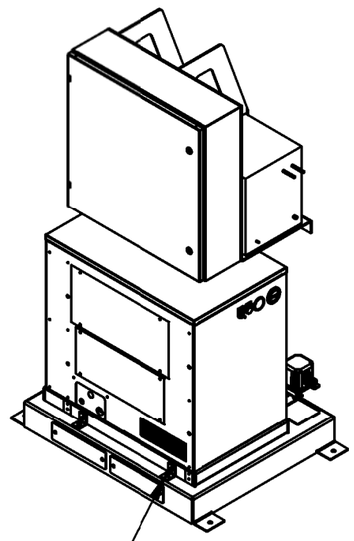
AIR DRYER MOUNTING
(4) 1/4-20 x 1" ZINC HEX BOLT
(4) 1/4" ZINC FLAT WASHER
(4) 1/4" ZINC LOCK WASHER

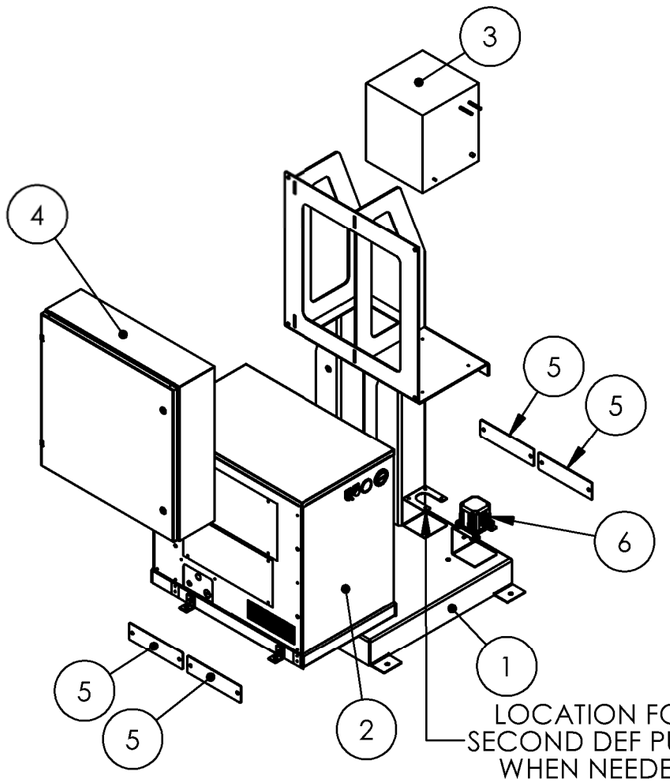












LOCATION FOR
SECOND DEF PUMP
WHEN NEEDED

SKID COVER PLATES
(8) 3/8-16 x 1" ZINC HEX BOLT
(8) 3/8" ZINC FLAT WASHERS
(8) 3/8" ZINC LOCK WASHERS

AIR COMPRESSOR MOUNTING
(4) 3/8-16 x 1.25" HEX BOLT
(4) 3/8 FLAT WASHER
(4) 3/8-16 LOCK WASHER

REV.	ECN	TIER	DESCRIPTION	DATE	APPROVED BY
A	N/A	2	RELEASED TO PRODUCTION	02/02/2022	lszura
B	N/A	3	4X MOUNT HOLES UPDATED FOR 3/8" HARDWARE	06/02/2022	blewan
C	N/A	3	ADDED CONFIGURATION FOR DUAL PUMPS	07/07/2022	lszura

VPN	COMP. VOLTAGE	DEF PUMP CAP.	DRYER MODEL	CONTROLS SPECIFIC TO PROJ.
1038764	208 VAC	SINGLE 57 KG/HR	HG-10	HOLT CATERPILLAR - SINGLE INJECTION
1039784	208 VAC	DUAL 38 KG/HR	HG-10	HOLT CATERPILLAR - DUAL INJECTION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGULAR: FABRICATED ±1.0°
MACHINED ±0.5°
ONE PLACE DECIMAL ±0.1
TWO PLACE DECIMAL ±0.06
THREE PLACE DECIMAL ±0.030
DUAL DIMENSIONS IN. {MM}

REMOVE ALL BURRS AND
BREAK SHARP EDGES

	NAME	DATE
DRAWN	cccintern	01/07/2022

MATERIAL:

THIRD ANGLE PROJECTION

DO NOT SCALE DRAWING

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES
311 RIGGS ST.
BLOOMER, WI 54724
TEL 715-568-2882
FAX 715-568-2884

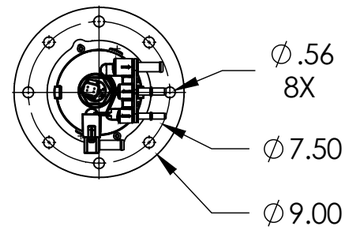
DESCRIPTION:
Aux Skid Assy - 30x30 Controls - Compressor - Single or Dual Pumps - Type 01

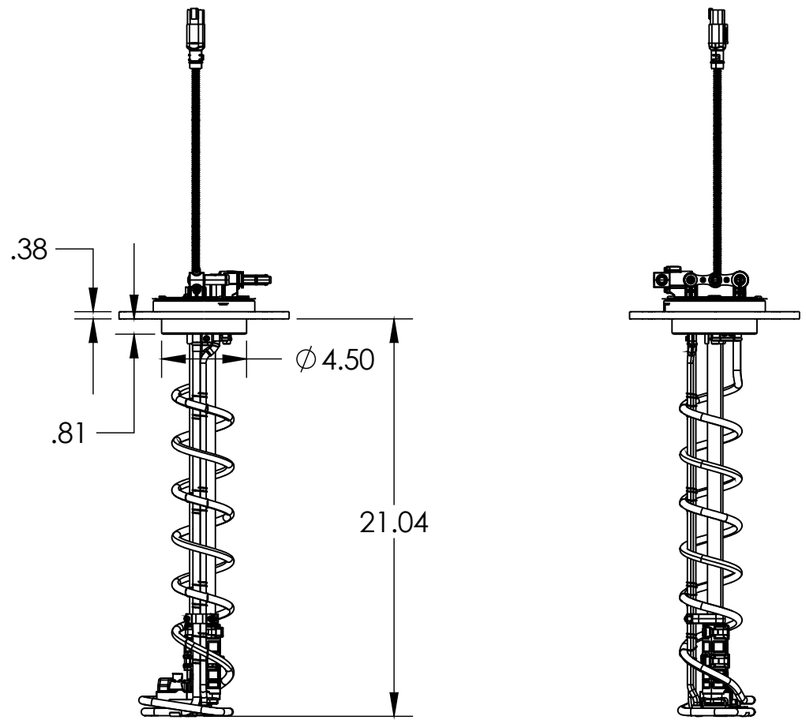
VISUAL PART NO.
SEE TABLE

SIZE B | DRAWING NO. 701455 | REV C

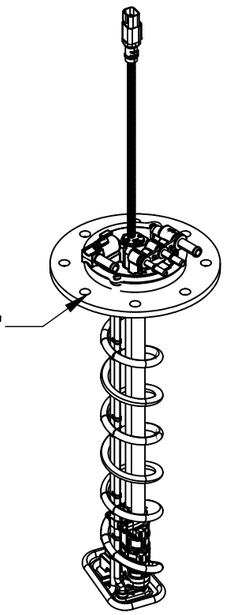
SCALE: 1:24 | WT: | SHEET 2 OF 2

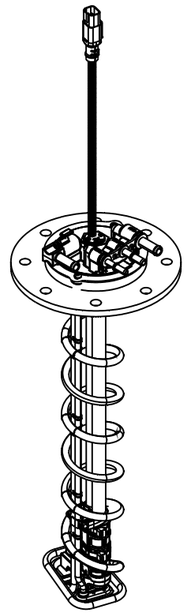
ITEM NO.	DRAWING NUMBER	REVISION	CONFIGURATION	VISUAL P/N	DESCRIPTION	MATERIAL	WEIGHT	QTY.
1	600315	A	Default	SEE TABLE	22INCH SHAW SENDING UNIT		0.003	1
2	600466	E	Default	1036201	SENDING UNIT FLANGE ADAPTER WELDMENT			1





GASKET AND HARDWARE NOT INCLUDED FOR THE 4" ANSI CONNECTION





KIT VPN	KIT DESCRIPTION	SENDING UNIT VPN
1040631	DEF TANK PICKUP KIT - 4" ANSI 150 LB - 21 DEPTH - SINGLE CIRCUIT W/LEVEL SENSING	1030877

REV.	ECN	TIER	DESCRIPTION	DATE	APPROVED BY
01	N/A	1	UPDATED TO INCLUDE DIFFERENT SHAW CONFIGURATIONS	09/09/2022	cmolls
A	N/A	2	RELEASED TO PRODUCTION	09/09/2022	cmolls
B	N/A	1	UPDATED NOMENCLATURE		

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:

ANGULAR: FABRICATED ±1.0°
MACHINED ±0.5°
ONE PLACE DECIMAL ±0.1
TWO PLACE DECIMAL ±0.06
THREE PLACE DECIMAL ±0.030
DUAL DIMENSIONS IN. (MM)

REMOVE ALL BURRS AND BREAK SHARP EDGES

	NAME	DATE
DRAWN	cmolls	10/27/2021

MATERIAL:

THIRD ANGLE PROJECTION

DO NOT SCALE DRAWING

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES
311 RIGGS ST.
BLOOMER, WI 54724
TEL 715-568-2882
FAX 715-568-2884

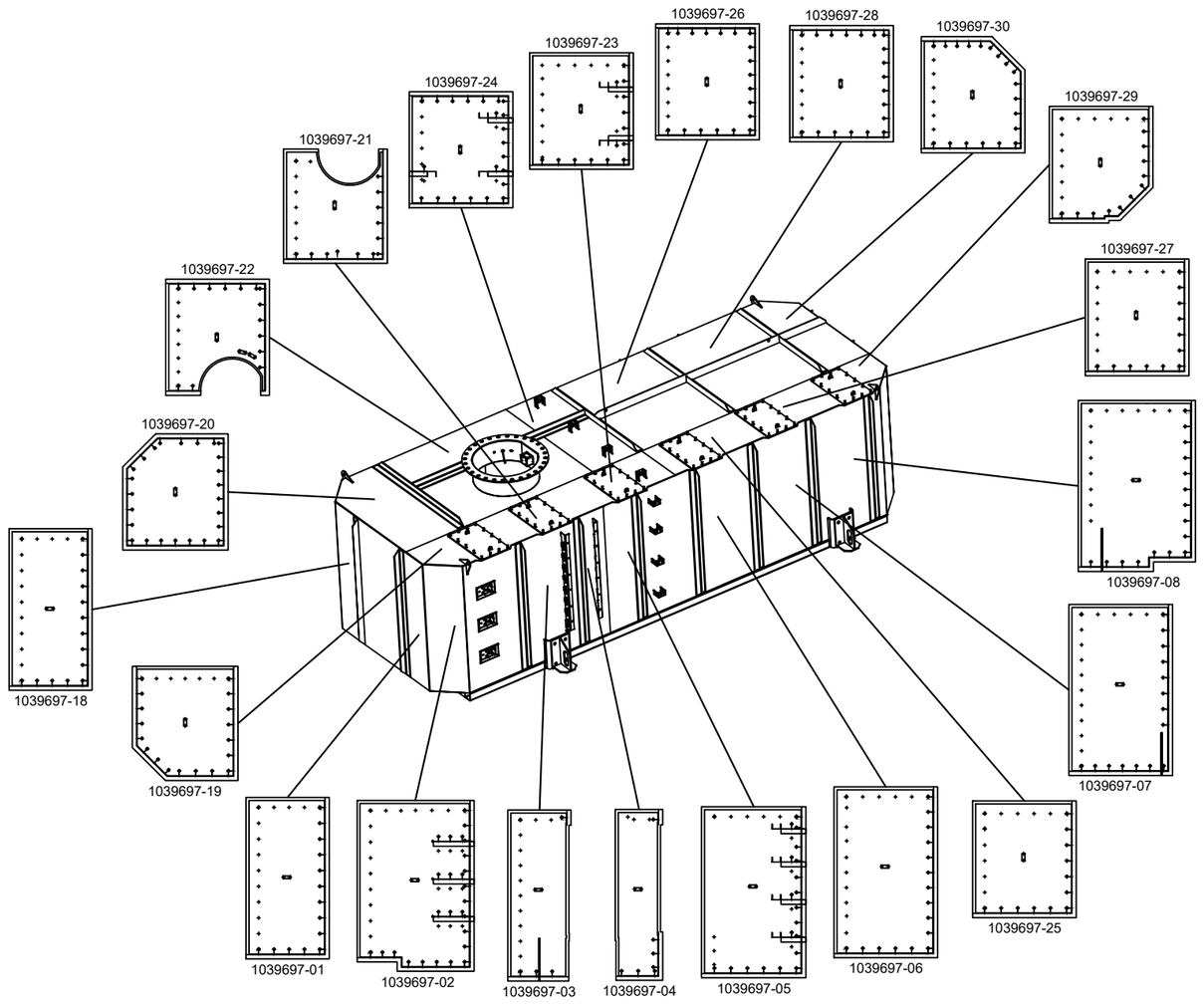
DESCRIPTION:
DEF TANK PICKUP KIT - 4" ANSI 150 LB - 21 DEPTH - SINGLE CIRCUIT W/LEVEL SENSING

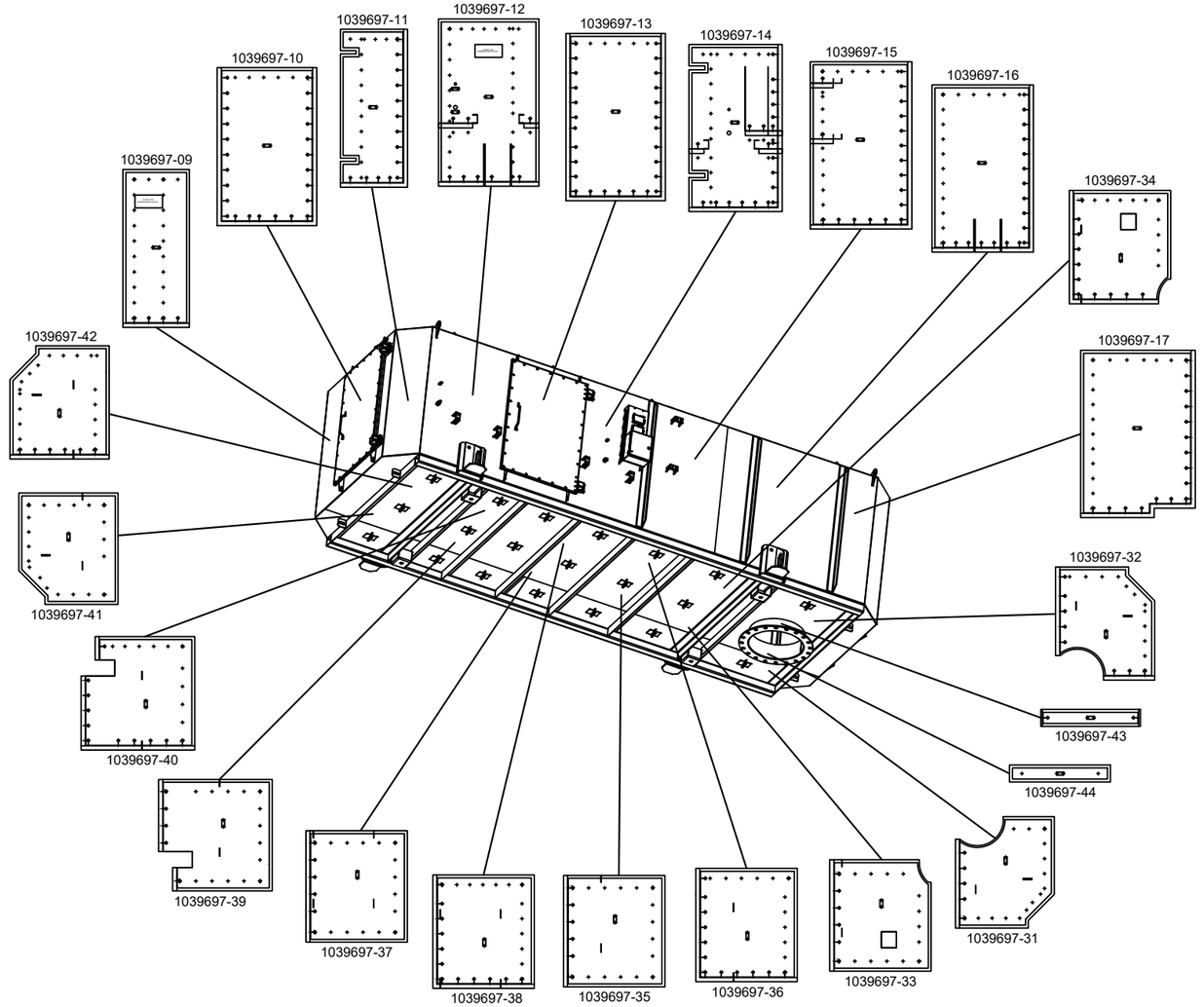
VISUAL PART NO.
SEE TABLE

SIZE B | DRAWING NO. 700379 | REV B

SCALE: 1:8 | WT: | SHEET 1 OF 1

P# 1039697
ASSEMBLY DRAWING





InsulTech
3530 W GARRY AVE • SANTA ANA • CA • 92704
TEL: 714.384.0506 • FAX: 714.384.0507

DRAWING NUMBER:
1039697 ASSEMBLY_MAP

ENGINEER: AR | DATE: 8/28/22 | REV: A

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Warranty

Holt Texas LTD.

Holt CAT Dual Lance (C175) SCR Systems

VPN 1040249

Holt CAT Single Lance (3516E) SCR Systems

VPN 1040251

Published September 2022

• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

WARRANTY TERMS & CONDITIONS
FOR DOTC and SCR CATALYST APPLICATIONS in RECIPROCATING ENGINES.
And FOR SCR SYSTEM COMPONENTS.

Holt Texas

Holt CAT Dual Lance (C175) SCR Systems VPN 1040249

Holt CAT Single Lance (3516E) SCR Systems VPN 1040251PO: 4055013785

For the period and subject to other terms and conditions specified below, Catalytic Combustion Corporation ("Catalytic Combustion"), a Wisconsin corporation, warrants to the purchaser to whom this Warranty is addressed ("Purchaser") that the Catalyst sold to Purchaser will conform to the required performance specifications set forth by the Purchaser and as confirmed by our sales proposal for this project.

If the Catalyst fails to meet the foregoing warranty, and notice of such failure is given by Purchaser and received by Catalytic Combustion within either the number of operating hours exposed to exhaust gas or the elapsed time after the date of shipment from Catalytic Combustion based on whichever time period expires first, as shown for the following Catalyst formulation in the table below, Catalytic Combustion at its discretion either supply replacement Catalyst free of charge, supply replacement Catalyst at a pro-rated price to the Purchaser or refund a pro-rated portion of the purchase price. The pro-rated factor will be calculated using the number of hours or months that the catalyst has been operated as a percentage of the warranted hours or months figure shown herein.

Formulation	Time from Shipment
SCR	24 months

Or 2,500 operating hours, whichever is sooner.

Catalytic Combustion warrants that the catalyst has been designed and fabricated to maintain its structural integrity while is service, that it is manufactured from new materials and that for a reciprocating engine: the NOx reduction rate and as referenced in our quotation 001-00-274359 Rev 9 for the application, referenced below, provided that the Diesel Engine is and has been operated properly, the amount of installed Catalyst is in compliance with Catalytic Combustion's recommendations and that the Catalyst is operated in compliance with Catalytic Combustion's prerequisites as listed below.

Prerequisites for this warranty are:

(1) The Diesel Engine is powered with ULSD.

(2) The Diesel Fuel shall not have a sulfur content in excess of 10 ppm.

(3) The Diesel Engine shall be maintained and operated in accordance with the manufacturer's guidelines and shall be operating at a steady state condition.

(4) Ignition of fuel in the exhaust system, otherwise known as a backfire, is avoided.

(5) The SCR Catalysts will be operated within a temperature range of 500^{o}F inlet to 900^{o}F outlet.

To ensure that the catalyst is not exposed to temperatures greater than 900^{o}F it will be the responsibility of the Purchaser to operate and maintain the Diesel Engine such that the 900^{o}F limit is not exceeded.

Successful operation of the Catalyst may require periodic cleaning of the Catalyst according to procedures approved or provided by Catalytic Combustion to remove masking agents, such as, but not limited to, noncombustible particulates.

Due to the potential for certain chemical elements to act as catalyst poisons and deactivation agents this Warranty and Catalytic Combustion's obligations hereunder shall become null and void, and Catalytic Combustion disclaims any Warranty with respect to Catalyst which has been exposed to:

(i) Any halogen-containing compounds,

(ii) Any other poisoning or masking agents, including but not limited to phosphorus, silicon, sulfur, arsenic, and heavy metals such as lead or zinc, at levels in the washcoat that exceed the concentrations seen in the table below or an aggregate total concentration of any combination of contaminants that exceeds the listed value as determined by Catalytic Combustion via X-Ray Fluorescence (XRF) analysis of a representative sample of the washcoat.

Chemical Species	Concentration in the Washcoat (ppmw)
Phosphorus (P)	700
Zinc (Zn)	500
Silicon (Si)	1,000
Sulfur (S)	1,000
Heavy Metals (Pb, Hg, As, Sn, etc.)	1,500
Halogens (Cl, F, Br, etc.)	500
Alkali Earths and Metals (Na, K, Ca, Mg)	1,000
Total Aggregate from all Elemental Contaminants	4,000

(iii) Temperatures in excess of 1,250 ^{o}F as determined through surface area analysis of the washcoat.

(iv) Operation of the turbine such that the catalyst inlet temperature is less than 650 ^{o}F which can result in an accumulation of sulfur leading to rapidly deactivation of the catalyst.

Attempts to clean or wash the catalyst by any process, procedure or entity that has not been approved or authorized by Catalytic Combustion shall also nullify and void the Warranty.

A representative sample of the non-performing Catalyst shall be removed from operation and returned to Catalytic Combustion pursuant to its instructions, and if so returned, freight shall be at Catalytic Combustion's expense.

If it is determined that the Catalyst has failed to perform and that no disqualifying conditions apply and if Catalytic Combustion provides replacement Catalyst the replacement Catalyst shall be Warranted only for the remainder of the stated Warranty period for the original Catalyst.

Catalytic Combustion, in no event, shall be liable for production losses or indirect or consequential damages resulting from a failure of the Catalyst to meet the performance Warranty.

Any failure of Catalyst to conform to this Warranty shall be demonstrated to the satisfaction of Catalytic Combustion by and at the expense of Purchaser. Determination of non-performing Catalyst shall be based upon the calculated average performance of the Catalyst from at least 6 measurements taken over a minimum of a 24-hour period of steady state turbine operation. The analytical data shall be gathered using the most current and appropriate EPA test methods by either a third party qualified to perform the measurements or through the use of a certifiably calibrated measurement instrument operated by trained personnel from either the Purchaser or the end user. Notification of Catalyst's failure to meet performance guarantees and supporting analytical data shall be submitted in writing within 5 (five) days to Catalytic Combustion for review. Catalytic Combustion reserves the right within 30 (thirty) days notice of failure, to request additional analytical measurements and inspection of the turbine's operating condition for the purpose of confirming the Catalyst's failure.

Seller hereby warrants to Buyer that the equipment herein described will be free from any liens or encumbrances, and that good title to said equipment will be conveyed to Buyer. Seller warrants equipment of its own manufacture against defects in material and workmanship under normal conditions of usage and service for thirty-six (36) months from commissioning or forty (40) months from date of shipment, or 2,500 operating hours, whichever is sooner. Equipment not manufactured by Seller shall receive such warranty, if any, of the manufacturer thereof and which are hereby assigned to Buyer without recourse to Seller; Seller agrees to act as a liaison with a manufacturer of equipment supplied hereunder regarding any warranty claims if requested by Buyer. Seller's sole obligation and Buyer's sole remedy under this warranty is limited to and shall be fully discharged by repairing or replacing any defective part F.O.B. point of manufacture. Seller shall not be liable for repair or alterations made without Seller's prior written approval. Seller shall not be liable for damages or delay caused by defective material or workmanship.

As listed in CCC Quote 001-00-274359 Rev 9 / Basis for this Warranty and this Project only.

Proposed Emissions After-Treatment Technology

P/N	QTY	Description
SCR for NOx Only to meet Tier IV NOx & Critical Grade Silencing aftertreatment system for CAT C175 PHX-1000ft and 120°F ambient / 18 Gensets/ TOAD & BLUE VPN 1040249		1) Urea injection, Mixing Duct, SCR catalyst, all integrated in one 304SST Reactor; Includes insulation blanket, Air compressor (with dryer), DEF pump shipped loose, temp and dP sensors, dosing and control panels, short exit exhaust stack (28" long) with a rain cap. This will need "Required Adder additional injection lance" see below. 2) Urea flow at max power is 15.83 gal/hr, at PSV NOx. 3) Maximum back pressure of SCR system is 16" WC clean. 4) Sized for CAT C175-16 rated at 3,100kW and DM8455. 5) **Guaranteed Emissions EPA Tier IV Compliant for NOx:** a. NOx at ≤ 0.50 g/bhp-hr b. Noise is controlled. Critical Grade Silencing integrated. **SCR Reactor Housing Dimensions:** Height = 75" | Width = 92" | Length = 230" Weight (loaded) = 9,500 lbs Inlet – Outlet flanges = 24" and 28" Includes insulation blanket for safety & performance Warranty = 24 month or 27 months after delivery or 2,500 hours, whichever is sooner.
REQUIRED ADDER for C175-16s	18	Additional SS injection lance, DEF pump, mounting bracket on SCR reactor, mounting bracket for DEF pump, control, dosing and sending unit additional wiring, limited engineering and manufacturing time added.

P/N	QTY	Description
SCR for NOx Only to meet Tier IV NOx & Critical Grade Silencing aftertreatment system for CAT 3516E 7 Gensets/ BLUE VPN 1040251		1) Urea injection, Mixing Duct, SCR catalyst, all integrated in one 304SST Reactor; Includes insulation blanket, Air compressor (with dryer), DEF pump shipped loose, temp and dP sensors, dosing and control panels, standard 28" outlet ANSI flange connection with NGB kit. 2) Urea flow at max power is 14.70 gal/hr, at PSV NOx. 3) Maximum back pressure of SCR system is 17" WC clean. 4) Sized for CAT 3516E rated 3,100kW and EM4717. 5) **Guaranteed Emissions EPA Tier IV Compliant for NOx:** a. NOx at ≤ 0.50 g/bhp-hr b. Noise is controlled. Critical Grade Silencing integrated. **SCR Reactor Housing Dimensions:** Height = 75" | Width = 92" | Length = 230" Weight (loaded) = 9,500 lbs Inlet – Outlet flanges = 24" and 28" Includes insulation blanket for safety & performance Warranty = 24 month or 27 months after delivery or 2,500 hours, whichever is sooner.

THE FOREGOING WARRANTY AND REMEDIES ARE EXCLUSIVE. TO THE FULLEST EXTENT PERMITTED BY APPLICABLE LAW, CATALYTIC COMBUSTION DISCLAIMS ANY IMPLIED WARRANTY, INCLUDING ANY WARRANTY OF MERCHANTABILITY, AND, ANY WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE. CATALYTIC COMBUSTION WILL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES, LOSS OF TIME OR PROFITS, OR ANY INCONVENIENCE. CATALYTIC COMBUSTION SHALL NOT BE LIABLE FOR ANY DAMAGES WHICH ARE BASED UPON NEGLIGENCE, BREACH OF WARRANTY, STRICT LIABILITY OR ANY OTHER THEORY OF LIABILITY OTHER THAN THE EXCLUSIVE WARRANTY SET FORTH IN THIS WARRANTY. INCIDENTAL AND CONSEQUENTIAL DAMAGES SHALL NOT BE RECOVERABLE EVEN IF THE REMEDIES OR THE ACTION PROVIDED FOR HEREIN FAIL OF THEIR INTENDED PURPOSE. THIS WARRANTY SHALL BE GOVERNED BY THE LAWS OF THE STATE OF WISCONSIN.

CATALYTIC COMBUSTION
EMISSION TECHNOLOGIES

Selective Catalytic Reduction (SCR) System

Test Documents

Holt Texas LTD.

Holt CAT Single Lance (3516E) SCR Systems

VPN 1040251

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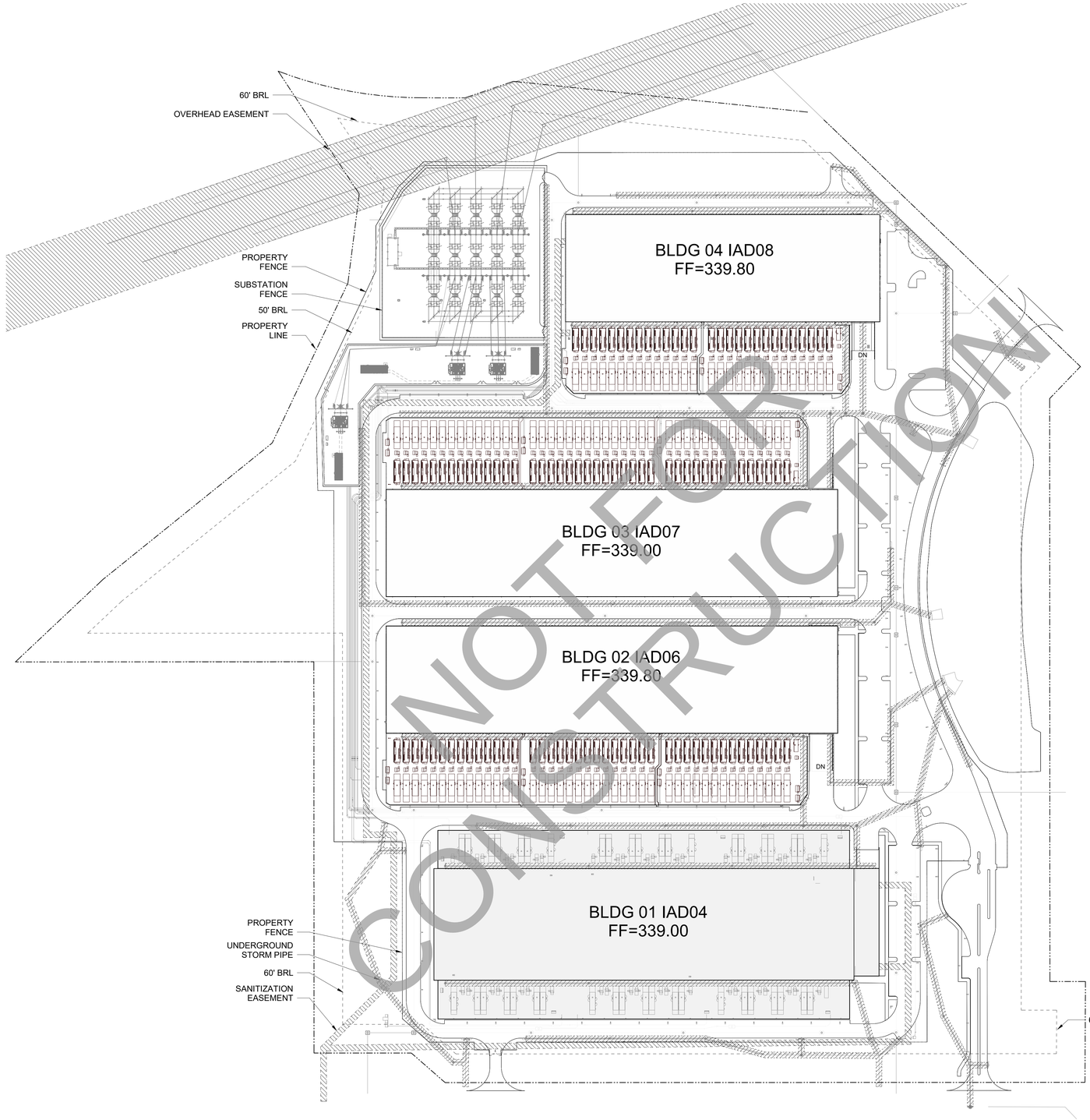
www.catalyticcombustion.com

Component level testing is performed at Catalytic Combustion's manufacturing facility. Final functional and system validation will occur as part of the commissioning activities on-site. Once system validation is completed on-site the final testing documents will be added to this O&M document and an updated version provided to the customer.

Catalytic Combustion Corporation
• 311 Riggs St. • Bloomer, WI 54724 • 715-568-2882 •
www.catalyticcombustion.com

Attachment C – Site Map



1 SITE PLAN
1" = 100'-0"

PARKING COUNT

TYPE	COUNT

CORGAN

urban Urban LTD
7712 Little River Turnpike, Annandale VA 22003

kW Mission Critical Engineering Member of WSP kW
40 E. Rio Salado Parkway, Suite 445, Tempe, AZ 85281

ISSUES	
1	
2	
3	
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REVISIONS	

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Date of issue:
mm/dd/yyyy

IAD 06/07/08

Aligned™ Adaptive Data Centers

KEYPLAN

PLAN N

O M K H F D B A N L J G E C

SITE PLAN

JOB 24396.0000
DATE 07.25.2024
SHEET

A01-01

7/25/2024 5:09:51 PM A01-01 SITE PLAN