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ENVIRONMENT

Ms. Susan Bull
Oil Control Program
Maryland Department of the Environment
1800 Washington Blvd., Ste. 620
Baltimore, MD 21230

Subject:
Response to Comments on Work Plan
Case No. 1986-1205-CE
Former Exxon Station #14489
285 Old Bayview Road, North East
Cecil County, Maryland
Facility ID No. 2615

Date:
10 December 2013

Contact:
Rusty Kahl

Phone:
410 923 7813

Email:
Rusty.kahl@arcadis-us.com

Our ref:
B0085851.0010

Dear Ms. Bull:

On behalf of ExxonMobil Environmental Services (EMES), ARCADIS U.S. Inc. (ARCADIS) has prepared this letter in response the e-mail correspondence from the Maryland Department of the Environment (MDE) dated 21 October 2013. In that e-mail, MDE included comments and questions regarding the corrective action proposed in the *Revised Corrective Action Plan* dated 15 April 2013 and comment responses in the *Injection Well Status and Response to Comments on Work Plan* dated 28 August 2013. The responses to these comments are presented below.

MDE Comment 1: *What is the calculated radius of influence for the proposed injections?*

Response to Comment 1: The anticipated approximate radius of influence at each injection point is 2.5 feet. This radius is used to develop the minimum spacing interval between points. In practice, the distribution around each point will be somewhat irregular, with distribution controlled by permeability of materials surrounding the injection point. Injections may be considered successful even though uniform ROI is not achieved because the injections will have the best practicable distribution and will have promoted placement of reagent in permeable areas through which groundwater flow is likely to occur.

MDE Comment 2: *Historically, the Department required bench tests to be conducted to determine (a) if the selected injectable the proper "tool" for the job and (b) what* *quantity of injectable was necessary to achieve realized benefit? Has this been completed for the current proposed injectable and what were the results?*

Response to Comment 2: Regarding the proposed injectable of gypsum (calcium sulfate dehydrate), ARCADIS has employed the injectable at former retail petroleum stations in a variety of geologic settings. The quantity of gypsum proposed in the CAP is based on ARCADIS' extensive institutional experience for employing this injectable in low permeability settings similar to those at former Exxon site #14489. Additional bench testing is not necessary to evaluate gypsum because of ARCADIS' institutional knowledge.

To support the proposal to use gypsum at former Exxon site #14489, attached to this letter are two case studies of petroleum retail sites in Kentucky and California with low-permeability geologic settings where gypsum was used by ARCADIS as an injectable. These cases are similar to the conditions at former Exxon #14489 and demonstrate the effectiveness of the injectable.

MDE Comment 3*: Contaminant migratory flow pathways are present off of this site. This has been seen over time within adjacent private drinking water wells. How do you plan to ensure that the injections are controlled enough to not re-mobilize contaminant flow to the close proximity wells, but aggressive enough to derive your desired contaminant reduction in the wells located at 259 and 261 Old Bayview Road?*

Response to Comment 3: Monitoring injection pressures at the well head and keeping pressures below a pre-determined maximum value will be the primary controls on injections to avoid remobilizing site-related constituents. Although maximum injections pressures vary from site to site, a typical maximum injection pressure is 5 psi (pounds per square inch). Maintaining injection pressures below a maximum number minimizes the propagation of new fractures or preferential pathways.

Additionally, the amount of water displaced by the injection events is expected to be minimal and would be accommodated vertically rather than horizontally in the saturated zone. Therefore, impacted groundwater is expected to be only minimally displaced and is not expected to affect potable wells proximate to the injection area. Nearby monitoring wells will be gauged during injection events to evaluate the volume of water displaced. The effects of the injections and the potential for remobilization will also be evaluated using subsequent groundwater analytical data from downgradient wells in subsequent monitoring events.

Regarding the ability of the injections to effect contaminant reduction at the off-site residential wells, please refer to the Response to Comment 6 (below).

MDE Comment 4: *Has sampling been conducted to determine that the initial electron acceptors (e.g. oxygen and nitrate) have been depleted at this site, thus reverting the site to an anaerobic environment?*

Response to Comment 4: Biogeochemical analysis will be included in subsequent groundwater monitoring events beginning in the first quarter of 2014 in order to characterize site conditions. Additional analyses will include sulfate, nitrate, and dissolved and total iron. Field parameters, such as dissolved oxygen and pH, that are already collected as part of standard procedure will also be included in this evaluation.

MDE Comment 5: *What additional parameters for enhanced bio-degradation have been analyzed to determine the current rate of natural degradation at the site?*

Response to Comment 5: To date, this information has not been evaluated for the site. As described in Response to Comment 4 (above), additional analysis will be completed to allow evaluation of conditions for attenuation.

MDE Comment 6: *Has the rate of groundwater flow been calculated for this site? Given your calculations, when would you expect to observe realized benefits of this injection to the wells located at 259 and 261 Old Bayview Road?*

Response to Comment 6: Historical pumping and recharge test completed at on-site monitoring well MW-5 indicated a hydraulic conductivity of 1.9×10^{-5} feet per minute and a groundwater flow velocity of 6.4×10^{-3} feet per day. However, because the bottom of well MW-5 is only 21.42 feet below ground surface (ft bgs), these values for conductivity and velocity are not likely representative of subsurface conditions in the water-bearing zones where nearby downgradient potable wells are screened, typically between 40 and 160 ft bgs. Calculating arrival times for treated groundwater at potable wells using the values above would have a large uncertainty and consequently little value.

Regarding Comment 6 as well as the second part of Comment 3, whether the injections are sufficient aggressive to effect change in off-site residential wells, ARCADIS does not anticipate that a technology could be employed for this case that would remediate off-site potable wells faster than natural groundwater flow conditions allow. The proposed corrective action will remediate groundwater on-site, and with on-site groundwater having been remediated, downgradient conditions will improve over time as attenuation processes operate with natural groundwater flow.

Alternatives to on-site remediation include off-site pumping to accelerate groundwater flow toward the off-site residential wells or performing injections at the residential properties. ARCADIS does not recommend either of these alternatives. Additional pumping to manipulate groundwater flow conditions could potentially remobilize site-related constituents, a concern expressed by MDE in Comment 3. ARCADIS also does not recommend performing injections at the residential properties for the same reasons expressed by MDE, that injections could adversely affect those residential wells.

Therefore, the fastest method to reduce concentrations of site-related constituents in downgradient off-site residential wells is to complete remedial activities at the site, which is the source of the off-site impacts, and allow natural groundwater flow and attenuation to reduce downgradient concentrations.

MDE Comment 7: *Please provide an MSDS Sheet for your proposed injectable.*

Response to Comment 7: MSDS for gypsum (calcium sulfate dehydrate) is attached to this letter.

MDE Comment 8: *Please provide pertinent hard rock/saprolite scenarios in which you have utilized this technology.*

Response to Comment 8: The maximum depth of injection proposed in the CAP is 15 feet. Because bedrock was not encountered in borings at the site as documented on boring logs, top of bedrock is deeper than 15 feet. Therefore, gypsum will be injected only into low permeability clay and silt and will not be injected directly into bedrock.

Pertinent scenarios for this technology are petroleum retail sites with low permeability geology. As described in the response to Comment 2, two case studies for the injection of gypsum to remediate retail petroleum sites are attached to this letter.

Conclusion

ARCADIS appreciates your review of the additional information presented above, and, on behalf of EMES, respectfully requests approval of the April 2013 *Revised Corrective Action Plan.*

Please contact me with any comments or questions.

Sincerely,

William R Kahl

William R. Kahl, PG
Associate Project Manager

Copies:
Ms. Jewel Cox, ExxonMobil

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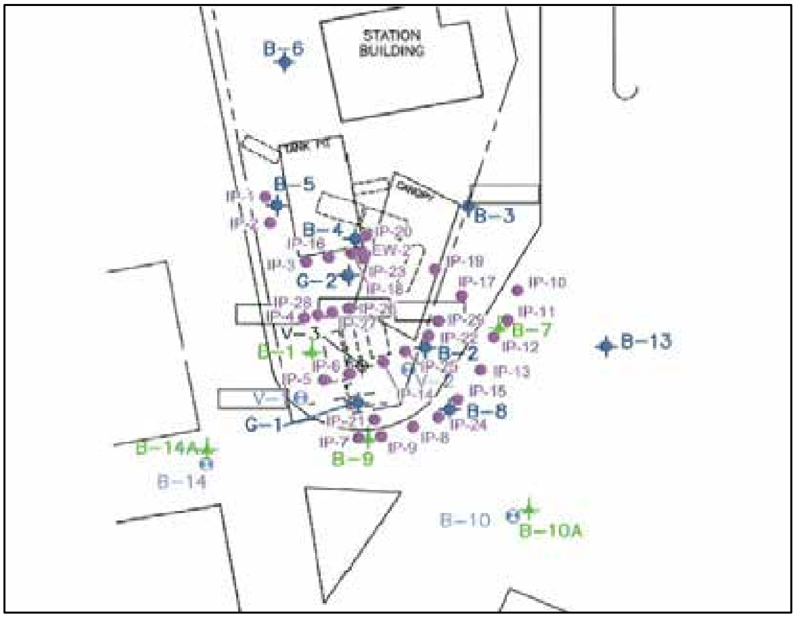
Sulfate Addition via Direct-Push Injection

Petroleum UST sites, Kentucky and California

At petroleum leaking underground storage tank (LUST) sites where the geochemical environment is strongly reducing, biodegradation of hydrocarbons is often limited by the presence of terminal electron acceptors (including oxygen, nitrate, iron, and sulfate). Sulfate addition is a widely used and effective treatment strategy for facilitating biodegradation of dissolved-phase hydrocarbon plumes via anaerobic oxidation processes. At locations where hydrogeology is conducive to injection of large fluid volumes via semi-permanent injection wells, delivery of highly soluble forms of sulfate (such as epsom salt or magnesium sulfate heptahydrate) is often preferred. However, in fine-grained or lower-permeability hydrogeologic settings, economical distribution of large volume injection events are typically impractical.

As an alternate sulfate emplacement strategy in low-permeability settings, ARCADIS has conducted injections of calcium sulfate dihydrate (gypsum) using direct push technology (DPT). Gypsum is sparingly soluble (approximately 0.2% gypsum by weight), and when it is applied as a water-based slurry of approximately 10 to 15% gypsum by weight, the emplaced slurry will act as a long-term sulfate source, slowly dissolving into passing groundwater over the months following placement. Combined with the relatively low groundwater flux values expected in low-permeability settings, the concentration of sulfate can be sustained at several hundred milligrams per liter (mg/L) over sustained periods of time to support anaerobic biological oxidation of hydrocarbons. The direct-push delivery concept is based on targeting a small radius of influence (ROI) and at each injection point, placing a large number of injection points throughout the target area to achieve distribution, and keeping injection pressures relatively low. The drilling and injection process in these settings creates contact between the injected fluid and impacted media by introducing localized changes in hydraulics and flow paths around the injection point, having the overall effect of accelerating mass reduction.

Site 1 (Kentucky)



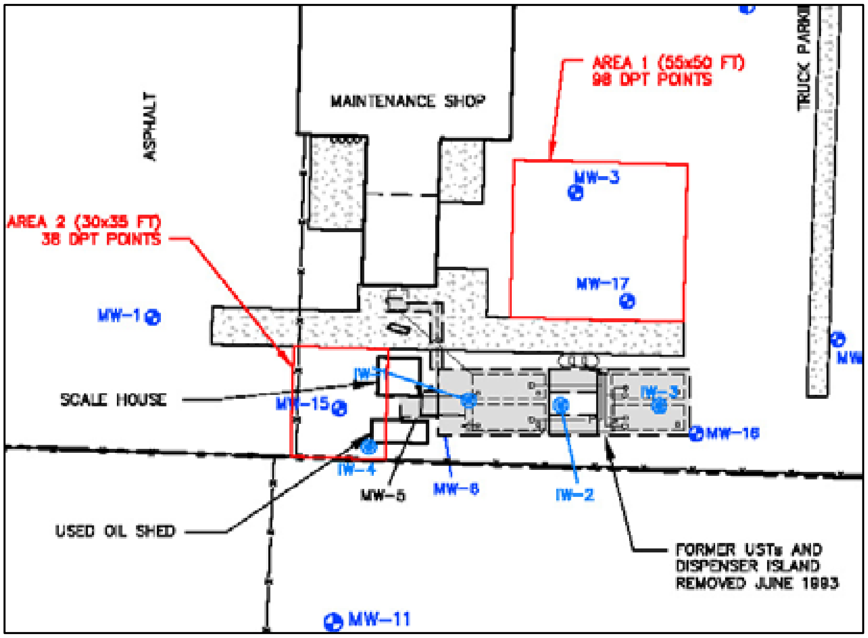
This gasoline release site had been identified as suitable for sulfate addition through previous geochemical data; however, previous injection efforts using semi-permanent injection wells were met with limited success. In July 2012, an injection event was completed using DPT to emplace approximately 8,000 gallons of gypsum slurry at 29 injection points. To supplement the DPT gypsum addition, 3,000 gallons of epsom salt solution (an additional source of soluble sulfate) was injected via gravity-flow into seven existing injection wells during the DPT event.

Sulfate concentrations at monitoring wells within the target treatment area ranged from 25 to 2,300 mg/L after the injection event, and follow-up monitoring data indicate that elevated sulfate concentrations remained for at least six months after the injection event. January 2013 data indicated reductions of up to an order of magnitude in dissolved-phase BTEX concentrations at wells within the treatment area, with greatest reductions in the areas where post-injection sulfate concentrations remained elevated over several months. Performance monitoring to evaluate the long-term effect of treatment is ongoing.

Site 2 (California)

This gasoline release site, with high sulfate concentrations in background wells and depleted sulfate in the impacted area, was also identified as a site suitable for sulfate addition to enhance anaerobic biological oxidation. Geochemistry data suggests an aquifer conducive to anaerobic biological oxidation, and hydrocarbon impacts are limited to the immediate source area where terminal electron acceptors have been depleted despite the release occurring many years prior. In the excavated former UST area, 4 semi-permanent injection wells were installed as the permeability supported the injection of epsom salt solution. Gypsum slurry injections were completed in low-permeability areas outside of the excavated area in April 2013. A 3-feet ROI was assumed in laying out the DPT injection points, with a targeted vertical interval of approximately 4 feet and a planned injection volume of 50 gallons of 10% gypsum slurry per point.

Elevated sulfate concentrations ranging from 69 mg/L to 3,400 mg/L were observed at monitoring wells in the target treatment area after the injection event, with hydrocarbon concentrations initially stable at two target wells (MW-15 and MW-17). TPH concentrations at MW-3 increased following the injection, indicating that hydrocarbon mass formerly stored within fine-grained stratigraphy was made accessible through vibrations and forced fractures as a result of DPT implementation. Performance monitoring is continuing, and TPH concentrations are expected to decline as the recently added dissolved sulfate is utilized.



National Gypsum®

Material Safety Data Sheet

MSDS No: GB-1201

Page 1 of 7

Gold Bond® BRAND Miscellaneous Gypsum Products

Date: July 30, 2013
Supersedes Date: July 1, 2009

1. PRODUCT AND COMPANY INFORMATION

Manufacturer Information:
National Gypsum Company
2001 Rexford Road
Charlotte, NC 28211

For Emergency Product Information Call:
Director Quality Services
(704) 551-5820 - 24 Hour Emergency Response
Website: www.nationalgypsum.com

Product Name:
Gypsum
Accelerator
Agricultural Gypsum
Land Plaster
Cement Rock

Use:	Accelerate set of gypsum plaster, Stabilize soil, Accelerate set of cement
Generic Descriptions:	Gypsum rock, Calcium Sulfate Dihydrate

2. HAZARDS IDENTIFICATION

Appearance and Odor: A white solid/powder with no odor.

Contains no asbestos. HMIS Hazard Class No. 1, 0, 0.

Emergency Overview

Gold Bond® BRAND Gypsum Products do not present an inhalation, ingestion, or contact health hazard unless subjected to operations such as sawing, sanding or machining which result in the generation of airborne particulate. This product contains quartz (crystalline silica) as a naturally occurring contaminant. It is recommended that a NIOSH approved particulate respirator be worn whenever working with this product results in airborne dust exposure exceeding the prescribed limits.
(See Section 11 - Toxicological Information)

OSHA Regulatory Status

While this material is not considered hazardous by the OSHA Hazard Communication Standard (29CFR 1910.1200), this MSDS contains valuable information critical to the safe handling and proper use of the product. This MSDS should be retained and available for employees and other users of this product.

2. HAZARDS IDENTIFICATION (CONTINUED)

Potential Health Effects

Primary Routes of Entry: Inhalation, Dermal contact

Target Organs: Respiratory system, skin, eyes.

Inhalation: Acute exposure to airborne dust concentrations in excess of the PEL/TLV may result in coughing, dyspnea, wheezing, general irritation of the nose, throat, and upper respiratory tract, and impaired pulmonary function. Chronic exposures may result in lung disease (silicosis and/or lung cancer). (See Section 11 - Toxicological Information)

Exposures to respirable crystalline silica have not been documented during normal use of this product. However, good housekeeping practices and industrial hygiene monitoring is recommended when the potential for significant exposure exists.

Skin Contact: Continued and prolonged contact may result in dry skin. Contact with dust or glass fibers may produce itching, rash and/or redness. Repeated or prolonged exposure may result in dermatitis.

Eye Contact: Direct contact may cause mechanical irritation.

Ingestion: No known adverse effects. May result in obstruction or temporary irritation of the digestive tract.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS-Number	Weight Percent
Calcium Sulfate Dihydrate (Gypsum)	10101-41-4	>85
Crystalline Silica (Quartz)	14808-60-7	<5

4. FIRST AID MEASURES

- **Inhalation:** Remove exposed individual to fresh air immediately. If breathing difficulty persists, seek medical attention.
- **Skin:** Flush and wash skin with soap and water. Utilize lotions to alleviate dryness if present. Seek medical attention if irritation persists.
- **Eye:** Immediately flush eyes with water for 15 minutes. Remove contact lenses (if applicable). Seek medical attention if irritation persists.
- **Ingestion:** Gypsum is non-hazardous and no harmful effects are expected upon ingestion of small amounts. Larger amounts may cause abdominal discomfort or possible obstruction of the digestive tract. Seek medical attention if problems persist.

5. FIRE FIGHTING MEASURES

Flammable Properties
- Not flammable or combustible
- NFPA Hazard Class No: 1/0/0

Extinguishing media
- Dry chemical, foam, water, fog or spray

Protection of firefighters
- Standard protective equipment and precautions

Fire and Explosion Hazards
- None

Hazardous Combustion Products
- None
- Above 1450^{o}C, material can decompose and release sulfur dioxide (SO_2) and oxides of carbon.

6. ACCIDENTAL RELEASE MEASURES

General recommendations:

- Shovel or scoop up back into container for use if possible, or disposal.
- Wear appropriate Personal Protective Equipment. (See Section 8)
- Maintain proper ventilation.
- Waste material is not a hazardous waste. Dispose of in accordance with applicable federal, state, and local regulations.

7. HANDLING AND STORAGE

- Avoid contact with eyes, skin and clothing.
- Wear recommended personal protective equipment when handling. (See Section 8)
- Avoid breathing dust.
- Minimize generation of dust.
- Store material in a cool, dry, ventilated area.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Exposure Guidelines

	Exposure Limits	
Component	**OSHA PEL** (mg/m3)	**ACGIH TLV** (mg/m3)
Calcium Sulfate Dihydrate (Gypsum)	15 $^{(T)}$ 5 $^{(R)}$	10 $^{(T)}$
Crystalline Silica (quartz)	0.1 $^{(R)}$	0.025 $^{(R)}$

T- Total Dust
R- Respirable Dust

Engineering Controls

- Work/Hygiene Practices: The score and snap method of cutting is recommended. Sawing, drilling or machining will produce dust.
- Ventilation: Provide local and general exhaust ventilation to maintain a dust level below the PEL/TLV.
- Utilize wet methods, when appropriate, to reduce generation of dust.

Personal Protective Equipment

- Respiratory Protection: A NIOSH approved particulate respirator is recommended in poorly ventilated areas or if the PEL/TLV is exceeded. OSHA's 29 CFR 1910.134 (Respiratory Protection Standard) must be followed whenever work conditions require respirator use.
- Eye Protection: Safety glasses or goggles.
- Skin: Gloves, protective clothing and/or barrier creams may be utilized if conditions warrant.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance: White/gray powder
Odor: None
Physical State: Solid
Ph: ~7
Solubility (H2O): 2.1 g/L @ 20°C
Boiling, Freezing, Melting Point: Not Applicable
Decomposition Temperature: 1450°C
Vapor pressure: Not Applicable
Vapor density: Not Applicable
Volatile organic compounds (VOC) content: None

Flammability: Not Applicable
Flash Point: Not Applicable
Upper/Lower explosive limits: Not applicable
Auto-ignition temperature: Not Applicable
Partition coefficient: n-octanol/water: Not applicable
Evaporation rate: Not Applicable
Molecular weight: 172.2 grams
Molecular formula: $CaSO_4.2H_2O$
Specific Gravity: 2.31 g/cc
Bulk Density: ~55 lb/ft3

10. STABILITY AND REACTIVITY

Chemical stability: Stable in dry environments.
Conditions to avoid: Contact with strong acids may result in generation of carbon dioxide.
Incompatibility: None
Hazardous decomposition: Above 1450°C gypsum will decompose to calcium oxide (CaO), with releases of sulfur dioxide (SO_2) and various oxides of carbon.
Hazardous polymerization: Will not occur.

11. TOXICOLOGICAL INFORMATION

Data presented is for the major component of this product: Gypsum (calcium sulfate dihydrate)

Human Data

There is no information on toxicokinetics, metabolism and distribution.

There have been reports of irritation to mucus membranes of the eyes and respiratory tract upon acute exposure to dusts in excess of the recommended limits.

Chronic exposure to crystalline silica (a naturally occurring contaminant in gypsum) in the respirable size has been shown to cause silicosis, a debilitating lung disease. In addition, the International Agency for Research on Cancer (IARC) classifies crystalline silica inhaled in the form of quartz or cristobalite from occupational sources as carcinogenic to humans, Group 1. The National Toxicology Program (NTP) classifies respirable crystalline silica as a substance which may be reasonably anticipated to be a carcinogen. OSHA does not regulate crystalline silica as a human carcinogen. Industrial hygiene monitoring to date has not identified any detectable respirable crystalline silica in dust sampling conducted during gypsum panel installation utilizing recommended procedures.

Animal Data

The acute oral toxicity study [OECD TG 420, Fixed dose procedure] of calcium sulfate dihydrate showed that this chemical did not cause any changes even at 2,000 mg/kg b.w. Therefore, the oral LD_{50} value was more than 2,000-mg/kg b.w. for female rats (Sprague-Dawley).

Calcium sulfate, dihydrate was not irritating to the skin of rabbits at 1, 24, 48 and 72 hours after removal of test patches [OECD TG 404]. There is no indication of skin sensitization in guinea pigs [OECD TG 406].

Invivo and *Invitro* studies for mutagenicity were negative.

Reproduction/Developmental Toxicity Screening Tests were negative.

12. ECOLOGICAL INFORMATION

This product does not present an ecological hazard to the environment.

Ecotoxicological Information

Toxicity studies performed with fish, aquatic invertebrates and aquatic plants showed no toxic effect.

Environmental Fate

Gypsum is a naturally occurring mineral. Biodegradation and/or bioaccumulation potential is not applicable.

13. DISPOSAL CONSIDERATIONS

- Dispose of according to Local, State, Federal, and Provincial Environmental Regulations.
- Recycle if possible.

14. TRANSPORTATION INFORMATION

- This product is not a DOT hazardous material
- Shipping Name: Same as product name
- ICAO/IATA/IMO: Not applicable

15. REGULATORY INFORMATION

All ingredients are included on the TSCA inventory.

Federal Regulations

SARA Title III: Not listed under Sections 302, 304, and 313
CERCLA: Not listed
RCRA: Not listed
OSHA: Dust and potential respirable crystalline silica generated during product use may be hazardous.

State Regulations
California Prop 65: Respirable crystalline silica is known to the state of California to cause cancer. Industrial hygiene monitoring during recommended use of this product failed to identify any respirable crystalline silica.

Canada WHMIS
All components of this product are included in the Canadian Domestic Substances List (DSL).
Crystalline silica: WHMIS Classification D2A

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16. OTHER INFORMATION

MSDS Revision Summary

Effective Date Change:	5/22/06	Supersedes: 1/26/04
Format Changes:	ANSI Z400.1-2004	

Key/Legend

ACGIH	American Conference of Governmental Industrial Hygienists
CAS	Chemical Abstract Services Number
CFR	Code of Federal Regulations
DOT	Department of Transportation
EPA	Environmental Protection Agency
HEPA	High Efficiency Particulate Air
HMIS	Hazardous Material Identification System
IARC	International Agency for Research on Cancer
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
NIOSH	National Institute for Occupational Safety and Health
NFPA	National Fire Protection Association
NTP	National Toxicology Program
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PPE	Personal Protective Equipment
TLV	Threshold Limit Value
TSCA	Toxic Substance Control Act
TWA	Time Weighted Average
WHMIS	Workplace Hazardous Materials Information System

16. OTHER INFORMATION (CONTINUED)

The information and recommendations contained herein are based upon data believed to be correct. However, no guarantee or warranty of any kind expressed or implied is made with respect to the information contained herein. This material safety data sheet was prepared to comply with the OSHA Hazard Communication Standard (29 CFR 1910.1200) and with the Workplace Hazardous Materials Information System (WHMIS).

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