Wheelabrator Baltimore
NOx RACT Review

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Wheelabrator
TECHNOLOGIES

Wheelabrator Baltimore
NOx RACT Review

Outline:

- Facility Overview
- NOx Control Overview
- NOx RACT Optimization Program
- LN^{TM} NOx Control Technology Feasibility

NOx RACT Review

Facility

- Three (3)-750 ton per day MSW fired WTE boilers
- Boiler MCR of 325 MMBtu/Hour and 193,600 lbs/hour of steam.
- Von Roll reciprocating grates with Babcock & Wilcox power boilers
- Single pass furnace with superheater and waterwall platen panels
- Power Generation 64 MW-enough for 40,000 homes
  - Combined heat and power facility
  - Steam supply to City of Baltimore
- Air Emission Controls (MACT)
  - SNCR-NOx Control (urea based)
  - Spray Dryer Absorber (SDA)
  - High Efficiency 4-Field ESP
  - Activated Carbon Injection

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NOx Limits for Large Massburn MWCs

- EPA MACT(SNCR)
  - New units 150 ppm7%
  - Existing units 205 ppm7%
- NOx RACT(SNCR)
  - NJ (May 2011) 150 ppm7% O2
  - PA (Jan 2017) 180 ppm7% O2
  - CT (Aug 2017) 150 ppm7%O2
  - MA (June 2019?) 150 ppm7% or 185 ppm7% subject to approval
- EPA BACT (SCR) 50 ppm 7% O2
- EPA LAER (SCR) 50 ppm7% O2

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SNCR NOx Control–Design Factors

Uncontrolled or baseline NOx levels (MWC Range 150-350 ppm)

- Function of boiler/grate design and combustion controls (low excess air /stage combustion)
- Lower baseline NOx-higher NSR required (reagent to NOx ratio) to achieve target NOx level or NOx removal efficiency
- Slower reaction kinetics
- Reduced reagent utilization

Residence time within optimum temperature and available for mass transfer, reagent transformation and NOx reduction reactions

- Function of furnace design/geometry/gas flow pattern and available furnace volume

Extent of reagent/flue gas mixing achievable

Must minimize ammonia (NH3) slip

- detached ammonium chloride plume formation
- NH3=PM2.5 precursor

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SNCR NOx Control-Design Factors

Massburn MWC Boiler vs Coal Fired Utility Boiler SNCR Consideration		
	MWC Boiler	**Utility Boiler**
Fuel Characteristic	Low and Variable Fuel Heating Value (4000-5500 Btu/lb)	High and Constant Heating Value (11,000-15,000 Btu/lb)
Excess Air	High Excess Air (80-100%)-variable	Low Excess Air (<30%)-constant
Furnace Temperature	Variable	Near Constant
SNCR Temp Window	Variable	Near Constant
Furnace Volume to Heat Release Ratio	Large	Small
Fuel Chlorine Content	High (corrosion/plume)	Low

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SNCR NOx Control-Baltimore Specific Design Factors

Lower Baseline NOx 200-224 ppm, original WAPC design of 240-260 ppm, 300 (max) ppm

- Good Combustion Control-Low excess air/staged combustion limits NOx formation
- Lower baseline increases difficulty of achieving higher NOx removal
- Need higher NSR or more urea but increases NH3 slip potential (visible detached ammonium chloride plume)

Water wall platens in single pass furnace

- Reduced working furnace volume
- Reduce SNCR window (reagent residence time available for mass transfer and chemical reactions)

MD SIP 0 visible emission standard in Baltimore

- Excessive NH3 slip cannot be reduced in ESP as in baghouse
- Detached visible plume = violation of SIP limit

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SNCR-NOx Optimization Test Program

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OBJECTIVE: Optimize existing SNCR system to establish facility specific NOx RACT limit

Phase I-Short Term Optimization

- Conducted furnace temperature profiling on clean and slagged boiler to verify furnace temperature range for SNCR (1800-2100 deg F)
- Optimized existing SNCR systems to determine target NOx RACT limit (injector location/number, urea injection rate)

Phase II-Longer Term Evaluation

- Conducted longer term evaluation of target RACT limit from Phase I
- Analyzed results to propose continuously achievable NOx RACT limit.
- Evaluate ammonia slip
- Convert short term performance variation/uncertainty to certainty of long term continuously achievable limit
- Calculate Upper Confidence Limit as done for EPA (MACT)/permit limits

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SNCR-NOx Optimization Test Program

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Phase I- Conducted Feb 29-Mar 4, 2016.

		Steam	Base	Controlled	NOx			Urea
	Test	**Flow**	**NOx**	**NOx**	**REM**	**Urea**		**Utili-**
	No.	**klbs/hr**	**ppm7%**	**ppm7%**	**%**	**gph**	**NSR**	**zation**
Unit 2	8	192.0	224	167	25%	12.0	0.71	36%
Unit 2	9	192.0	224	157	30%	12.0	0.71	42%
Unit 1	11	192.0	203	150	26%	10.0	0.65	40%
Unit 1	12	192.0	203	144	29%	15.0	0.98	30%
Unit 1	13	192.0	203	150	26%	15.0	0.98	27%

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SNCR-NOx Optimization Test Program

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Phase II-Conducted March-May 2016:

- Target 160-165 ppm/24 hour average from best of Phase I results
- Establish daily baseline NOx (assume steady for day)
- Run to maintain target NOx for 24 hours
- Operator adjustments as needed to achieve target
- Obtained 23-24 hour averages over several weeks
- Overall Results
- Conduct data analysis

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SNCR-NOx Optimization Test Program

Phase II-All Results			
	Upper Confidence Limit Summary		
One Tail	0.95	0.975	0.99
Student-t Value	1.714	2.069	2.5
Count	23	23	23
Average ppm7%	169	169	169
Standard Deviation	5.1	5.1	5.1
Upper Confidence Limit ppm7%	**178**	**180**	**182**

Phase II-Results below 170 ppm7%			
	Upper Confidence Limit Summary		
One Tail	0.95	0.975	0.99
Student-t Value	1.782	2.179	2.681
Count	13	13	13
Average ppm7%	165	165	165
Standard Deviation	2.3	2.3	2.3
Upper Confidence Limit ppm7%	**169**	**170**	**171**

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NOx Variability

Year	NOx Tons	NOx 24-Hr Average
2015	1124	Annual 168 ppm Max values, 190, 198, 196 50% of 24-Hr averages above annual average
2016	1147(est)	Annual 170 ppm Max Values 193, 198,197 170 days above annual average

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NOx RACT/SNCR Summary

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RACT Cost Effectiveness

- 2016 annual NOx emissions = 1146 tons (est.)
- Proposed RACT limit 170 ppm
- Setpoint to maintain 170 ppm limit = 160 ppm
- NOx annual average=160 ppm
- NOx reduction = 67 tons
- 2016 average urea usage = 5.2 gallons/hour (gph)
- Additional urea required 5 gph x 3 x 8760 x 0.93 = 122,202 gal/yr
- Urea $1.50/gallon = $183,303 additional annual cost
- Cost Effectiveness = $2731/ton

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LN^{TM} NOx Control Feasibility at Baltimore

Differences in boiler/furnace design between Baltimore and Montgomery County boilers make it very difficult if not infeasible to apply the LN^{TM} technology at Baltimore.

Application of LN^{TM} technology to Baltimore is limited by:

- Smaller furnace volume-single pass furnace
- Presence of water wall platen panels in furnace radiant section
- Location of pendant superheater in furnace at exit
- Very limited room to add effective tertiary air level at required height above secondary air level in furnace
- Cannot inject urea above tertiary air in furnace cavity between waterwall platens and superheater
    - Severe and rapid superheater corrosion via liquid impingement on boiler tubes

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LN™ NOx Control Feasibility at Baltimore

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Design Differences Between the Montgomery County and Baltimore Boilers		
	Montgomery County	**Baltimore**
MCR Steamflow (klbs/hr)	171	193.6
Steam pressure and temp	865 psig/830 degF	900 psig/830 degF
Grate System	Martin Gmbh	Hitachi Zosen (Von Roll)
Boiler Design	Tail end-"European"	Vertical (B&W)-"American"
Number of Furnace Passes	2+	1
Superheater Location	Downstream of Two-Pass Furnace and Generating Bank	Exit of One-Pass Furnace
Screen Platens in Furnace	None	12 Large Platens on Front Wall
SNCR Spray Nozzle Elevation	>30 ft. above secondary air and above tertiary air	~17 ft. above secondary Air
Total Excess Air	80%	100%
Combustion Air Distribution	Primary = 60%, Secondary = 20%, Tertiary = 20%	Primary= 55%, Secondary = 45%
Baseline NOx (No SNCR control)	300-320 ppm7% (LN 20% tertiary = 211 ppm7%)	200-224 ppm7%

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LN^{TM} NOx Control Feasibility at Baltimore

Design Differences Between the Montgomery County and Baltimore Plant Boilers		
	Montgomery County	**Baltimore**
Boiler Design	Tail end-"European"	Vertical (B&W)-"American"
Furnace Exit Gas Temperature Control (critical for minimizing superheater corrosion)	Two-pass waterwall furnace, flue gas passes through a water cooled generating bank section prior to reaching the superheater	High excess air (100% design), limiting heat input, furnace size, and use of the water cooled screen platens for additional heat removal in the upper furnace.
	Larger furnace volume without platens and superheater, lower excess air = longer flue gas residence time for SNCR and no risk of superheater corrosion	Smaller furnace volume with platens and superheater in furnace, shorter flue gas residence time for SNCR, high superheater corrosion

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LN™ NOx Control Feasibility at Baltimore

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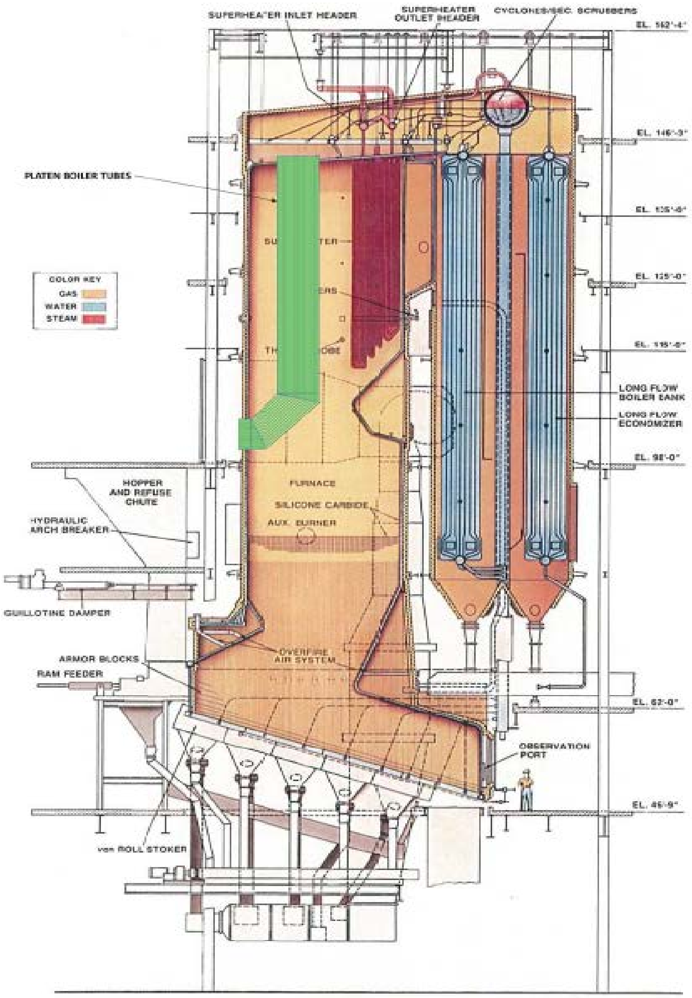

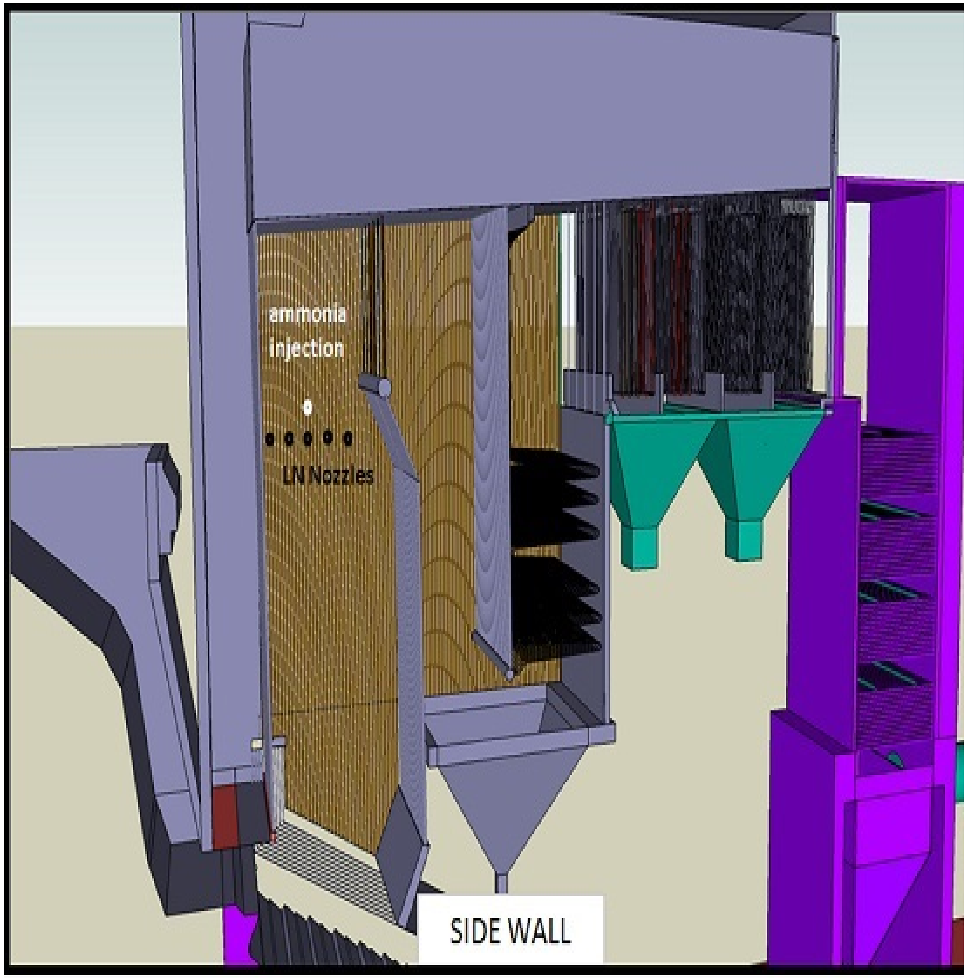

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LN^{TM} NOx Control Feasibility at Baltimore

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- Baltimore boiler/furnace design significantly different than Montgomery Cty
- Differences are reason why LN^{TM} technology infeasible at Baltimore
- Very limited room to add effective tertiary air level at required height above secondary air level (25-50 ft recommended)
- Tertiary air injection at bottom of water wall platens/superheater
  - increased high temperature corrosion and erosion of platens-cannot remove platens-impact boiler performance/decrease boiler availability
- Cannot relocate urea injectors above tertiary air-cannot inject urea in furnace cavity between waterwall platens and superheater.
  - Severe and rapid corrosion via liquid impingement on platen and superheater boiler tubes
  - Would required major boiler/furnace design/modification and reconstruction
- LN^{TM} is not: "…*reasonably available considering technological and economic feasibility*". (USEPA)

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