STACK EMISSION TEST RESULTS FROM EXISTING AND NEW HIGH TEMPERATURE FLUID BED MUNICIPAL SLUDGE INCINERATORS OPERATING IN US AND ONTARIO (CA)

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ready for the resource revolution
TOPICS OF DISCUSSION

- High Temperature Fluid Bed Municipal Sludge Incinerators (Thermylis®, SSI, HTFB, Thermal Oxidizer)
- MACT Background Information & MACT Limits
- MACT Compliance Equipment
- Stack Emission Test Results
- Conclusions
High Temperature Municipal Sludge Incinerators
PROCESS BLOCK DIAGRAM

Flue gas
- Combustion gas
- Ashes (mineral matters)
- Water vapour

Thermylis furnace

Heat recovery

Flue gas treatment

Purified flue gas

Sludge

Fluidization air

Ashes

Purification residues
FLUID BED REACTOR

- Tear Drop Reactor Design
- Freeboard
- Sludge Feed Nozzle
- Sand Removal Nozzle
- Hot Air Inlet (1200°F)
- Fluidized Bed
- Windbox
- Freeboard
- Sand Port
- Sand Bed
- Tuyere
- Auxiliary Fuel Injectors
- Preheat Burner
- Self Supporting Refractory Roof
FLUID BED REACTOR

1. Self-supporting roof dome
2. Support burner
3. Sludge feed nozzle
4. Start-up burner
5. Flue gas duct
6. Sand feed nozzle
7. Tuyeres
8. Fluidisation air
9. Fuel injection
10. Sand extraction nozzle
11. Bed spray

FREEBOARD
SAND BED
WINDBOX
TYPICAL HEAT INPUT / OUTPUT

MUNICIPAL SLUDGE 27-28%TS

70%

REACTOR

EXHAUST GAS & HEAT LOSS

100%

AUX FUEL

30%

PREHEAT AIR
AUXILIARY FUEL REQUIREMENT

Basis: Excess Air 40%, Feed Rate 454 kgDS/hr (1,000 lbs/hr), 75% VS, 5,556 kcal/kg (10,000 btu/lb) VS, 1550 F Freeboard, Auxiliary Fuel HHV 10,500 kcal/kg (18,900 btu/lb)
Primary Heat Exchanger (Tube & Shell)

- Preheat Combustion Air
- Eliminate Auxiliary Fuel Usage
SECONDARY HEAT RECOVERY

Secondary Heat Exchanger (Tube & Shell), Waste Heat Boiler, Thermal Oil Economizer, Hot Water Economizer

- Plume Suppression
- Process Steam Generation
- Seasonal Building Heating
- Thermal Fluid Heating
- Electricity Production (Turbine Generator)
WET ASH SYSTEM (WET APCS)

- Compressed Air
- High Pressure Water Pump
- Sand Storage
- Sand
- Sludge Dewatering
- Feed Pump
- Purge Air Blower
- Gas Feed
- Urea (or Ammonia) Injection
- Exhaust Gas Duct
- Heat Exchangers (Primary, Secondary)
- Fluidizing Air Blower
- Preheat Burner
- Combustion Air
- Service Water
- Carbon Bed Adsorber
- CEMS
- Stack
- Caustic
- Purge Blower
- Circulating Pump
- Service Water
- Venturi Scrubber
- Tray Scrubber
- Wet ESP
- Ash Treatment
- Settling Lagoon
DRY ASH SYSTEM (DRY APCS)

- Inlet Sludge
- Sand Silo
- Incinerator
- Flue Gas
- Heat Exchanger
- Expansion Tank
- Econoizer
- Sodium Bicarbonate and Activated Carbon
- Bag Filter
- ID Fan
- Ash Silo
- Hot Water Circuit
- Fin Fan Cooler
- Building Usage
- Natural Gas
- Air for Fluidization
- Stack
SEMI-DRY ASH SYSTEM (SEMI-DRY APCS)

- Inlet Sludge
- Sand Silo
- THERMYLIS Incinerator
- Flue Gas
- Heat Exchanger
- Expansion Tank
- Fin Fan Cooler
- Building
- Heat Exchanger
- Economizer
- Air for Fluidization
- Hot Water Circuit
- Bag Filter
- ID Fan
- Ash Silo
- Stack
- Natural Gas
- Water
- Scrubber
- Caustic Soda Circuit
- Drain
- Continuous Autothermic Process
- Flexible Process for Variations in Total Solids
- Turbulence Without Moving Parts
- Nearly Isothermal Conditions
- Quick Response to Variations in Feed Rate
- Minimum Heat Loss During Shutdowns
- High Combustion Efficiency at Low Excess Air
- Power Generation
2 Trains – 115 DTP each with Steam Generation
MILL CREEK, OH

3 Trains – 96 DTP each
GREEN BAY, WI

1 Train – 51 dry TPD
1 Train – 60 dry DTP
SNCR FOR NO\textsubscript{x} REMOVAL

Urea, when combined with NO\textsubscript{x} of the flue gas at high temperatures, transforms the noxious substances into N\textsubscript{2}, CO\textsubscript{2} and H\textsubscript{2}O.

SNCR = Selective Non-Catalytic Reduction
VENTURI SCRUBBER FOR PM, HCl and SO$_2$
MACT Background Information

MACT Limits
MACT (Maximum Achievable Control Technology)

Issued by US EPA on March 21st, 2011

Applies to new and existing municipal sludge fluid bed incineration plants in US

Compliance by March 21st, 2016 for all plants in operation

Plants not in compliance with MACT should be retrofitted to meet the new emission limits

Retrofit Equipment: Wet ESP, Mercury Removal System, Scrubber Caustic Addition, NOx Removal System
# US EPA MACT LIMITS

## EPA Guideline for NEW and EXISTING FB Incinerators

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Units</th>
<th>Existing FB (@ 7% O₂)</th>
<th>New FB (@ 7% O₂)</th>
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<tbody>
<tr>
<td>Cd</td>
<td>mg/dscm</td>
<td>0.0016</td>
<td>0.0011</td>
</tr>
<tr>
<td>CO</td>
<td>ppmvd</td>
<td>64</td>
<td>27</td>
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<tr>
<td>HCl</td>
<td>ppmvd</td>
<td>0.51</td>
<td>0.24</td>
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<tr>
<td>Hg</td>
<td>mg/dscm</td>
<td>0.037</td>
<td>0.0010</td>
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<tr>
<td>NOₓ</td>
<td>ppmvd</td>
<td>150</td>
<td>30</td>
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<tr>
<td>Pb</td>
<td>mg/dscm</td>
<td>0.0074</td>
<td>0.00062</td>
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<tr>
<td>PCDD/PCDF,TEQ</td>
<td>ng/dscm</td>
<td>0.1</td>
<td>0.0044</td>
</tr>
<tr>
<td>PCDD/PCDF,TMB</td>
<td>ng/dscm</td>
<td>1.2</td>
<td>0.013</td>
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<tr>
<td>PM</td>
<td>mg/dscm</td>
<td>18</td>
<td>9.6</td>
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<tr>
<td>SO₂</td>
<td>ppmvd</td>
<td>15</td>
<td>5.3</td>
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### Pollutant based equipment selection

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Equipment</th>
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</thead>
<tbody>
<tr>
<td>CO</td>
<td>High Efficiency Combustion</td>
</tr>
<tr>
<td>NO(_x)</td>
<td>Ammonia/Urea Injection at Freeboard (SNCR)</td>
</tr>
<tr>
<td>SO(_2)</td>
<td>Caustic injection at Wet Scrubber</td>
</tr>
<tr>
<td>HCl</td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td></td>
</tr>
<tr>
<td>Cd</td>
<td>Venturi Scrubber + Wet ESP</td>
</tr>
<tr>
<td>Pb</td>
<td></td>
</tr>
<tr>
<td>Hg</td>
<td></td>
</tr>
<tr>
<td>PCDD/PCDF,TEQ</td>
<td></td>
</tr>
<tr>
<td>PCDD/PCDF,TMB</td>
<td></td>
</tr>
</tbody>
</table>
MACT Compliance Equipment
TYPICAL PROCESS FLOW DIAGRAM
(RETROFIT EQUIPMENT)

Compressed Air

Sand

High Pressure Water Pump

Sand Storage Silo

Sand

Exhaust Gas Duct

Urea or Ammonia

Centrifuge Decanter

Feed Pump

Purge Air Blower

Fuel Oil Pump

Fuel Oil

Fuel Oil Pump

Natural Gas

Softener

Deaerator

Steam Recovery & Condensate System

Electricity Generator

Wet ESP

Fixed Carbon Bed Adsorber or SPC Modules

Waste Heat Boiler & Economizer

Secondary Heat Exchanger

Quench Scrubber

Silo

Exhaust Gas Duct

Primary Heat Exchanger

Waste Heat Boiler & Economizer

Secondary Heat Exchanger

Quench Scrubber

Steam Turbine

Electricity Generator

Primary Heat Exchanger

Steam Turbine

Electricity Generator

Plant Water

Caustic Injection

To Ash Treatment

SPC: Sorbent Polymer Composite
Stack Emission Test Results
RETROFIT PLANT INFORMATION

(SPC MODULES)

Flue Gas Flow

From Waste Heat Recovery → Scrubber → SPC Modules → To Stack
MERCURY REMOVAL

Guaranteed to achieve up to 70% removal of Hg*

Proprietary expanded PTFE material
MERCURY REMOVAL

Simple Operation / Complex Chemistry

Open channels provide low pressure drop and fouling resistance

Hg is strongly bound to SPC material (chemisorption)

SO₂ oxidized by SPC material and forms H₂SO₄

Continuous acid wash + PTFE-rich SPC surface resists fouling by carryover

H₂SO₄ is expelled to the surface and falls into the absorber reaction tank
THERMYLIS PLANT EMISSIONS (EXISTING INCINERATORS)

Cd

CDD/CDF, TMB

CDD/CDF, TEQ

CO
THERMYLIS PLANT EMISSIONS (EXISTING INCINERATORS)

PM

SO2
Average mercury removal efficiency for Incinerator 4, 5, 6 and 7 = 87%
NEW PLANT INFORMATION
(FIXED CARBON BED)

From Waste Heat Recovery → Scrubber → Conditioner → Adsorber → To Stack

Start Up Heater Skid

Flue Gas Flow
Incinerator No. 1 is equipped with fixed carbon bed installed after scrubber (Canadian Installation)
Incinerator No. 2 is equipped with fixed carbon bed installed after scrubber (Canadian Installation)
Incinerator No. 3 is equipped with fixed carbon bed installed after wet ESP (US Installation)
Incinerators No. 4 & 5 are equipped with fixed carbon bed installed after scrubber (Canadian Installation)
Incinerators No. 6 is equipped with fixed carbon bed installed after scrubber (Canadian Installation)
Incinerators No. 7 is equipped with fixed carbon bed installed after scrubber (Canadian Installation)
Incinerator No. 8 is equipped with fixed carbon bed installed after wet ESP (US Installation)
MERCURY EMISSIONS (SPC)

**Existing Incinerators (US Installation) -vs- MACT**

- Hg Emission (mg/dscm)
- Existing Incinerators (US Installation) vs MACT
- MACT Limit For Existing Incinerator

**Existing Incinerators (US Installation) -vs- Ontario (CA)**

- Hg Emission (mg/drcm)
- Ontario Limit For New Incinerator
MERCURY EMISSIONS (FIXED CARBON BED)

New Incinerators (US Installation) -vs- MACT

- Designed and Built Before MACT
- Designed and Built After MACT

0.037 mg/dscm (MACT Limit for Existing Installation)

0.001 mg/dscm (MACT Limit for New Installation)

New Incinerators (Canadian Installation) -vs- Ontario (CA)

Ontario Limit For New Incinerator

0.07
Conclusions
CONCLUSIONS

- 9 existing and 8 new incinerators have been considered for this study. Incinerators are located in US and Ontario (CA).

- Retrofitted plants are meeting the MACT emission limits in US.

- For new incineration systems in US, we recommend fixed carbon bed adsorber to be able to meet 1 micron/dscm mercury emission requirement in stack. Extremely high efficiency (>95%).

- For existing incineration systems in US, we recommend SPC modules to be able to meet 37 micron/dscm mercury emission requirement. Low removal efficiency (>70%).

- Fixed carbon bed adsorber is difficult to operate compared to SPC modules. However, it has significantly higher removal efficiency.

- For new incineration systems in Ontario (CA) (70 microgram/drm3), we recommend SPC modules for mercury removal.
Thank you