Catalytic Filter for Dioxin Control - Experience and Case Studies

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Agenda

• Technology Introduction

• Application Experience: Proven Performance Worldwide
  – IVRO Municipal Waste Incinerator-Belgium
  – Phoenix Medical Waste Incinerator-USA
  – Secondary Aluminum Production Plant-UK
  – Ashibe Municipal Waste Incinerator - Japan

• Conclusions
Dioxin Control Technologies

- Powder Activated Carbon (PAC) injection
- Selective Catalytic Reduction (SCR)
- Catalytic filters
PAC Injection – Process Diagram
PAC Injection

- Injection of PAC up stream of baghouse
- Most D/F captured at the filter bag
- Transfer D/F from gas to solid phase
- Efficiency varies based on injection rate
- Proven and reliable
PAC Injection

- Move D/F from air to solid waste
- Increase disposal cost
- Active system - high maintenance
- Safety - hot spots in filter house
- Large area required for carbon silo
Selective Catalytic Reduction
Selective Catalytic Reduction

- High equipment & catalyst cost
- High temperature requirement (>250 °C)
- High pressure loss - energy costs
- Large footprint for catalyst house
- Vulnerable to dust
Remedia Catalytic Filter System
Why REMEDIA Filter??

- Reduces the total Dioxin released to the environment
- Easy to adopt and use
- Cost effective
- Provides reliable & consistent operation
Remedia Catalytic Filter System
Remedia Catalytic Filter System

The Combination of Two Proven Technologies:

Surface Filtration
- GAS STREAM
- Dioxin
- Furan
- O₂
- Particulate
- GORE-TEX® Membrane

Catalytic Filtration
- Catalyst/ePTFE Felt
- H₂O
- Clean Gas
- HCl
- CO₂

Remedia Catalytic Filter System
Catalysis

Uncatalyzed reaction

Catalyzed reaction

Energy

Ea. (uncat)

Ea. (cat)

Products

Reaction Pathway
Catalytic Destruction of PCDD/F
Catalytic Destruction of PCDD/F
Catalytic Destruction of PCDD/F

- **PCDDs**
  \[ C_{12}H_nC_{18-n}O_2 + (9+0.5n)O_2 \rightarrow (n-4) H_2O + 12 CO_2 + (8-n) HCl \]

- **PCDFs**
  \[ C_{12}H_nC_{18-n}O + (9.5+0.5n)O_2 \rightarrow (n-4) H_2O + 12 CO_2 + (8-n) HCl \]
REMEDIA Catalytic Filter

- High PCDD/F removal efficiency
- Destruction of the PCDD/F molecule
- Lower disposal cost
- Passive system
- Low temperature requirement (150-250°C)
- Use existing filter house
- Lower pressure loss - energy costs
REMEDIA Catalytic Filter System is an evolution of 2 proven technologies: Surface Filtration & Catalysis
Remedia Catalytic Filter vs. Adsorption

**Adsorption Process**
- Activated Carbon
- Raw Gas
- Highly Contaminated Dioxin/Waste
- < 0.1 ng/Nm³ Dioxin

**REMEDIA Catalytic Filter System**
- Raw Gas
- Less Waste to Landfill
- > 90% Dioxin Destroyed
- < 0.1 ng/Nm³ Dioxin
Remedia Catalytic Filter vs. Catalytic Reactor

**SCR Catalytic Reactor System**

- Raw Gas
- Re-Heat System
- Catalytic Tower
- < 0.1 ng/Nm³ Dioxin

**REMEDIA Catalytic Filter System**

- Raw Gas
- < 0.1 ng/Nm³ Dioxin

< 0.1 ng/Nm³ Dioxin
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Worldwide REMEDIA Catalytic Filter System Applications

- Municipal Waste Incinerators
- Medical Waste Incinerators
- Industrial Waste Incinerators
- Pyrometallurgical
- Crematoriums
Worldwide Proven Performance
Worldwide Proven Performance

Before Remedia
After Remedia

Dioxin (ng TEQ/Nm³)

TLB  IVBO  Karume  Ashibe  Phoenix  Kasugai
Proven Performance You Can Rely On

- Over 50 applications worldwide meeting the most stringent emission regulations.
- Applications in 10 countries.
- Over 130 years cumulative global experience.
- Thousands of successful measurements.
IVRO Municipal Waste Incinerator - Belgium
IVRO Municipal Waste Incinerator
Reliable Performance

Municipal Solid Waste Incinerator IVRO
Dioxin destruction with Catalytic Filter Media

PCDD/F Concentration
(ng TEQ/Nm³@11%O₂)

- Raw Gas (Gas Phase)
- Clean Gas (Gas + Solid Phase)

Months of Operation (Compartment) | Months of Operation (Full Installation)
IVRO Comparison Testing

**Adsorption Process**

1ng TEQ/Nm³

**REMEDIA Catalytic Filter System**
IVRO Results

- Over 10 measurements, gas phase dioxins averaged 75% of total.
- Dioxin emissions well below 0.1 ng TEQ/Nm³ for over 6 years.
- Gas phase dioxin destruction greater than 99% for all isomers.
- Dust emissions less than 0.4 mg/Nm³
- Only Belgian incinerator to have never been shut down for dioxin.
Baltimore Regional Medical Waste Incinerator - USA
Plant Information

• Largest dedicated facility in the world
• Capacity: two incineration process lines, each rated at 77 metric tons per day throughput
• Service area: within a radius of approximately 400 kilometers from Baltimore, Maryland
Process Flow Diagram

Primary Combustion Chamber

Secondary Combustion Chamber

Tertiary Chamber

Boiler

Water Quench (inactive)

Dry Injection Reactor

Baghouse

Spent Sorbent / Fly Ash

To ID Fan and Stack

Waste

Gas

Air

Bottom Ash

Trona

Gas

Air
Phoenix Introduced to Catalytic Filter Technology by Gore in Late 1997

Advantages Compared with PAC Injection
- Destruction vs. Adsorption
- Passive Solution, No Active Chemical Feeding
- Conversion is Simple (Install New Filters)
- Reduction of Potential Future Liability
- Advantages of ePTFE Filter Media

Phoenix Refitted Both Baghouses with Catalytic Filters in May - June 1999
Measurement Results: PCDD/Fs

PCDD/F Concentration (ng TEQ/dscm @ 7% O₂)

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<thead>
<tr>
<th></th>
<th>RUN 1</th>
<th>RUN 2</th>
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<tbody>
<tr>
<td>RAW GAS</td>
<td>3.35</td>
<td>0.055</td>
</tr>
<tr>
<td>CLEAN GAS</td>
<td>0.098</td>
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</table>

 RAW GAS

 CLEAN GAS

35
Measurement Results: PCDD/Fs

<table>
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<tr>
<th>Clean Gas PCDD/F Concentration (ng TEQ/dscm @ 7% O₂)</th>
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<tbody>
<tr>
<td>Historical Value (1998)</td>
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<td>New Emission Guideline</td>
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<tr>
<td>Guaranteed Value</td>
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<tr>
<td>Catalytic Filter (mean)</td>
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<tr>
<td></td>
</tr>
<tr>
<td>5.5</td>
</tr>
<tr>
<td>2.3</td>
</tr>
<tr>
<td>2.3</td>
</tr>
<tr>
<td>0.077</td>
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Key Findings

- Overall, 98.4% of PCDD/F (gas + solid phase) were removed
  - 97.7% of gas phase PCDD/F were destroyed
  - 99.9% of solid phase PCDD/F were removed

- PCDD/F emission < 0.1 ng TEQ/dscm
- 99.95% of the particulate was removed
Secondary Aluminum Production Plant - UK
Process Flow Diagram

- Shredder to Decoater to Melting Furnace
  - Al Shreds
  - Dilution Air
  - Incinerator and Heat Exchanger
  - Fan
  - Bag House
  - Raw Gas Sampling Port
  - Clean Gas Sampling Port
  - Temperature After Fan
Catalytic Filtration

- **PCDD/F Concentration** [ng I-TEQ/Nm³ @ 11% O₂]

  - **Inlet**
  - **Outlet**

<table>
<thead>
<tr>
<th>Month</th>
<th>Inlet</th>
<th>Outlet</th>
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<tbody>
<tr>
<td>January 2000</td>
<td>1.5</td>
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<tr>
<td>March 2000</td>
<td>0.039</td>
<td>0.068</td>
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<tr>
<td>November 2000</td>
<td></td>
<td>0.027</td>
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<tr>
<td>April 2001</td>
<td></td>
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</table>
Results

- Successful operation for more than 4 years
- Total removal efficiency more than 97%
Ashibe Municipal Waste Incinerator - Japan
Fig. Scheme of Ashibe MSWI
Dioxin Destruction vs. Operating Condition

PCDD/F [ng WHO-TEQ/Nm³ @ 12% O₂]

- Inlet
- Outlet

Start-Up | Steady State | Shut-Down
PCDD/F, ng WHO-TEQ /m³N @12% O₂

Particulate phase
Gas phase

IN OUT IN OUT IN OUT
Start-up 0.003 0.020 0.79
Normal 0.001 0.018 3.1
Shut-down 0.003 0.021
Dioxin Isomer Distribution: Inlet/Outlet

PCDD/F (ng / Nm³ @12% O₂)

BH inlet

BH outlet

T₄CDDs

P₅CDDs

H₆CDDs

H₇CDDs

O₈CDDs

T₄CDFs

P₅CDFs

H₆CDFs

H₇CDFs

O₈CDFs
Ashibe Results

- Greater than 99.5% dioxin control for all levels of inlet concentration.
- Effective dioxin destruction for all stages of daily batch process.
- Consistent and efficient destruction of all TEQ isomers.
- All dioxin emission values significantly below 0.1 ng regulation.
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Remedia Catalytic Filter Bag

- Reduces the total Dioxin released to the environment
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- Cost effective
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Industry Recognition

2001 Environmental Innovation Product of the Year Award

2002 J. Deane Sensenbaugh Award Outstanding Achievement in the Field of Air Pollution Control