NOx Control for Stationary Gas Engines

Advances in Air Pollution Control Technology
MARAMA Workshop

May 19, 2011
Outline

• Types of Gas Engines
• 3-Way NSCR
• SCR
• Field Experience
Types of Gas Engines

• **Rich Burn** - Excess amount of **fuel to air** (exhaust contains < 1% O₂)
• **Lean Burn** - Excess amount of **air to fuel** (exhaust contains > 4% O₂)
4SRB:
  • 3-Way (NSCR)

2SLB and 4SLB:
  • SCR (Selective Catalytic Reduction) – Urea and Ethanol
NSCR Systems
NSCR Performance Curve

% Conversion

- Red: NOx
- Yellow: CO
- Green: THC

A/F Ratio (Mass)

14.5 15.0 15.5 16.0 16.5 17.0 17.5

Rich     Stoich     Lean
3-Way NSCR Catalytic Converters
for Stationary Gas Engines
Stationary Engine Gas Compression
Typical Rich Burn Engine for Gas Compression

- Engine Type & Model: Waukesha P9390
- Engine HP: 1980
- Expected NOx reduction: 98%+
- Target NOx 0.15 g/bhp-hr
- Expected CO reduction (HAP’s) 76%+
- Offered in both silenced and non silenced versions to meet state regulations and NESHAPS
- Silenced versions pricing = approx $18.00 per Hp.
- Non-silenced version pricing = approx. $ 15.00 per Hp.
SCR Systems
Typical V-SCR NOx Activity

V$_2$O$_5$ Content
- high
- medium
- lower

$\text{kNOx}$

$T \; [^\circ\text{C}]$

150 200 250 300 350 400 450 500 550
V-SCR Operating Temperatures

<table>
<thead>
<tr>
<th>Temperature Range</th>
<th>Type of Catalyst</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>200°C - 350°C</td>
<td>SINOx® Low Temp.</td>
<td>Tail End Applications in Power Plants, Waste Incinerations</td>
</tr>
<tr>
<td>350°C - 800°F</td>
<td>Standard SINOx®</td>
<td>Typical High Dust Applications in Power Plants</td>
</tr>
<tr>
<td>800°F - 1000°F</td>
<td>SINOx® High Temp.</td>
<td>Simple Cycle Gas Turbines</td>
</tr>
</tbody>
</table>

Typical High Dust Applications in Power Plants

IC Engines

Combined Cycle Power Plants

Simple Cycle Gas Turbines

Tail End Applications in Power Plants, Waste Incinerations
Ethanol SCR NOx Performance

E85 Reductant, Inlet NOx=500ppm, C1:NOx=5

NOx Conversion (%) vs. Temperature (Celsius)
Coated Metal Honeycomb Catalyst

NOTES:

BLOCK WEIGHT: = 50-75 LBS.
APPLICATION AND CELL DENSITY DEPENDANT

304 STAINLESS STEEL FRAME.

(*) THIS DIMENSION MUST ALWAYS BE INSTALLED PARALLEL TO GRADE.

Confidential
Extruded SCR Catalyst
IC Engine SCR System

- SCR Catalyst
- CO Oxidation Catalyst (optional)
- Catalyst Housings
- Mixing Duct
- Injection Lance
- Urea Injection Control System
- Air Purge
- On-site Training/Start-up Service (O&M Manual)
SCR Catalyst Housing for IC Engines

- Stainless steel construction
- Access door for inspection/maintenance
- Designed for even flow distribution
- Ports available for monitoring $\Delta P$ and $T$
- Extra space available for additional catalyst
Urea Injection Control Panel

- Electronics located in the top of the panel
- Instrumentation in the bottom of the panel
- Precise control of urea delivery
- Redundant magnetic gear driven pumps
- Urea or aqueous ammonia compatible
Urea Injection System

Injection Schemes

Piping Panel

Control Panel
SCR System Controls

- Electronics located in the top of the panel
- Touch screen operator interface
- PC based with Intel processor
- Feed forward, feed back/closed loop injection control
- SCADA compatible
- Data storage capability with Ethernet access
- External Communication- RS-485, RS-232
- I/Os accessed for remote monitoring and data collection.
- ModBus communication protocol
Injection Lance

- Pipe in pipe arrangement - urea in center pipe
- Air utilized for cooling and atomization
- Urea and air mix in the injection nozzle
- Layer of insulation around air pipe
- Small urea droplet size facilitates the SCR reaction
SCR Installations
These engines are installed and operating at Loudon Compressor Station, Clarksburg, WV and Lodi Compression/Storage, Sacramento, CA.

<table>
<thead>
<tr>
<th>Engine Model</th>
<th>Engine Hp</th>
<th>NOx g/bhp-hr</th>
<th>CO* g/bhp-hr</th>
<th>NOx Reduction</th>
<th>CO* Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT G3516</td>
<td>1340</td>
<td>1.5</td>
<td>1.88</td>
<td>90%</td>
<td>90%</td>
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<tr>
<td>CAT G3608</td>
<td>2370</td>
<td>0.7</td>
<td>2.5</td>
<td>90%</td>
<td>90%</td>
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<tr>
<td>CAT G3612</td>
<td>3550</td>
<td>0.7</td>
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<td>90%</td>
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<tr>
<td>CAT G3616</td>
<td>4735</td>
<td>0.7</td>
<td>2.5</td>
<td>80%</td>
<td>90%</td>
</tr>
</tbody>
</table>

*Installed prior to HAPs requirement
Lodi Gas Compression/Storage
Kirby Hills, CA

- Engines - CAT G3516
- Installed 2006
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