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% $O_2$)
- **Lean Burn** - Excess amount of air to fuel (exhaust contains > 4% $O_2$)
NOx Control Technologies for Gas Engines

4SRB:
• 3-Way (NSCR)

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

% Conversion

A/F Ratio (Mass)

Rich                      Stoich                      Lean

14.5  15.0  15.5  16.0  16.5  17.0  17.5

NOx

CO

THC
3-Way NSCR Catalytic Converters
for Stationary Gas Engines
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

V₂O₅ Content
- high
- medium
- lower
V-SCR Operating Temperatures

**SINOx® Low Temperature Catalyst**
- 200°C - 300°C
- Typical High Dust Applications in Power Plants
- Tail End Applications in Power Plants, Waste Incinerations

**Standard SINOx® or Coated Catalyst**
- 300°C - 400°C
- Combined Cycle Power Plants
- IC Engines

**SINOx® High Temperature Catalyst**
- 400°C - 550°C
- Simple Cycle Gas Turbines

**Operating Temperature**
- 400°F - 600°F
- 600°F - 800°F
- 800°F - 1000°F

**Notes:**
- SINOx® Low Temperature Catalyst is suitable for temperatures below 300°C.
- Standard SINOx® or Coated Catalyst is suitable for temperatures between 300°C and 400°C.
- SINOx® High Temperature Catalyst is suitable for temperatures above 400°C.
Ethanol SCR NOx Performance

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

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

- **Serial No. (Both Side)**
  - 22 1/4" ±1/16"
  - 23 1/4" ±1/16"
  - 1/2" LIP (Both Sides)
- **NOTES:**
  - Block Weight: 50-75 LBS
  - Application and Cell Density Dependant
  - 304 Stainless Steel Frame
  - (*) The dimension must always be installed parallel to grade

**STANDARD CATALYST WHOLE BLOCK**
- 22 1/4" x 23 1/4" x 3 11/16"
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

Piping Panel

Injection Schemes

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
Budgetary Cost of SCR System

- $42/hp
- $150/hp
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>
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<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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<td>CAT G3608</td>
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<tr>
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<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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