Solutions for Low Emissions Locomotives

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Contents

- Introduction / Background
- Low emissions locomotive engines
- Tier 4 discussion
Cummins’ Strengths:

- The world’s largest independent manufacturer of diesel engines
- Global manufacturing & support
- Over 1,200 OEM customers
- Powering more types of equipment in more markets than any other engine company
Leveraging Scale And Global Presence

900,000 engines produced in 2008

North America
325,000

Europe
80,000

China
201,000

India
107,000

Japan
82,000

South America
85,000
Key Technology Enablers

- Combustion
- Fuel Systems
- Electronic Controls
- Turbochargers
- Aftertreatment Systems
- Filtration
- Diesel Exhaust Fluid
Cummins: Proven Rail Platforms

- Over 100,000 19L+ engines in service worldwide
- 60 years experience of high speed diesels in rail
- Proven reliability and durability in the rail industry
- 10,000+ engines in current railway service
- 1,800+ engines in current locomotive service including 800+ HHP QSK series engines
- In more applications & types of equipment than any comparable engine range
- Manufacturing almost 15,000 19L+ engines annually
Mission: Provide a complete lineup locomotive engines that give OEMs flexibility to provide superior life cycle and environmental benefits

- Complete lineup of low emissions engines from 200 – 3300+ hp
- Locomotive certification for switcher and line haul cycles
- Engines to provide better than Tier 3 emissions
- Ability to provide multiple or single engine repower solutions with common architectures
Worldwide Locomotive Product Lineup

QSK78
QSK60
QSK50
KTA50
QSK45
QSK38
QST30
QSK23
QSK19
KTA19
QSX15
QSM11
QSL
QSL
QSB

hp
0 500 1000 1500 2000 2500 3000 3500
Low Emissions
Locomotive Engines
Cummins Solutions for Low Emissions Locomotives

- Building on the success of the QSK19
- Expanded lineup of low emissions loco engines
- 184 day service interval capable
- No mid life overhaul event
- ULEL engine solutions
- Tier 3 capability now
US EPA Locomotive Product Lineup
Tier 2 or Better

- QSB
- QSL
- QSM11
- QSX15
- QSK19
- QSK23
- QSK38
- QST30
- QSK50
- QSK60
- QSK78

Tier 3 capability now
- <= 4g NOx
- <= 3g NOx

Low emissions locomotive solutions + track machinery, auxiliary power

Railcar movers, industrial locos, track machinery, aux power
US EPA Part 89 Tier 3 (Tier 4 in 2011)
Tier 4 & Aftertreatment
### Tier 4 Locomotive – SCR Integration

**The best Tier 4 solution ≠ Tier 2 engine + (SCR+DPF)**
- Current engines have not been optimized for AT backpressure considerations
- Low backpressure requirements = large systems / frequent service
- High engine PM out = frequent DPF plugging / frequent regen cycles

**Cummins is optimizing its engines for Tier 4 locomotive to provide the lowest life cycle cost and best performance**

<table>
<thead>
<tr>
<th>Air-Fuel Ratio</th>
<th>Injection Pressure</th>
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</thead>
<tbody>
<tr>
<td>Peak Cylinder Pressure</td>
<td>Altitude</td>
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<tr>
<td>Start of Injection</td>
<td>Turbine Inlet Temperature</td>
</tr>
<tr>
<td>Engine Back Pressure</td>
<td>Engine NOx out</td>
</tr>
<tr>
<td>Engine PM out</td>
<td>Fuel vs. Urea consumption</td>
</tr>
</tbody>
</table>
Holding Power and Injection Pressure Constant...

- **Air Fuel Ratio ↑** Particulate Matter ↓
- **Air Fuel Ratio ↑** Cylinder Pres ↑
- **Altitude Req ↑** Turbine Inlet Temp ↑
- **Back Pressure ↑** AF ↓ fuel cons ↓
The right solution requires system integration

System Engineering in contrast to “Throw It Over the Wall”
Thank You!