Technology For Locomotive Emissions Reductions – Manufacturer’s Perspective

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Agenda

1. Australian Locomotive Fleet
2. U.S. Locomotive Exhaust Emissions Standards
3. Emission Kits for Older Locomotives
4. Review of Recent Testing
5. Next Generation Locomotives
Australian Locomotive Fleet

• About 2,000 total diesel locomotives in Australia
• Average age ~ 30 years
• Only small percent of fleet replaced each year
Emissions for U.S. Locomotives

• Major factor in engineering development over past 15 years
Emissions for Existing Locomotives

- Applies to locomotives manufactured since 1973
- Locomotives must be upgraded when they are overhauled
Emissions Kits

- Tier 0+ emissions kits for 645 & 710 diesel engines
- Low oil use power assemblies
- Fuel Injectors & Four Pass Aftercoolers
- Locomotives certified that they meet Tier 0+ with kits applied
## Tier 0+ Kits for Australian Locomotives

<table>
<thead>
<tr>
<th>Engine</th>
<th>Tier 0+ Kit</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-645E</td>
<td>40162002</td>
<td>Normally Aspirated</td>
</tr>
<tr>
<td>16-645E</td>
<td>40162005</td>
<td>Normally Aspirated</td>
</tr>
<tr>
<td>12-645E3B</td>
<td>40169282</td>
<td>Alternate kit 40188099 has Haynes injectors</td>
</tr>
<tr>
<td>16-645E3B</td>
<td>40162008</td>
<td>Includes 4 Pass Aftercoolers; Alternate kit 40188101 has Haynes injectors</td>
</tr>
<tr>
<td>16-645E3C</td>
<td>40169278</td>
<td>Includes 4 Pass Aftercoolers</td>
</tr>
<tr>
<td>12-710G3</td>
<td>40171611</td>
<td></td>
</tr>
<tr>
<td>12-710G3A</td>
<td>40171611</td>
<td></td>
</tr>
<tr>
<td>16-710G3A</td>
<td>40156921</td>
<td>Includes 4 Pass Aftercoolers</td>
</tr>
<tr>
<td>16-710G3B</td>
<td>40156917</td>
<td>Already has 4 Pass Aftercoolers</td>
</tr>
<tr>
<td>12-710G3-ES</td>
<td>40168671</td>
<td>Locomotive has Electronic fuel injection and separate aftercooling.</td>
</tr>
<tr>
<td>16-710G3-ES</td>
<td>40161852</td>
<td>Locomotive has electronic fuel injection &amp; separate aftercooling</td>
</tr>
</tbody>
</table>
Testing June, 2015 – 9024 with 16-710G3A Engine

PM and NOx Results - 9024

- Tier 0+
- Baseline
- Emissions Kit Applied
Testing June, 2015 – 8113
With 16-645E3B Engine
PM and NOx Results
Current Testing

• Optimization of injection timing
  – Improved fuel consumption
  – Reduced CO$_2$
  – Higher NO$_X$ emissions

• Application of High Capacity (T3) Oil Separator on 710 Engine
Voluntary Emission Reduction

SD70ACe-LCi Loco for BHP Australia Meets U.S. EPA T2 Emissions
GT46C-ACe Gen II

• Locomotive configured to meet U.S. EPA Tier 3
• Variable speed inverter drive for fans and blowers to reduce parasitic loads and reduce noise
• Locomotives will arrive in mid-2016
Questions