Locomotive Engine Re-Power Emission Review

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- VP-GM 317-240-1951

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Purpose

- Evaluate new locomotive EPA Tier regulations and provide examples of Locomotive Repowers using Tier 2 Certified Engines.
Agenda

- EPA Locomotive Tier Regulations
- Future EPA Locomotive Tier levels
- Tier 2 Re-Power Locomotive Examples
- Future Locomotive Engine Products
- Conclusion
EPA Locomotive Tier Regulations

- In the past decade, the EPA has introduced the following mandated marine emission regulations for locos greater than 1006 hp.
  - Tier 1  Expired End 2004
  - Tier 2  Expires End 2010 for Switcher and End 2011 for Line Haul
  - Tier 3
  - Tier 4
- Switcher Locomotive definition: 1006 -2300 bhp
- Line Haul Locomotive definition: 2301 bhp & above
Not regulated under locomotive rule (probably less than 1006hp and not diesel)
EPA Locomotive Tier Regulations

- US EPA Locomotive 1997 Ruling 40 CFR 92 introduced Tier 1 & 2 Regulations:
  - EPA Tier I Locomotive Regulation effective Jan. 2002
  - EPA Tier II Locomotive Regulation effective Jan. 2005
- US EPA Locomotive 2008 Ruling 40 CFR 1033 introduced Tier 3 & 4 Regulations
  - EPA Tier 3 Switcher Regulation effective Jan. 2011
  - EPA Tier 3 Line Haul Regulation effective Jan. 2012
  - EPA Tier 4 Locomotive Regulation effective Jan. 2015

* Above regulations at time of new build
### LOCOMOTIVE EMISSION REGULATION SCHEDULES

**NOx / HC / CO / PM (g/bhp-hr)**  
[Conversion: g/bhp-hr / 0.7457 = (g/kW-hr)]

#### U.S. EPA

<table>
<thead>
<tr>
<th>Originally Built Between</th>
<th>Standards at time of build</th>
<th>Standards if remanufactured between</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-January 1, 1973</td>
<td>None</td>
<td>9.5 / 1.00 / 5.0 / 0.60</td>
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<tr>
<td>January 1, 1973 - December 31, 1992</td>
<td>None</td>
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<td>None</td>
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#### Line-haul (NOx / HC / CO / PM) (g/bhp-hr)

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#### Switch (NOx / HC / CO / PM) (g/bhp-hr)

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#### Notes:

- **Tier 0**: Unless significantly upgraded
- **Tier 1**: For MY 2008-2009 only if no remanufacture system is available. Otherwise must meet Tier 1 standards
- **Tier 2**: For MY 2008-2012 only if no remanufacture system is available. Otherwise must meet Tier 2 standards
- **Tier 3**: Tier 2 line-haul locomotives must also meet Tier 2 switch standards
Future EPA Locomotive Tier Levels

- In 2008, the US EPA signed the final rule for locomotive Tier 3 and Tier 4.
- Tier 3 is enforceable January 2011 for new Switcher Locomotives.
- Looking ahead, new locomotive EPA Tier 3 & 4 regulations represent the most dramatic reduction of emission levels to date for the industry.

<table>
<thead>
<tr>
<th>Switcher</th>
<th>Phase-in beginning</th>
<th>NOX Reduction*</th>
<th>PM Reduction*</th>
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<tr>
<td>Tier 3</td>
<td>2011</td>
<td>38%</td>
<td>58%</td>
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<tr>
<td>Tier 4</td>
<td>2015</td>
<td>84%</td>
<td>88%</td>
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* Compared to Tier 2 standards
Passenger Excursion Locomotive

White Pass & Yukon Route Railroad – Skagway, AK

- Engine + Alternator Skid
- Refurbished Loco
Tier 2 Locomotive Re-Powers

- CSX 2100 hp Switcher
- G&W 1400 hp Switcher
- WP&YR 1400 hp Locomotive
Switcher Re-Power to Tier 2

CSX 2100 hp Switcher Repowers – Various Locations

- CSX EMD SD40-2 Repower
- Original Power 1974:
  EMD 16-645E3 3000 HP non-cert.
- Re-Power in 2010 by National Railway Equipment Co.
  3X T2 Cummins QSK19-L, 700 HP ea = 2100 hp total
- Customer savings: 25-50% fuel, 85% noise, 35% maintenance
Switcher Re-Power to Tier 2

G&W 1400 hp Switcher Repower – Butler, PA

- G&W EMD SW-series Repower Kit
- Original Power 1950s:
  EMD 12-567 1500 HP non-certified
- Re-Power in 2010 by Brookville Equipment Co.
  2X T2 Cummins QSK19-L, 700 HP ea = 1400 hp total
- Customer savings: 20%+ fuel, 58% NOx, 80% Particulate Matter
Passenger Excursion Locomotive

White Pass & Yukon Route Railroad – Skagway, AK

- WP &YR GE GEX3341 Shovel Nose
- Original Power 1950s:
  - Alco 6-251  990 HP
- Re-Power in 2010 by **Global Locomotive**:
  - Cummins QSK45-L1, 1500 HP
- Customer savings: 30% fuel, 85% consumables, 1 less loco per train
Passenger Excursion Locomotive

White Pass & Yukon Route Railroad – Skagway, AK

- Engine + Alternator Skid
- Refurbished Loco
Benefits for the customer

- Reduced Emissions
- Reduced Fuel Consumption
- Improved light load fuel efficiency
- Reduced required Idle Time
- Improved Oil Drain intervals
- Improved Service Intervals
- Improved Traction Controls
- Reduced Noise
Challenges of Locomotive Repowers

- **Medium Speed** (900 rpm) to **High Speed** (1800 rpm)
  - Requires different alternator capable of 1800 rpm
  - Multiple engine installation requires new controls to share power

- **Packaging**
  - Adding Charge Air Cooling
  - Requires robust rail-duty mounting
  - Making the engine power module easy to remove

- **Electronic controls**
  - Integrating existing machine controls and safeties designed for a mechanical engine into an electronic engine
Future Locomotive Products

- Cummins product plan is designed to implement the right technology for each market we serve.
- As we approach each set of implementation dates, Cummins plans to offer a complete line-up of engines certified to the new emission standards for Locomotive Re Powers and New Build projects.
Rail Engine Product Lineup

- **QSK23**
  - 567-709 kW
  - 760-950 hp
  - EU stage 3a: 670 kW
  - Tier 3 pending

- **QSK19**
  - 410-597 kW
  - 550-800 hp
  - Tier 3 pending

- **QST30**
  - 709-895 kW
  - 950-1200 hp
  - EU stage 3a pending
  - Tier 3 pending

- **QSK38**
  - 933-1119 kW
  - 1250-1500 hp
  - EU stage 3a: 1492 kW
  - Tier 3 pending

- **QSK50**
  - 1119-1492 kW
  - 1800-2000 hp
  - EU stage 3a: 1864 kW
  - Tier 3 pending

- **QSK50**
  - 1640-2015 kW
  - 2200-2700 hp
  - Tier 3 pending
Conclusion

- Cummins is committed to meeting or exceeding clean air standards worldwide.
- New locomotive emission regulations present a significant technological hurdle for engine manufacturers.
- You can count on Cummins to provide information on the regulations for Re Power opportunities.
- Cummins will have the Right product, utilizing the Right technology at the Right time.
Additional Information

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