Selection of Diesel Engines for Underground Mining Applications.
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MSHA Diesel Engine Requirements for M/NM Underground Mines
§ 57.5067 (a) Engines

- Any Diesel Engine Introduced Underground
  - (a)(1) Have Affixed A Plate Evidencing Approval Under Subpart E of Part 7, Or Under Part 36
  - (a)(2) Meet Or Exceed The Applicable PM Emission Requirements Of The U.S. EPA Listed In Table 57.5067-1
MSHA Approved Engines
Approval Number

- Permissible Engines:
  7E-A001 or 07-EPA030001

- Non-permissible Engines
  7E-B001 or 07-ENA030001
Information on Approval Plate

- Approval Number
- Ventilation Rate
- Rated Power
- Rated Speed
- High Idle Speed
- Maximum Altitude before Fuel Deration
- Engine Model Number
Internet Link to MSHA Approved Engines

- or
- [www.msha.gov then click on “Approved Products”, then click on “Part 7 Diesel Engines”](www.msha.gov)
<table>
<thead>
<tr>
<th>Approval Number</th>
<th>Engine Manufacturer</th>
<th>Model</th>
<th>HP @ RPM at 1000ft Elevation</th>
<th>DPM grams/-hp-hr weighted</th>
<th>Exhaust BP Max Limit, in.H2O</th>
</tr>
</thead>
<tbody>
<tr>
<td>07-ENA040001</td>
<td>CUMMINS</td>
<td>QSB-155C</td>
<td>155 @ 2500</td>
<td>0.11</td>
<td>41</td>
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<tr>
<td>07-ENA040018</td>
<td>DEUTZ</td>
<td>F6L 914</td>
<td>117 @ 2300</td>
<td>0.09</td>
<td>40</td>
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<td>07-ENA050001</td>
<td>MITSUBISHI</td>
<td>S4S-DT</td>
<td>77 @ 2500</td>
<td>0.18</td>
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<td>7E-B001</td>
<td>DEUTZ</td>
<td>MWM 916</td>
<td>94 @ 2300</td>
<td>0.42</td>
<td>40</td>
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<td>7E-B003</td>
<td>CATERPILLAR</td>
<td>3306 PCNA</td>
<td>150 @ 2200</td>
<td>0.49</td>
<td>34</td>
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<td>7E-B035</td>
<td>DEUTZ</td>
<td>F8L 413FW</td>
<td>182 @ 2300</td>
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<td>7E-B063</td>
<td>CATERPILLAR</td>
<td>3306PCTA</td>
<td>215 @ 2200</td>
<td>0.45</td>
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<tr>
<td>HP Range</td>
<td>Emission Limit</td>
<td>Tier</td>
<td>Model Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------</td>
<td>------</td>
<td>------------</td>
<td></td>
<td></td>
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<tr>
<td>Hp &lt; 11</td>
<td>0.75 g/bhp-hr</td>
<td>Tier 1</td>
<td>MY2000</td>
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<tr>
<td>11 \leq HP &lt; 25</td>
<td>0.60 g/bhp-hr</td>
<td>Tier 1</td>
<td>MY2000</td>
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<tr>
<td>25 \leq HP &lt; 50</td>
<td>0.60 g/bhp-hr</td>
<td>Tier 1</td>
<td>MY1999</td>
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<td>50 \leq HP &lt; 100</td>
<td>0.30 g/bhp-hr</td>
<td>Tier 2</td>
<td>MY2004</td>
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<td>100 \leq HP &lt; 175</td>
<td>0.22 g/bhp-hr</td>
<td>Tier 2</td>
<td>MY2003</td>
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<td>175 \leq HP &lt; 750</td>
<td>0.40 g/bhp-hr</td>
<td>Tier 1</td>
<td>MY1996</td>
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<td>Hp \geq 750</td>
<td>0.40 g/bhp-hr</td>
<td>Tier 1</td>
<td>MY2000</td>
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</tbody>
</table>

- On highway diesel vehicles such as pickup trucks from 1994 vehicle model year
Engine’s Diesel Particulate Matter (DPM) Emissions
Engine Combustion Design

- **Pre 1993 Direct Injection Engines**
  - 0.5 – 1.0 gm/hp-hr.

- **Indirect Injection (Pre Chamber) Engines**
  - 0.3 – 0.5 gm/hp-hr.

- **Post 1993 Direct Injection Engines**
  - High Pressure Fuel Direct Injection
  - Turbocharged
  - Computerized Electronic Fuel Injection
  - 0.05 – 0.2 gm/hp-hr for the higher horsepower engines
Total Emissions = Horsepower specific emissions $\times$ Horsepower $\times$ Hours of use.
Total Engine Out Emissions

Emissions x Horsepower x Hours = DPM

- **Loader:**
  \[0.1 \times 275 \times 8 = 220 \text{ grams}\]

- **Haul Truck:**
  \[0.1 \times 350 \times 8 = 280 \text{ grams}\]
  \[0.3 \times 350 \times 8 = 840 \text{ grams}\]

- **Drill:**
  \[0.5 \times 150 \times 4 = 300 \text{ grams}\]
Three Strikes and It’s Out

**Strikes:**
- High horsepower (greater than 150),
- High emissions (greater than 0.3 gm/hp-hr),
- High use (greater than 6 hours per shift).

**Target Equipment:**
- Production Loaders and Trucks (primary),
- Drills and Scalers (secondary)
- PC engines (specialty mining equipment).

**One bad engine can spoil the entire fleet.**
Clean Engines vs. Ventilation

- Clean engines reduce emissions by 80 to 90%.
  - Fuel savings pay for engine in 2 to 3 years.

- Estimate that 80% of engines are currently Tier 1 or better.

- Ventilation is important, it can be expensive unless improvements are made by improved distribution.
  - 25% increase in mine air flow doubles the ventilation cost.
EPA Tier 3

- 50 ≤ HP < 100          Tier 3          MY2008
- 100 ≤ HP < 175          Tier 3          MY2007
- 175 ≤ HP < 750          Tier 3          MY2006

- NOX reductions only, no change in DPM
EPA Tier 4

- Hp < 25 Tier 4 MY2008
- 25 ≤ HP < 75 Tier 4 MY2008 & 2013
- 75 ≤ HP < 175 Tier 4 MY2012 - 2014
- 175 ≤ HP < 750 Tier 4 MY2011 - 2014
- Hp ≥ 750 Tier 4 MY2011 - 2015

- Substantial DPM reductions above 25 hp
- Substantial NOX reductions above 75 hp
Diesel Fuel

- MSHA §57.5065 requires diesel fuel with a sulfur content of less than 0.05 percent (500 ppm)
- EPA requirement for on-highway diesel fuel to be at 0.0015 percent (15 ppm) sulfur by mid – 2006
- EPA requirement for non-road diesel fuel to be at 0.0015 percent (15 ppm) sulfur by 2010
QUESTIONS?