UGM Emission Reduction Technologies

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LET'S DO THE WORK.
Caterpillar Emission Solutions for UGM Equipment

- Ventilation Reduction (VR)
- Ventilation Reduction (VR) + Flow Through Filter (FTF)
- Ventilation Reduction (VR) + Wall Flow Filter (WFF)
- EU Stage IV & V
- Battery Electric (in development)

Selected models only
DPM reductions for UGM

• Ventilation Reduction options available for many Cat M/NM products:
  – Lower PM engine calibrations
  – Flow Through Filter (DPM reduced 50%)
  – Wall Flow Filter (DPM reduced 98%)
(Surface) Nonroad Emissions Standards

130-560kW Diesel Engine Emissions

Tier 3, Stage IIIA (2006)
Tier 2, Stage II* (~2002)
Tier 1, Stage I (1996)
Stage V (2019) 1x10^{12} PN (Particulate Number) Limit
Tier 4 Final, Stage IV (2014)
Tier 4 Interim, Stage IIIB (2011)
Stage V Emission Reduction for UGM

• Stage V technologies being implemented for M/NM mining: Includes Wall Flow Filter and SCR/DEF. (Coal has performance requirements that are incompatible with Stage V)

• Additional safety design requirements apply (eg. engine shutdown)

• DEF storage may be an issue. (Exceeding 32°C/90°F will result in accelerated decay)

• DEF/SCR systems may emit traces of ammonia
### Stage V Aftertreatment Configurations

<table>
<thead>
<tr>
<th>Engine Models</th>
<th>Power Category [ kW ]</th>
<th>Stage V NOx Limit [ g/(kW*hr) ]</th>
<th>Stage V PM Limit [ g/(kW*hr) ]</th>
<th>Aftertreatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>C0.5 – C1.5</td>
<td>&lt; 19</td>
<td>7.5 *</td>
<td>0.4</td>
<td>no aftertreatment</td>
</tr>
<tr>
<td>C1.5 - C3.6</td>
<td>19 - 56</td>
<td>4.7 *</td>
<td>0.015</td>
<td>DOC DPF</td>
</tr>
<tr>
<td>C3.6 – C18</td>
<td>56 – 560</td>
<td>0.4</td>
<td>0.015</td>
<td>DOC DPF SCR</td>
</tr>
<tr>
<td>C18 – C32</td>
<td>&gt; 560</td>
<td>3.5**</td>
<td>0.045**</td>
<td>DOC SCR</td>
</tr>
<tr>
<td>3500, C175</td>
<td>&gt; 560</td>
<td>3.5**</td>
<td>0.045**</td>
<td>SCR</td>
</tr>
</tbody>
</table>

* NOx limit includes HC (hydrocarbons)

** Non-genset limit stated. Gensets >560kW have more stringent emission limits.
Aftertreatment Configurations

Examples of engine + aftertreatment configurations:

- **C3.4**
  - DOC+DPF

- **C4.4**
  - DOC+DPF+SCR

- **C7.1**
  - DOC+DPF+SCR
Caterpillar R1700, available with Stage V engine.
Other Stage V models in development

- AD45, AD60
- R2900 LHD
Battery Electric machines are in development

- Stay tuned!