Engine Control Systems

# Managing PM and $NO_2$ Emissions

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## Outline

- **Managing Fleet Emissions**
- **Choosing New Engines**
- **Choosing DPF's to manage PM and NO2 emissions**

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# Managing PM Emissions

- **Have a complete fleet list**
- **Proper Pro-active Maintenance procedures, Maintenance Records and Training is Vital**
- **Plan to Retire or Repower those machines which contribute disproportionately to maintenance and emissions**
- **Base New Equipment Purchases knowing the true certified emissions values of the specific engine**
  - **Anticipate emissions in the given application**
    - **Steady state vs. transient equipment**
    - **Use certification smoke measurements as a guide**
    - **Lower NOx levels should correlate to lower $NO_2$ levels?**
- **Apply Exhaust Controls for PM**
  - **Manage $NO_2$ emissions**

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# Choosing New Engines

(applies to fleet manager & equipment mfr)

- Emissions Limits for New Non-road Engines are Phased-in
  - **Tier 1 overlaps with Tier 2 which overlaps with Tier 3 which overlaps with Tier 4**
  - **Averaging of production engines allowed**
  - **Necessary to allow manufacturers some flexibility in development and production**
  - **It means customers must be aware of their purchases on a case by case basis**
- **You need to know the EPA Engine Family Name to definitively identify the certified emissions values and true compliance level of the specific engine in available EPA engine certification files at**

**http://www.epa.gov/otaq/certdata.htm#largeng**

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# EPA Certified Actual Emissions Values

(Steady State PM Values)

| | (g/kW-hr) | | Smoke (%) | | |
|---|---|---|---|---|---|
| 2007 Engine | HC +NOx | PM | Accel | Lug | Peak |
| A | 3.3 | 0.073 | 4.3 | 1.6 | 8.6 |
| B | 3.4 | 0.12 | 3 | 1 | 6.8 |
| C | 3.8 | 0.12 | 4 | 7 | 8 |
| D | 3.4 | 0.14 | 6 | 2 | 10 |
| E | 3.9 | 0.19 | 13 | 2 | 19 |
| F | 3.4 | 0.25 | 13 | 3 | 25 |
| G | 3.8 | 0.25 | 13.5 | 4 | 30 |

# Steady State Certification Cycle Underestimates PM for Some Engines

| **Tier 2** | **Fuel** | **HC + NOx (g/hp-hr)** | **NO2 (%)** | **PM (g/hp-hr)** |
|---|---|---|---|---|
| **Certification Values (#2 Cert Fuel)** | **#2 Cert Fuel (<500ppm)** | **4.14** | **NA** | **0.094** |
| **ISO 8178 C1 (in triplicate)** | **CARB / TEXLED ULSD** | **3.53** | **8%** | **0.100** |
| **Ramped Modal (in triplicate)** | **CARB / TEXLED ULSD** | **3.55** | **6%** | **0.089** |
| **Non-Road Transient Cycle (3 Hot Starts)** | **CARB / TEXLED ULSD** | **3.30** | **8%** | **0.203!** |

Source: ECS emissions data from tests performed at SwRI

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## Summary on Choosing New Engines

- **Certified PM levels vary greatly amongst new engines**
  - **Many engines will yield even greater PM over transient duty cycles**
- **There is value in knowing the EPA Engine Family Name / Certified Emissions Values prior to purchasing new equipment**
- **Have to consider the anticipated PM and NOx levels when choosing exhaust emissions controls**
- **NOx and $O_2$ levels are coming down in new engines and this represents a challenge to passive DPF's. % $NO_2$ levels may be increasing in new engines but NO2 mass emissions rates are constant or declining**

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## % $NO_2$ levels in New Engines Unknown

| Engine Configuration | $NO_2$ (% - wrt Baseline total NOx) |
|---|---|
| 2004 XXX Baseline **with OEM DOC** | 1.3% |
| 2004 XXX Engine-out **Without OEM DOC** | 21.4% |

Source: Environment Canada

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# Croton NY In-use $NO_2$ Levels

(PM Levels reduced 97 to >99%)

| Equipment | Measurement Location | % NO2 (wrt to Total NOx) | NO2 (grams/minute) | Total NOx change |
|---|---|---|---|---|
| 2004 Dozer 15.2L Engine 332hp | Pre Purifilter | 38% | 5.41 | |
| | Post Purifilter | 40% | 5.50 | 5% reduction |
| 2004 Excavator 15.2L Engine 474hp | Pre Purifilter | 29% | 6.33 | |
| | Post Purifilter | 34% | 6.51 | 12% reduction |
| 2005 Hydraulic Drill 6L engine 173hp | Pre Purifilter | 47% | 3.52 | |
| | Post Purifilter | 58% | 3.90 | 5% reduction |

Source: Env. Can. / Emisstar / NYSERDA

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# How to Choose a DPF Retrofit System to Manage PM and $NO_2$ Emissions

- Common Questions
  - How can I extend the application range of Passive DPF's?
  - How do I address variability in PM emissions which may occur in transient operation?
  - Which technologies are feasible for my application?
  - How do I minimize $NO_2$ as an issue?
  - How do I ensure equipment up-time?
  - How do I reduce the maintenance requirement?

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# DPF Technology Options

| Filter Type / Regeneration Method | Base Metal Passive | Precious Metal Passive | Active |
|---|---|---|---|
| Regeneration Temperature | 25% time > 380 – 420 C | 25% time > 280 – 320 C | Not Required |
| Regeneration Catalyst | Base Metal Coating | Precious & Base Metal Coating | Electrical Connection or Burner |
| Regeneration Downtime | None | None | 30 minutes to 8 hours |

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# ECS DPF Product Line Overview

**Cattrap™**

Basemetal catalyst, passively regenerating
Decreased $NO_2$

**Purifilter™**

Pt / base metal catalyst, passively regenerating
Modest Increase in $NO_2$

**Combifilter™**

Electrically Regenerated
Decreased $NO_2$

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# What about Combining Passive and Active Regeneration?

- Allows soot oxidation by two methods
  - Primary method is passive regeneration
  - Secondary method is active regeneration
- extends application range of passive DPF's without applying more highly active $NO_2$ generating catalysts
- increases passive filter tolerance of duty cycle and mechanical condition variations
  - Allows a back-up regeneration method

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# What about Combining Passive and Active Regeneration?

- **Allows DPF use on higher emitting engines**
- **Reduce filter size employed on smaller non-road engines over traditional un-catalyzed active systems**
- **Greatly reduces panel infrastructure over traditional Combifilter**

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# On-board Components


## SiC DPF Substrate

- catalyzed Purifilter H or L
- catalyzed Cattrap

## Heater Elements

- # of elements = speed of regeneration
- K Model = 8hrs
- S Model = 120 min.

**Note:** (Type S element temp turned down to 650 C in Purifilter Plus)

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# Common Off-Board Panel

- **Can be used by multiple pieces of equipment with different sizes of Purifilters and Cattraps**
- **Can be located in various locations in the mine to faciltate plug-in**

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# Purifilter Plus Examples


Cargo Handling

Construction

Highway


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## When to employ Active Regeneration?

- **At Preventative Maintenance Intervals**
  - **Service tool to maintain benefits of low backpressure and extend DPF life**
- **When indicated by backpressure monitor**
  - **Duty cycle or engine condition variances**
- **At pre-determined pro-active intervals**
  - **Based on data-logging of equipment in operation over a period of time**

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## New ECS Backpressure Monitor / Loggers

- New ECS BP monitors
  - Extended datalogging capability (up to 2 yrs)
    - BP and Temperature
    - Regen. frequency
  - Multi-light displays to indicate system faults, warnings and alarm conditions
  - Real time monitoring
- Systems come with software to allow data analysis

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# Summary

- **When planning new equipment purchases, investigate the EPA Engine Family Name to determine anticipated emissions levels**
- **Employ Passive DPF's where possible**
  - **Consider incorporating active controls to facilitate maintenance and reduce labor**
  - **Schedule implementation and monitor $NO_2$ levels**
- **Employ Combined Passive & Active DPF's on equipment with variable duty cycles or marginal applications**
- **Employ Active DPF's on remaining equipment to reach target levels.**

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# ECS Contacts

**ECS East (Newmarket) :** **(905) 853-5800**
**1-800-661-9963**

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**1-800-331-9247**

New ECS Website:
www.enginecontrolsystems.com

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