Aftertreatment Systems:
Proactive Approach to Protecting the Equipment

S.3 Engines
Summary

• Past presentations . . .
  – New technologies
  – Fleet feedback
  – Aftertreatment Systems
    • Maintenance Challenges and Best Practices
    • 3C – Complaint, Cause, Correction >> Take Aways
• Now – prevention . . . A proactive approach
  – Fleet perspective
  – OE perspective
  – Maintenance perspective
Emissions System Protection

Kirk Altrichter
Vice President Maintenance
Crete Carrier Corporation
Emissions Systems – Gotta Love-Em

Emissions systems - a positive note

• Reduction in particulate matter
• Reduction in NOx
• Reduction in CO$_2$
• Better for our health and for the environment
Emissions Systems - Upstream Problems = Downstream Woes

- Coolant
- Fuel
- Oil
Diesel & DEF Do Not Mix

- DEF in the fuel tank - $15,000 repair
- Diesel in the DEF tank - $5,000+ repair
Sensors are numerous, but……

- An EGR cooler failure can damage a DOC and/or DPF
- Over fueling the 7th injector can melt a DPF
- A clogged fuel water separator will allow fuel to bypass and destroy the injectors
Warranty Numbers

• OEM warranty numbers – Do they tell the whole story?

• PDC sales vs. warranty

• What do PDC sales show as the components with problems?
Fleets, Emissions & Costs

• Fleets are being eaten alive by emissions related problems

• What is being done at the OEM level to drive ownership costs down?
Vic Meloche
Manager Technical Sales Support
Daimler / Detroit
Typical Engine and After-treatment

- Proper care and maintenance is essential
- Anything up stream (engine) will effect after-treatment components
- Understand duty cycle(s) and their impact to the after-treatment system
Categories

• Controllable
  – Proper Maintenance
  – MIL/Fault Codes and Lamps
  – Hardware/Calibration Updates

• Semi-Controllable (Manageable)
  – Duty Cycles

• Un-controllable
  – Abuse
  – Ignoring lights and fault codes
Proper Maintenance

- Most aftertreatment issues stem from upstream issues.

- This also includes maintenance items that can affect the ATS.

- Proper maintenance goes a long way towards ATS health!

  “An ounce of prevention is worth a pound of cure.”

- There are dozens of fault codes related to ATS pressure, temperature, NOx levels, etc., to prevent damage to the ATS.
Proper Maintenance

- Diesel Particulate Filters
- Fuel System
- Air System
- Air Tanks
- DEF Cleanliness and Quality
DPF Functionality

Particulate Filter has a soot storage capacity – soot must be regenerated on a regular basis

- Method 1: Passive Regeneration
- Method 2: Active Regeneration

Particulate Filter also collects ash from the lube oil in the exhaust

- Ash must be physically removed from the filter
- Active regeneration causes the ash to pack in the back of the filter element
DPF Maintenance

- Ash Cleaning Intervals are set in the engine calibration & are dependent on:
  - EPA vintage
  - Engine displacement
  - Application
  - Duty cycle
  - Lubricating oil consumption
DPF Cleaning

Inlet

Operational Flow

Outlet

Ash filled Particulate Filter

Inlet

Cleaning Flow

Outlet

Inadequate Cleaning

Inlet

Cleaning Flow

Outlet

Adequate Cleaning
Inadequate Cleaning removes ONLY 1" to 1 ¼"

DPF Over Temp Codes

Soot Load High & Soot Load Very High Codes

Reset DPF Ash Accumulation Mileage

DPF Cleaning - Importance

1st DPF Loading Cycle

Miles X 1000

Inches of ash

RISK
DPF Cleaning - Importance

• DPF will overheat if ash level in the DPF gets to be too excessive

• When a DPF overheats:
  • The substrate will crack allowing unfiltered exhaust to pass thru to the SCR catalysts
  • Platinum (the catalyst for burning the soot) vaporizes and plates out on the SCR catalysts
  • The SCR Catalyst is then “poisoned” due to the migration of platinum
  • Low NOx Conversion Efficiency codes
  • SCR Catalysts must be replaced
Model Year 2016

• Introduction of Soot Sensor
  – Installed at or near outlet of Aftertreatment Device (ATD)
  – Only purpose is to detect soot emissions which exceed OBD limits due to reduced DPF filtration efficiency
  – New diagnostic trouble codes associated with soot sensor; includes sensor electrical checks, sensor functional performance checks & DPF filtration checks
Fuel System

• Issues with the fuel system may impact the aftertreatment system by providing an external fuel source

• Any failure that allows unburned fuel to go through exhaust pipe (injectors, doser, etc.)
Water in Fuel - Issues

- Deposits and rust forming in injectors
- Sticking Injectors / Internal Deposits
- Backwards running engines
- Oversped engines
- In some cases we can detect and react, but not always
Water In Fuel & Fuel Filter Restriction

• Water in Fuel checks/draining should be part of weekly post-trip inspections per engine OE guidelines

• Low fuel pressure/filter restriction may impact the effectiveness of the aftertreatment injector resulting in regeneration issues

• Fuel filters should be changed according to engine OE guidelines
Fuel filters / water separators

• Provides water separation & primary filtration, but not final filtration

• Extends engine primary / secondary fuel filter life, but does **NOT** ultimately replace them

• Recommended
Fuel Additives

- Fuel additives can decrease the effectiveness of water coalescent filter(s)

- Although Cold Flow additives may be effective at improving the cold weather operability of diesel fuel, extreme caution must be taken not to use too much additive

- As with any fuel additive, too much may cause other operability problems

- Some are high in sulfur and when added to the fuel can effect the diesel oxidation catalyst
AfterTreatment Injector - Doser

- Follow proper engine OE maintenance guidelines for the AT injector
- Prevent potential sticking (open or closed)

Poppet valve
DEF in Fuel

• DEF is 2/3 water and will cause rust in the fuel system
• Employ fuel tank stickers
• **Driver training a MUST!**
Air Inlet Restriction

• Proper air flow is key to a smooth running & healthy engine

• Plugged air filters greatly restrict flow & reduce the amount of fresh air going into the engine. The engine may begin to run poorly & cause ATS issues

• Much like fuel filters, air filters have an exponential restriction curve. Once they begin to plug, they will start to plug at a faster rate

• Engines with very low air to fuel ratios make very high particulates

• Follow engine OE guidelines for maintenance
Rust / Debris in the Air System

- Air tanks need draining daily (without automatic drain valves) or monthly (with automatic drain valves)

- Most OEs require the use of a coalescing filter in the air dryer system

- Rust in the air system can plug DEF air filters
**DEF Quality and Cleanliness**

- American Petroleum Institute certifies:
  - Supplies of DEF meet these standards at the pump
  - Across the nationwide supply chain

- Only certified DEF should be used

- Take care not to contaminate on board DEF tanks
  - Debris ingestion
  - Only dedicated DEF containers, pumps, funnels, etc
Kevin Otto
Aftertreatment Systems Program Leader
Fault Codes / Lamps

• Do NOT ignore the MIL/Fault Lamps

• In the past, you might be able to get away with this, but not today
  – OBD faults can lead to severe derates, even 5 mph max speed
  – OBD regulations require that manufacturers must detect when catalyst function is compromised
ATS Compensation Limits

• The aftertreatment control system can compensate for some of these issues, but only to a certain degree

• How?
  – Adjusting to the conditions that the sensing systems can ‘see’
  – Manufacturers use the sensor suite to detect temperatures, pressures, NOx readings outside of normally expected ranges for the conditions and adjust the control system accordingly
  – All have limits and that is when fault codes start coming on
Diagnostic Process

- Failures can be very difficult to diagnose
  - Many times visual inspection of components or a quick test are not enough to make an accurate repair

- Need to follow troubleshooting and inspection guidelines of the manufacturer
  - Procedures are designed to lead service facilities to replace the correct component(s)
  - Sometimes more than 1 component can be damaged or its function compromised
Calibrations / Hardware

• Have all campaigns done **promptly**

• Engine OEs are always working to improve our customers’ experience with product functionality and reliability
Duty Cycles

- Aftertreatment systems like it HOT. However, excessive heat will be a problem

- They are designed primarily for over-the-road duty cycles

- Light load, high engine speed, long periods of idle have challenges

- Extreme cold ambient temperatures
DOC Face Plugging

- Plugging happens when the front face of the DOC or DPF is obstructed by un-burnt fuel
- Duty cycles with not enough engine speed and load for the exhaust heat to oxidize
- Causes increase in aftertreatment pressure

Clear

Plugged
Duty Cycle Variations

- There is no one single indicator that constitutes a “poor” duty cycle. Trip data should be examined for the following items:
  - Idle time
  - Low rpm and light engine load operation
  - High rpm and light engine load operation
  - Number of parked regens
DOC Face Plugging - Prevention

• Don’t buy more HP than you need
  • Lower HP works the engine harder

• Vehicles need to be geared properly to avoid operating over 1800 rpm

• PTO systems should be optimized to avoid operating over 1800 rpm

• If possible, duty cycles should allow for some over the road operation
Work Stoppage

- Certain duty cycles cause ‘work stoppage’ to perform ‘parked’ regens

- Extended Idle Operation
  - Unburned fuel (hydrocarbons) can collect in the Aftertreatment System
  - High Idle – ‘controlled’ burn off is needed

- PTO Operation
  - High particulate duty cycle
  - Potential for active regeneration (dosing) to remove soot
Cold Weather Operation

- Extreme cold ambient temps can impact aftertreatment systems
  - Minimum exhaust temperature to dose fuel (regen issues)
  - DEF dosing is disabled below -20 deg C (-4 deg F)

- Location of ambient air temp sensors
  - Winter fronts can cause false readings

- False ambient air temp readings can cause problems for the DEF line and tank heaters and may lead to codes
Abuse

Driver Training is KEY

- Pre-trip inspections are more important than ever
- No longer can you ignore fault lamps
- Diesel in Fuel Tanks / DEF in DEF tank
Key Take Aways

• Proper maintenance is essential

• DO NOT ignore fault codes and lamps

• Get the latest software/hardware improvements

• Understand the systems operation and limitations
  – Impact from the duty cycle

• Driver Training is KEY

• Engine OEs are always working to improve our customers experience with product functionality and reliability
Bryan Lewis
ASE Master Truck Technician
Expensive Repair Bills

What is the Cause of the Expensive Repairs?

Is It Things We are Doing?
Expensive Repair Bills

• What is the Cause of the Expensive Repairs?
  – Fault Light On
  – Low Performance (Power, MPG)

• Is It Things we are doing?
  – Preventative Maintenance
  – Routine Repairs
Expensive Repair Bills

- Preventative Maintenance and Repair
  - Electrical Systems
  - Exhaust Systems
  - Cooling Systems
  - Air Systems
  - SCR Systems
Electrical Systems

Know your Equipment Electrical Systems

- Battery Condition
- Terminal/Connection Integrity
- Proper Voltage Drop
- Ground Connection Locations
Chassis Grounds

Starter Main Cables
Electrical Systems

Check Cable Connections Routinely

• Don’t Assume

• Looks are Deceiving
Galvanic Corrosion
Incorrect Electrical Values

- Inaccurate Sensor Readings
- Intermittent System Operations
- Engine Performance
- MPG
- Aftertreatment System
Exhaust Systems

Check Integrity Routinely

• No Leaks

• Maintain Support Hardware

• Use New Gaskets and Clamps
STAINLESS EXHAUST PIPE

• Small Exhaust Leak

• Loss of Exhaust Heat and Fuel Doser Vapor
Diesel Particulate Filter

- Can’t Oxidize Soot
- Fails Regeneration
- DPF Face Plugging
Cooling Systems

Test Coolant & Monitor Usage

System Must Maintain Pressure

Proper Engine Operating Temperature
Cooling Systems

• Monitor Coolant Usage
  • Identify the Coolant Leak
  • Use Oil Analysis for Early Detection
Cooling Systems

• Monitor Coolant Protection Levels
  
  • Freeze Point  50/50
  
  • Boiling Point  50/50
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Cooling Systems

• System Must Maintain Pressure
  • Maintain Coolant System Boiling Point
  • Test Pressure Caps
• FILL CAP

• PRESSURE CAP
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EGR COOLER

- EGR Cooler Cracks
- EGR Cooler Internal Leaks
- DPF/DOC Failures
Cooling Systems

• Proper Engine Operating Temperature
  • Thermostats
  • Thermostat Seals
Thermostat

Thermostat Seal
Cooling Systems

• Refilling after Repairs
  • Utilize Manufacturers Guidelines
  • Don’t Refill too Fast
  • Vacuum / Pressure Fill
• Must Get All the Air Out of the System
Right Tools for the Job

• Coolant Vacuum Kit

• GET the AIR OUT of the COOLING SYSTEM!
AIR Systems

Air Tank Inspection

Air Dryer Maintenance

Air Compressor Operation
AIR Systems

Air Tank Inspection

Do you have Moisture in the air systems?
AIR Systems

Air Dryer Maintenance

Coalescing Filters?
AIR Systems

Air Compressor Operation

25- 30% Duty Cycle
SCR Systems

System Type

Diesel Exhaust Fluid

System Maintenance

What Type of Components?
SCR Systems

Diesel Exhaust Fluid

Testing the DEF

Contamination and Quality
OIL TEST PAPER

For the Determination of Oil in Water

Qty: 100
Dimensions: 20 x 70 mm
Lot: 3312
Refractometer
SCR Systems

System Maintenance

Component Maintenance Intervals

Filters

Accumulator Charge
Expensive Repair Bills

• Know your Vehicle Systems
  – What Type of System and Components
  – Where the Components are Located
Take Aways

- Change Our Maintenance Practices
  - Electrical Systems
  - Exhaust Systems
  - Cooling Systems
  - Air Systems
  - SCR Systems
THANK YOU

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Aftertreatment Systems: Proactive Approach to Protecting the Equipment

Q & A