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Destructive / Non-destructive Inspection and Failure Analysis of Diesel Particulate Filters and Catalytic Converters

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Diesel Emission Control

- Oxidation Catalysts:
 - Ceramic monolith.
 - Stainless steel.
- Diesel Particulate Filters:
 - Ceramic monolith.
 - Silicon carbide.



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Mining Applications

- Manufacturer field trials.
- 2002 Ontario Ministry of Labour survey:
 - 71% of devices are DOC-based.
- DEEP Research Activity:
 - Diesel particulate filter projects.
 - Maintenance practices.
- Regular purchasing and installation.

3

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Recognizing Device Failure

- Visual inspection at regular PM service:
 - Disassembly and cleaning as required.
- Engine backpressure increase over baseline.
 - Smoking exhaust.
 - Engine performance loss.
- Emissions-based maintenance program.
 - Regularly quantify device performance.

4

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DOC Failure Modes

- Diesel Oxidation Catalyst:
 - Clogging / masking of active sites (DPM).
 - Poisoning – fuel sulphur, metals.
 - Loss of washcoat and catalyst material.
 - Physical damage:
 - Melting of ceramic.
 - Cracking (impact / thermal).
 - Separation of metal foils – vibration.

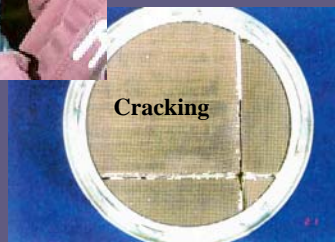
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Identifying DOC Failures

- Visual Inspection:



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Corrective Actions

- Clogging:
 - Regular cleaning procedure.
 - Repair engine faults.
- Poisoning:
 - Remove poison – Lower fuel sulphur.
 - DOC will usually recover – test.
- Physical damage:
 - Review application and installation.
 - Advise correct handling / cleaning.

7

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DPF Failure Modes (1)

- Operational / Application:
 - Clogging DPM – insufficient regeneration.
 - Clogging ash – overdosing additive.
 - Water ingress – vehicle cleaning.
 - Oil ingress – turbocharger seal failure.
 - Melting – uncontrolled regeneration.

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Visual Identification (1)



9

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Breakthrough of DPM



Test for suspected
breakthrough with
compressed air in
normal flow direction.



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DPF Failure Modes (2)

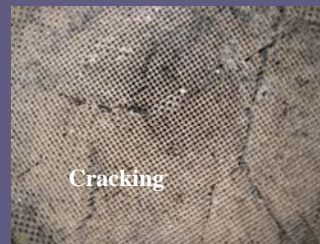
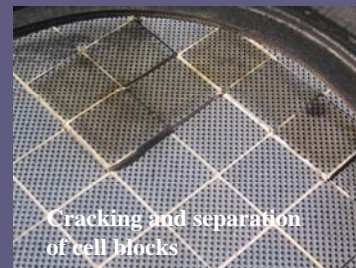
- Physical Damage:
 - Surface damage:
 - Impact abrasion – mishandling.
 - Substrate contact with can or retaining rings – vibration / deterioration of mat.
 - Melting – uncontrolled regeneration.
 - Cracking – vibration / impact / thermal stress (regeneration).

11

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Visual Identification (2)



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Destructive Inspection

- Visual inspection can be misleading to the failure mode and root cause.
- Several failures can have the same outward appearance.
- For critical applications, further examination of the failure may be required.
- Analysis can lead to changes in DPF application or corrective actions.

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Destructive Inspection

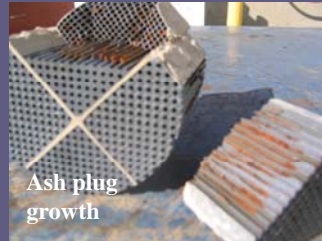


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Destructive Inspection

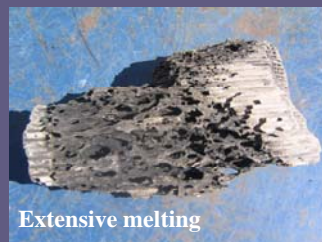
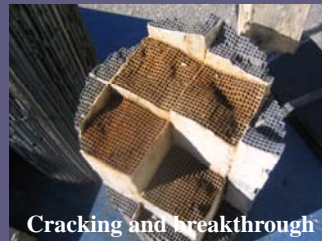


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Destructive Inspection



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Non-destructive Inspection

- Visual – Cheap, requires skilled operator to evaluate and analyze. Cause not known.
- Boroscope – Can identify if DPF failure is cracking or melting and thus provide insight into possible cause. Labour intensive, slow to map extent of damage.
- X-ray photography - Quick location and extent of melt area, separation or cracking.

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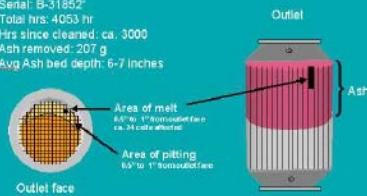
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Boroscope Analysis

Boroscope Analysis of Cattraps

Top filter in manifold:
 Model: CT 23
 Serial: B-31852
 Total hrs: 4063 hr
 Hrs since cleaned: ca. 3000
 Ash removed: 207 g
 Avg Ash bed depth: 6-7 inches



- Identify melted area.
- Cracking
- Must go from “clean” side!
- Extent of ash buildup.

Sample Boroscope Video


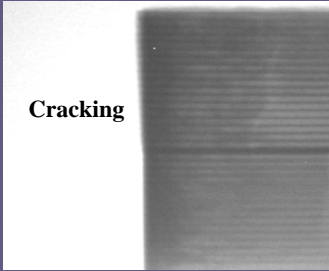
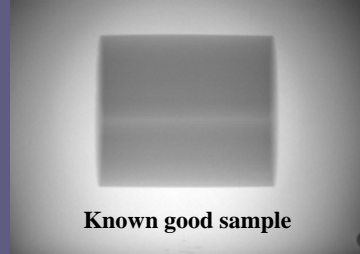
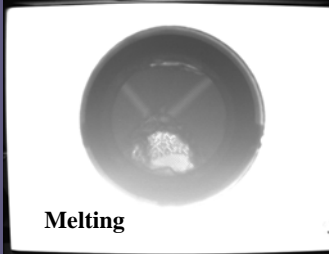


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X-ray Inspection

 <p style="text-align: center;">Melting</p>	 <p style="text-align: center;">Cracking</p>
 <p style="text-align: center;">Known good sample</p>	 <p style="text-align: center;">Melting</p>

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Conclusions

- A variety of inspection methods are available for diesel particulate filters and catalysts at increasing levels of complexity and cost.
- Visual inspection alone cannot always clearly identify the cause of failure.
- The criticality of the vehicle application will determine the level of analysis required.

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- CANMET-MMSL Diesel Laboratory
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- McGinn Integration

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