

LUBRIZOL
Engine Control Systems



**Passive and Actively Regenerated
Particulate Filter Systems for Mining
Applications**

MDEC 2002 Kevin Brown

The Lubrizol Corporation
(www.lubrizol.com)

Worldwide facilities in over
100 countries on 6
continents

4,000 employees

**Engine Control Systems
(ECS est. 1980) is one of the
“systems” divisions**

(see the ECS On-line Catalogue at
www.lubrizol.com/enginecontrol/)



The Lubrizol Corporation

- 41 subsidiaries and branches
- 5 affiliates
- 29 manufacturing plants
- 51 sales and technical offices
- 3 technical centers

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ECS Diesel Particulate Filter Product Line for Mining Applications

- **Unikat Combifilter™**
 - Types V, K, and S
- **Cattrap™**
 - Base Metal Catalyst
- **Combiclean™ DPF Cleaning Station**
- **Backpressure Alarm Kit**
- optional DOC's for DPF's



New ECS DPF Design Features

- **Computational Fluid Dynamic [CFD] was used to optimize flow distribution.**
- **Modular design concept**
- **Insulated filter skin**
- **All Stainless steel including flanges**



ECS Design Concept

Modular design allows;

- Installation versatility
- Servicing of filter
- Component interchange between product lines
- Flexible manufacturing



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Unikat Combifilter™

Actively Regenerated DPF for Captive Fleet Use & Stationary Engines

- filter system which stores soot
- regeneration is done daily by connection to regeneration station
- thousands in Europe, commercial for approx. 20 years
- VERT approved- over 25,000 hours in-use – no NO₂ emissions
- can be used to extend the use of passive filter (Purifilter or Cattrap) to colder duty cycles



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Combifilter: K Model Family



- 8 hour regeneration
- Air supplied from panel

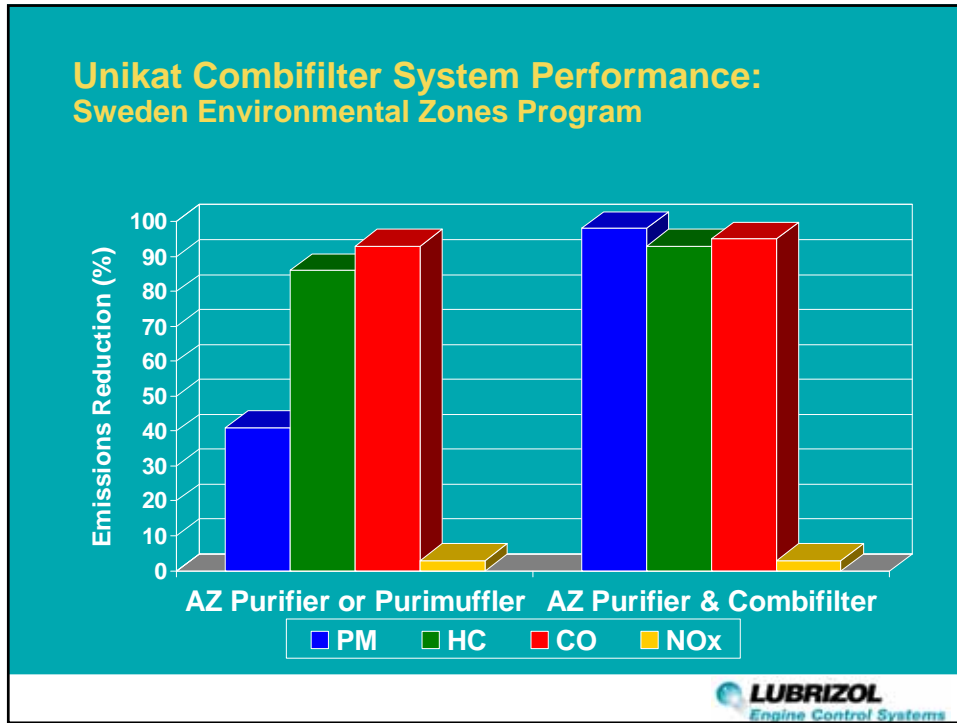


Combifilter: S Model Family



- <60 min. regeneration
- Closed loop element control
- Optional blower or use available compressed air





Combifilter Test Programs - Stobie Mine

Canadian DEEP Trials:
Stobie Mine
Kubota Tractor
Kubota F2803 (2.7L NA)
Combifilter S5

- regenerated weekly

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Combifilter Test Programs



DEEP Trials:
Stobie Mine

Wagner ST-8 Loader
DDC Series 60
with Combifilter
Model 2xS18

- regenerated daily



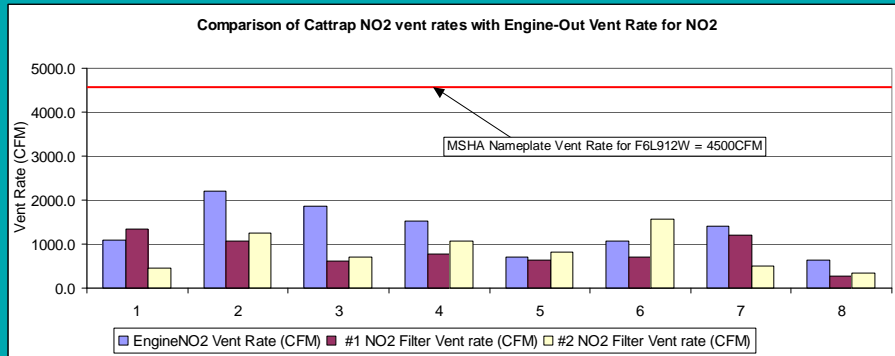
Catrap™ DPF

- Base Metal Catalyst
- Self-regeneration with exhaust temperatures of 380-420 ° C for 25% of operation time.
- Fuel Sulfur tolerant
- No NO₂ increase
- used in mining, heavy industrial and other occupation health applications since 1991



US MSHA Tests of Cattrap

- 88% PM reduction over ISO 8 Mode on Deutz F6L912W
- Only catalyzed DPF tested found not to increase NO₂



Cattrap™ Test Programs - Brunswick Mine



Canadian DEEP Trials Wagner ST8-B Loader; DDC S60 325 hp

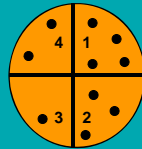
- Cattrap: 4053 hrs total accumulation
 - >25% above 380 °C
 - 21.9% time at idle (887 hrs)
 - One mine cave-in
- CANMET testing showed 83-85% filtration efficiency after 4053 hrs



Non-destructive Filter Inspection and Evaluation

- Visual Inspection
- Video Boroscope
- Mass

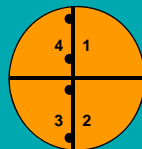
Outlet face



Video map points

- Looking for areas of melt, cracks, pitting

Inlet face



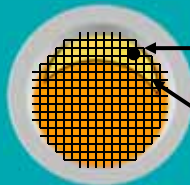
Video map points

- Looking for depth of ash accumulation



Boroscope Analysis of Cattraps

Top filter in manifold:
 Model: CT 23
 Serial: B-31852*
 Total hrs: 4053 hr
 Hrs since cleaned: ca. 3000
 Ash removed: 207 g
 Avg Ash bed depth: 6-7 inches

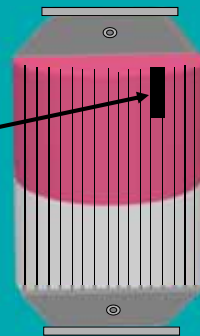


Outlet face

Area of melt
 0.5" to 1" from outlet face
 ca. 24 cells affected

Area of pitting
 0.5" to 1" from outlet face

Outlet



Ash



Env. Canada Tests of Aged Cattraps (>4000 hrs) Particulate Emissions (g/bhp-hr) DDC Series 50 (275 hp)

Mode	Baseline	Cattrap B31854	Cattrap B31852*
1	0.04	0.00	0.01
2	0.04	0.01	0.01
3	0.04	0.01	0.01
4	0.25	0.06	0.08
5	0.03	0.02	0.02
6	0.02	0.01	0.00
7	0.02	0.01	0.00
8	0.23	0.06	0.07

* Filter which showed some visual deterioration



Environment Canada Emissions Comparisons 1996 Series 50 275 hp

	Test	PM (g/hp-hr)
Baseline	FTP Transient	0.07
Baseline	FTP 8-Mode	0.043
Pt Trap Avg w'ULSD (<10 hrs) 17L filter volume	FTP Transient	0.0065*
Cattrap Avg (new) 23L filter volume	FTP 8-Mode	0.009
Cattrap Avg (>4000 hrs) 23L filter volume	FTP 8-Mode	0.010

Note: Avg represent 3 repeats



Summary for Brunswick Cattraps

- Ash / residuals filled half the filter volume even after CANMET flushed with compressed air
 - Compressed air alone does not effectively clean filters;
 - Proper method is compressed air, heat treatment, compressed air cycle
 - Filters should be cleaned every 1000 hrs
- Extended ash / residual build up leads to interaction with filter media
 - Higher rate of media deterioration
 - Pitting and areas of thermal melt deterioration
- Steady state testing of filters may lead to reductions in observed % efficiency on mass basis due to exaggerated temperature / flow conditions or uncertainties in post filter emissions levels



Cattrap Test Programs - Carlin East Mine

- AC Wagner MT426 truck
- DDC Series 60; 335 hp
- 10% to 22% of time >380 °C
- >20% of time at idle
- 3260 hours to date on Cattraps
- service filters every PM
- blow our ash every other PM
- use Combifilter elements to service the filters
- outlet hats contain optional oxidation catalysts



CombiClean™ DPF Cleaning Station



- Provide safe & healthy way to clean DPF products.
- Effective way to remove ash and improve DPF durability
- Offers improved flexibility and reduced cost



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How to extend Cattraps to colder duty cycles ?

- Increase cleaning frequency from 1000 hrs to 500 hrs or 250 hrs
 - Incorporate Cattrap into on-board Combifilter system and use periodic electrical regeneration (ie. Weekly)

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SUMMARY

- Cattrap, Combifilter, DPF Cleaning Station are used as a system to reduce ambient PM levels in mines
 - no increase in NO₂ emissions
- optional DOC for additional SOF/gaseous emissions reductions
- Preventative Maintenance of DPF's extends filter life and ensures performance
 - LZ-ECS is committed to the support of mining