DPF Study at INCO's Stobie Mine – Introduction
Joe Stachulak, INCO

Health Effect and Regulations

- The suspected adverse health effect of diesel emissions have received increasing attention over the last 'several decades'. NIOSH - NCI, 10 mines study should be an important contribution to the epidemiological understanding for everyone.
- ACGIH progressively reduced its TLV for diesel exhaust from 0.15 to 0.05 then 0.02 mg/m3 over the last 6 years
- The current Ontario standard is 1.5 mg/m3 measured as RCD
- Typical average level of RCD at Inco ranges from 0.1 – 0.5 mg/m3
- Inco trap field test has the nominal DPM emission target of 0.05 mg/m3, EC

The Challenge

- The changes in TLV amount to at least one order of magnitude reduction in DPM
- It would be technically an impossible task to achieve this reduction, by increasing the ventilation rate
- The only effective, practical and commercially available DPM reduction strategy for EC, appears to be diesel particulate filter system

Diesel Particulate Filter Technology

- Particulate trap filters have been available since the mid – 80's,
- However the experience in mining has been mixed due to problems with
    - Regeneration
    - Maintenance, and
    - Reliability issues

(South-Western German Salt mine (Sudwestdeutsche Salzwerke AG), has been using diesel particulate filter traps since early 90's, (1), (2) - with sulfur content of fuel < 0.05 %, and also Saskatchewan Potash mine, in Canada (3), (4) for the last several years apparently without significant operational or maintenance problems)

Trap Selection Process/ Methodology

- 4 days duration technical workshop program was launched at Inco (5), (6) in Nov. 2000, at which sessions (presentations, discussions, etc.) were held with
    - Various European and North American trap, engine manufacturers, and fuel additive companies
    - DEEP technical members, NIOSH scientists
    - Mine personnel, USWA members
    - DEEP primary technical consultant – A. Mayer, TTM, Switzerland
- Input and important discussions were held with 3 offshore underground mining operations in Sweden and Germany, as well a visit to two underground mine sites in Germany to acquire 'first hand' knowledge of trap's system, and associated operational challenges.

Note: (1), (2), (3), (4), (5), (6), refer to references

Trap Selection Criteria

- Greater than 90% reduction (filtration rate) in elemental carbon – mass
- Effective filter lifetime (> 2000 hrs until ash removal and > 6000 hrs until filter replacement)
- Filter system must be reliable, robust and easy to maintain
- No increase of any other toxic emissions, (or secondary emissions)
- No increase in fire risk
- VERT certified, or in process of approval

Trap's Selected for Inco Project (Nov. 2000)

1. DDEC Scoop – Oberland Mangold *Germany backup – ECS
2. Deutz Scoop – JMC - Germany - Engelhard
3. DDEC Scoop - Engelhard – UK - USA - ECS
4. Kubota Tractor – ECS/3M - Canada - Engelhard
5. Deutz Truck Deutz - Germany ** - Engelhard
6. Kubota Tructor – Greentop – Germany*** - JMC

Note: 1 – 4 trap system installed, June/July, 2001

* Oberland, filter de-installed in July, and Oberland discontinued participation in the project in Sept.

** Deutz elected not to participate in DEEP program, April

*** Greentop – some technical and logistics' issues – not ready, April

Issues Encountered and Lessons Learned

- The project was adversely affected by not being able to get

  -- full in kind contribution from the suppliers as originally expected
  -- commitment to the project's terms and conditions
  -- agreed trap delivery schedule

- However equipment and installation in kind contribution by ECS, Engelhard, and Oberland – Mangold, plus an equipment in kind contribution by JMC are greatly appreciated

- European experience and expertice was garnered through

  -- a visit by Inco personnel to Oberland in Germany and JMC one week installation and training, at mine site (reimbursed by Inco)

  -- participation in recent ETH Nanoparticle Conference

Where is the Inco project going?

- Inco realizes that the project has been significantly delayed from its original schedule, but we are committed to its completion, and will test the best system, and provide scientifically sound information to protect our employees

- Inco may have to buy 2 trap systems, namely: for light duty Kubota vehicle, (replacement for Greentop system), and a replacement for Oberland – Mangold on DDEC Scoop

- Truck is presently not being used at Stobie mine, and it may be a missing component in the project

Conclusion

- To date, we are fairly impressed with the various diesel filter trap systems that we are testing, even though it is too early to draw conclusions

- Let us remember, that the most important aspect is the long term robustness of the system, reasonable operating maintenance, cost, and operational acceptance

- I would like to expressed my thanks to NIOSH scientists, Drs. G. Schnakenberg and A. Bugarski, and D. Wilson, President of RBR-Ecom, USA, for their enthusiastic, in kind participation in trap system efficiency measurements

- Last, but not least my gratitude is also extended to the members of Stobie team, DEEP technical committee, and management board

Technical Assessment and Justification of Selected Trap System for Inco Project (Nov. 2000)

1 DDEC Scoop – Oberland Mangold

Positive aspects: - VERT approved, - fuel additive needed is US-EPA approved, - Oberland is confident in its ability to work, - On –board dosing system, - Toxicity of additive is equal to diesel fuel

Areas of concern: It was agreed that the practical positive aspects of this choice overrode any negative proposals.

2 Deutz Scoop – JMC

Positive aspects: - VERT approved. – Widely used in Europe, - Option of both electric regeneration and fuel additive systems, - Automatic on-board dosing

Areas of concern: - Not used in the mining environment to-date, Both on board electric regeneration and fuel additive using computerized dosing may add to the complexity of the system

3 DDEC Scoop – Engelhard

Positive aspects: - - Convenient modular system for maintenance, - One piece self-regenerating system that is quite simple in design, - Tested to perform well in underground mines, - MSHA agrees with manufacture efficiency data.

Areas of concern: -- Passive system, thus no integral backup system, may be a concern, - VERT suitability test not performed or not completed yet

4 Kubota Tractor – ECS/3M Omega

Positive aspects: - VERT approved filter, - On-board electric regeneration

Areas of concern: - The system uses electrical heating coils/elements, which may result in some additional maintenance work

5 Deutz Truck – Deutz

Positive aspects: - Second level VERT certified, - Manufactured by the parent company of the engine, - No heat loss issues, - Proven and viable technology, - Used in German salt mine since early 90's

Areas of concern: - Complex electronic control module, - Probable maintenance, and breakdown issues, - Higher initial capital

6 Kubota Tractor - Greentop

Positive Aspects: -- On-board regeneration using existing alternator and battery, - Needs no fuel additives but the option is available

Areas of concern: - Not yet VERT certified,

References:

1, Ruther, W.,1996 , "Experience in Waste Gas Treatment in Salt Mining". European Commission, Doc.No 5810/96 EN, Luxembourg, Sept. 16, 1996

2,Stachulak, J., 1998, "Field Trip Report – Sept. 23, 24, 1998 – Germany. DEEP, Vol. 3, Jan. 1999.

3, Postnikoff, Jim,.A., 1999, " Diesel particulate matter minimization at Agrium". MDEC 99, Nov 3 – 4, Toronto, pages 1.1 – 1.12.

4, Stachulak, J., 2002, "Private communication with Agrium Potash Operation.

5, Nelson, R., 2000, "Diesel particulate trap project minutes – The Inco/Stobie mine diesel particulate trap project. Request for proposals – trap, manufacturers" day 1 – 4. Inco, Nov. 13 – 16, 2000, pages 1-11; 1-16; 1-7; 1-11. (Distributed to DEEP technical committee and management board)

6, Mayer, A., 2000, "Datalogging review, trap selection and in mine trap test planning". DEEP/Inco in mine trap test at Stobie-Mine/Sudbury – Meeting Nov. 13. 2000.

MDEC 2001

OPERATION OF DIESEL PARTICULATE TRAP VEHICLES/STOBIE MINE.

Greg Nault, INCO

SSF-132.1

About 2180 Kubota With E.C.S./3M Diesel Particulate Filter System.

2180 Kubota is equipped with an E.C.S. Omega Diesel Particulate Filter system. The stainless housing holds the series of 3M Nextil Fiber filters

Build up of soot and ash in the filter system may present backpressure limitations on the engine of the unit.

The diesel particulates must be removed on a scheduled bases to ensure proper functioning of the Kubota engine. The unit must be electrically regenerated burning the existing soot in the ceramic filters.

The system consists of a particulate filter and regeneration system.

During normal operations a single green led will be illuminated on the dash display unit.

A red light indicates a system failure or plugged filters.

25%
50%
75%
100%

Particulate build-up

As particulates are trapped in the filters a series of yellow lights will indicate build-up levels.

Should the system plug or fail a second alarm located on the left dash will illuminate red.

To regenerate the trap system:

1. 

The vehicle must be tagged using a white status tag.

2. 

Wheel chocks must be set in place.

3. 

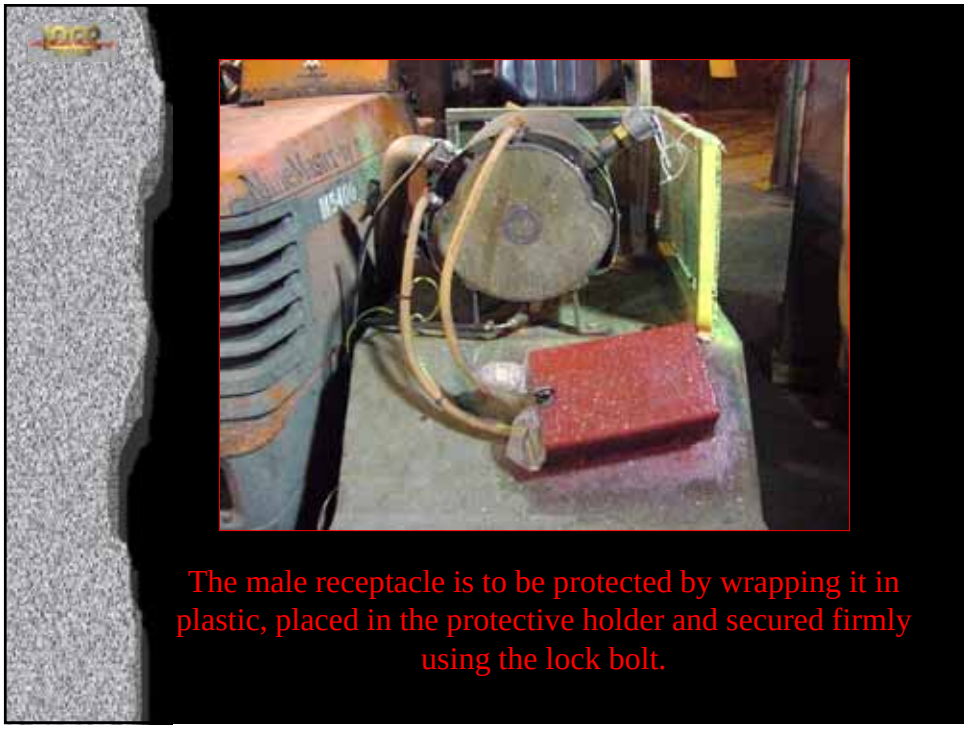
Turn the ignition to the 'OFF' position and shut off the master switch.

To regenerate the trap system:

9. 

Turn the regeneration station door switch to 'ON' – turn the power supply to 'ON' and connect the power harness and air hose.

CARE MUST BE TAKEN WHEN JOINING THE MALE AND FEMALE POWER CONNECTORS TO ENSURE THEY ARE PLACED TOGETHER PROPERLY BEFORE ASSERTING PRESSURE.



The male receptacle is to be protected by wrapping it in plastic, placed in the protective holder and secured firmly using the lock bolt.

7.

The green ‘power’ light on the front panel will be illuminated and the green LED on the dash display will be flashing.

8.

The regeneration process will take 9-10 minutes to complete.

Press the button in the center of the dash display to start the regeneration cycle.

The amber dash display will visually count down the regeneration process. The red and green lights will flash when the process is complete.

The dash display will now show only a green LED and the vehicle can be put back into operation.

SSF-132.2

About #445 Scooptram With Oberland/Mangold Particulate Filter System and Additive Dosing System.

#445 Scooptram at Stobie Mine is equipped with an Overland/Mangold Catalytic Exhaust Diesel particulate Filter. The stainless housing holds a series of eight ceramic micro fiber filters.

Build up of soot and ash in the filter system may present backpressure limitations on the engine of the unit.

The diesel particulates are removed during normal operations of the unit and the filters are regenerated

The filter unit is installed on the exhaust system and protected by a metal grate covering.

The key to successful regeneration of the filters is to maintain and reach required operating temperatures, therefore, the exhaust has been insulated to assist in maintaining required temperatures.

The filter unit is equipped with sensors to control both regeneration and monitor backpressures on the engine of the scoop.

The dosing additive system installed on the unit consists of the following parts.

Fuel Additive Sensor Unit.

Fuel electronic control sensor.

Fuel additive tank.

Electric fuel additive pump.

Additive filter.

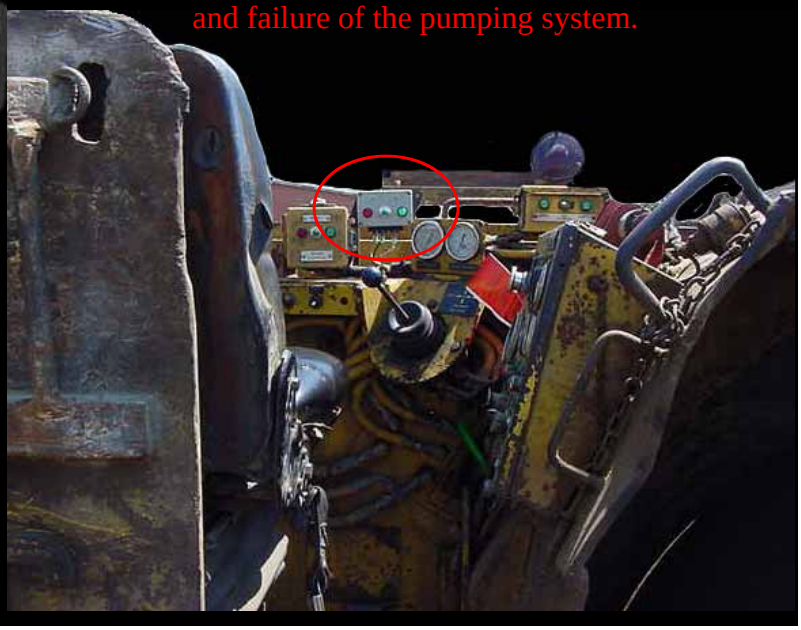
Diesel fuel tank.

Fuel hoses connecting the additive tank to the diesel fuel tank of the unit.

A visual inspection of the system is required as part of the initial check of the unit before operating.

Fuel additive will be added to the additive tank by the Maintenance department during regular monthly inspections of the unit.

Two new signals lights have been installed on the dash of #445 to signal both power to the electronic pump and failure of the pumping system.



The green light on the fuel additive signal display will illuminate immediately upon turning the key. This will ensure that there is power to the additive pump. The red light on the fuel additive signal display will illuminate only in the event of a fuel pump failure.

Upon start-up, immediately after refueling, the pressure sensor will detect the increase in diesel fuel, in-turn starting the fuel pump.

The green light will remain flashing until the correct amount of dosing additive fuel is mixed in the diesel tank SHOULD A RED LIGHT SIGNAL THE OPERATOR MUST TAKE THE UNIT IMMEDIATELY TO THE MAINTENANCE DEPARTMENT FOR INSPECTION.

Should the system not regenerate resulting in excessive back pressure, sensors are wired into the engine E.C.M. system and buttons located on the dash of the unit.

It may not be directly attributed to a plugged filter system should these indicator lights signal. It may be attributed to other engine functions.

STANDARD PROCEDURES ARE TO BE FOLLOWED.

SSF-132.3

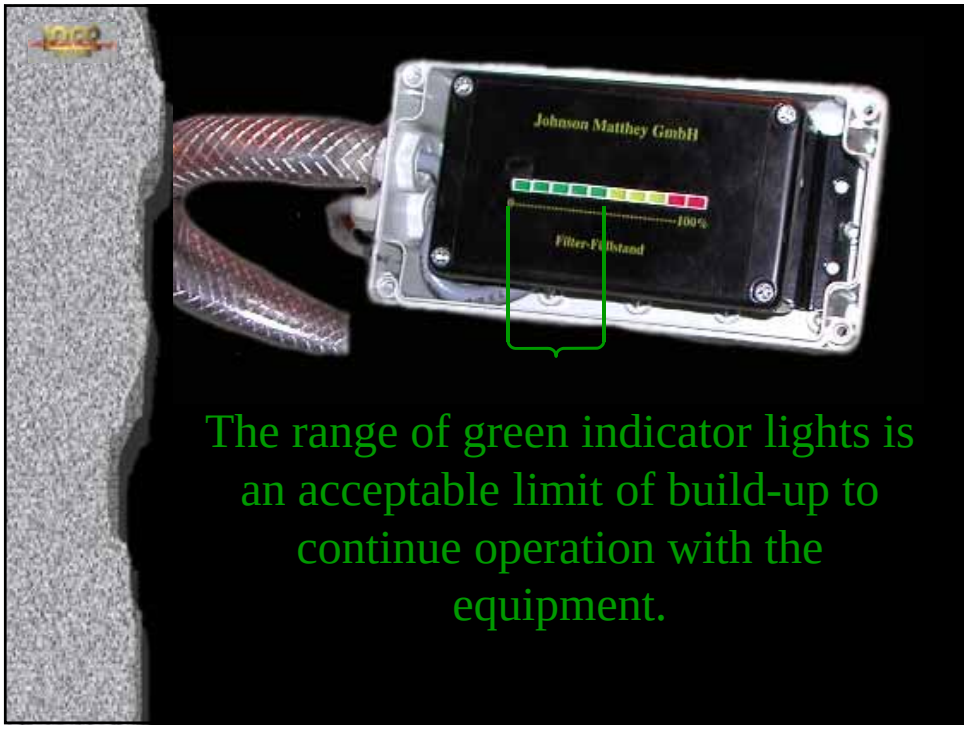
About 820 Scoop with Johnson Matthey Particulate Filter System.

#820 Scooptram at Stobie Mine is equipped with two integrated Johnson Matthey Catalytic Exhaust Diesel Particulate Filters. Each stainless housing holds a ceramic monolith filter.

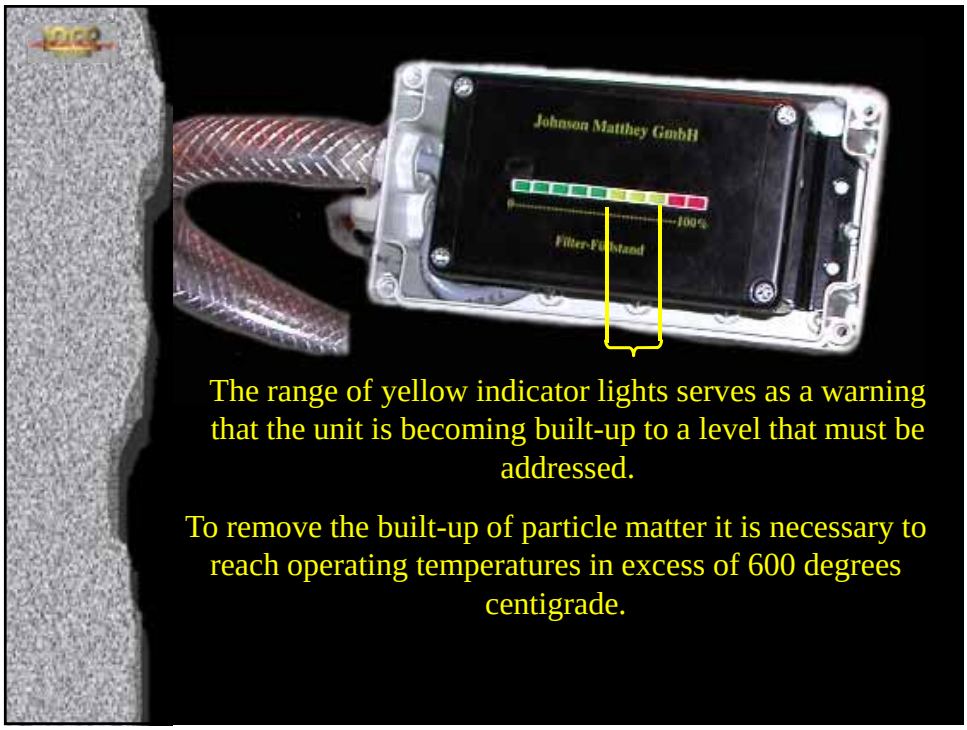
Both units are independent sharing only monitoring gauges and electrical input to the regeneration heater systems.

A monitoring gauge is installed on the dash of 820 allowing the operator to view the possible buildup of sediment in the filter unit.

A build-up of particulates will result in the lights on the monitor gradually signaling from left to right. The greater the accumulation the more lights will be displayed.



The range of green indicator lights is an acceptable limit of build-up to continue operation with the equipment.



The range of yellow indicator lights serves as a warning that the unit is becoming built-up to a level that must be addressed.

To remove the built-up of particle matter it is necessary to reach operating temperatures in excess of 600 degrees centigrade.

To regenerate the filter the operator must put the vehicle in park mode and rev the engines to increase the operating temperatures.

If regeneration is successfully taking place the operator will see the illuminated lights going out from right to left. When only the green lights remain illuminated the equipment may be used again.

Should the red lights illuminate, the machine must be driven to the garage immediately for service.

The diesel particulates should be removed during normal operations of the unit.

In addition #820 scoop has also been equipped with a fuel additive dosing system, as well as, a second regeneration system that allows for electrical regeneration of the filter units.

The scoop is equipped with a stainless tank that contains fuel additives. Additives are to be added to the equipment only during regular maintenance.

In the event that electrical regeneration of the filter is necessary the unit is equipped with a heater and compressor unit capable of burning the soot at a temperature exceeding six hundred degrees Celsius.

The heater unit is located at the base of the filter system.

To regenerate the trap system:

1. 

THE VEHICLE MUST BE TAGGED USING A WHITE STATUS TAG.

2. 

WHEEL CHOCKS MUST BE SET FIRMLY IN PLACE.

3. 

TURN THE MACHINE ‘OFF’ USING BOTH THE KEY AND THE MASTER SWITCH.

VISUALLY INSPECT ALL CABLE CONNECTIONS AND ELECTRICAL EQUIPMENT PRIOR TO BEGINNING THE REGENERATION PROCEDURE.

To regenerate the trap system:

4.

PLUG THE FEMALE REGENERATION CORD FROM THE STATION INTO THE MALE RECEPTACLE MOUNTED ON THE MACHINE.

To regenerate the trap system:

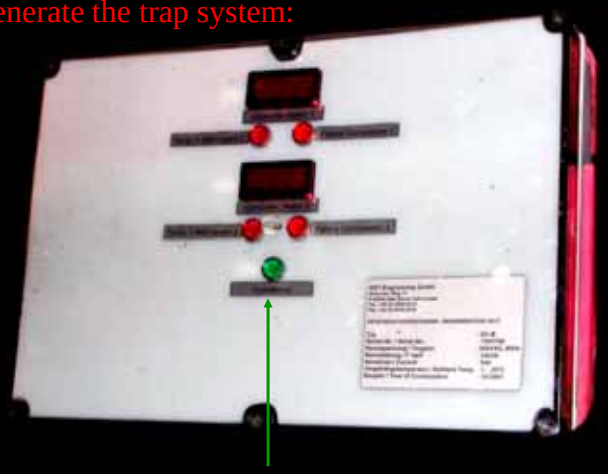
5.

When turning on or off a square ‘D,’ always stand to the right of the electrical box. With your left hand turn the switch to the required position. NEVER LOOK TOWARD THE BOX – always turn your head away from the box – to the right, when switching.

PLUG THE FEMALE REGENERATION CORD FROM THE STATION INTO THE MALE RECEPTACLE MOUNTED ON THE MACHINE.

To regenerate the trap system:

6.



When power is switched on the green indicator light will illuminate. The light will go out when the regeneration of the trap filter is complete.

REGENERATION MAY TAKE A MINIMUM OF TWO HOURS

To disconnect the unit after regeneration has been completed:

SHUT OFF THE MAIN POWER SUPPLY USING PROPER SHUT DOWN PROCEDURES.

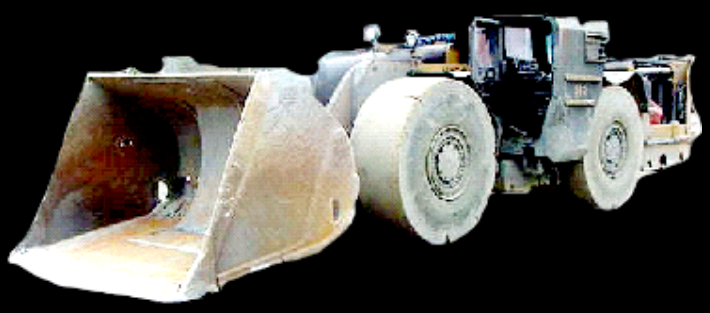
DISCONNECT THE POWER PLUG FROM THE SCOOP AND STORE NEATLY ON THE WALL AT THE REGENERATION BOX

THE STATUS TAG MAY NOW BE REMOVED.

USE CAUTION NEAR ANY COMPONENTS OF THE PARTICULATE TRAP FILTER UNIT. THE SYSTEM MAY BE ABOVE FIFTY DEGREES CELSIUS.

SSF-132.4

About #362 Scoop with Englehart DPX Particulate Filter System.



The Englehart Trap System consists of a filter that passively regenerates itself. No additive dozing or electrically assisted regeneration techniques are required to clear the filters of soot build-up. Normal operations and operating temperatures are all that should be required to keep the filters regenerated and free of soot build up.

INITIAL INSPECTION.

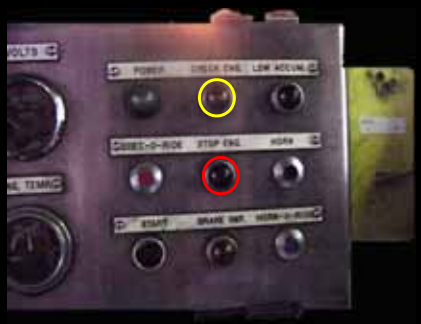
Care must be taken not to damage any part of the particulate trap unit. Should any damage occur to any part of the trap system report it to your supervisor and record it on your Operator's pre-operation slip.

CAUTION

Although much of the trap system is insulated, the operating temperatures of the equipment pose a significant burn hazard.

ALWAYS TAKE EXTRA CARE WHEN WORKING NEAR ANY EXPOSED AREAS OF THE EQUIPMENT.

Should the filters not regenerate and plugging results in backpressure, sensors are wired into the engine E.C.M. system and buttons located on the dash of the unit.



It may not be directly attributed to a plugged filter system should these indicator lights signal. It may be attributed to other engine functions.

STANDARD PROCEDURES ARE TO BE FOLLOWED.

A second set of indicator lights is mounted in the engine compartment and are directly tied into the exhaust system at the inlet to the DPF.

This system also consists of a yellow warning light and a orange warning light.

Turning on the ignition initially will illuminate both lights for 2 seconds.If the back pressure builds up to a preset level for 15 seconds a yellow light will illuminate. If the pressure remains above preset for more than 60 seconds the yellow and orange lights will illuminate. If the pressure drops below preset for 5 seconds the lights will go out.

All indications of both yellow and orange lights should be recorded on your Operator's pre-operation slip.

D.E.E.P.
FILTER TRAP & DATA LOGGER
OPERATIONS CHECKLIST

- Inspect Data Logger Case
- Inspect All Wires and Connections

Open Case Door To Take Readings
(light should be flashing)
NOTE: Engine must be idling for all readings
Press 'MODE' Button and Record Readings

Red	Green	Start of Shift | End of Shift
☐	☐	Pressure _____
☐	☐	Temp. 1 _____
☐	☐	Temp. 2 _____
☐	☐	R.P.M. _____

DO NOT PRESS THE SET BUTTON
REPORT TO MAINTENANCE FOR REPAIRS:

- If no power to unit
- Lights are out
- Red alarm is displayed

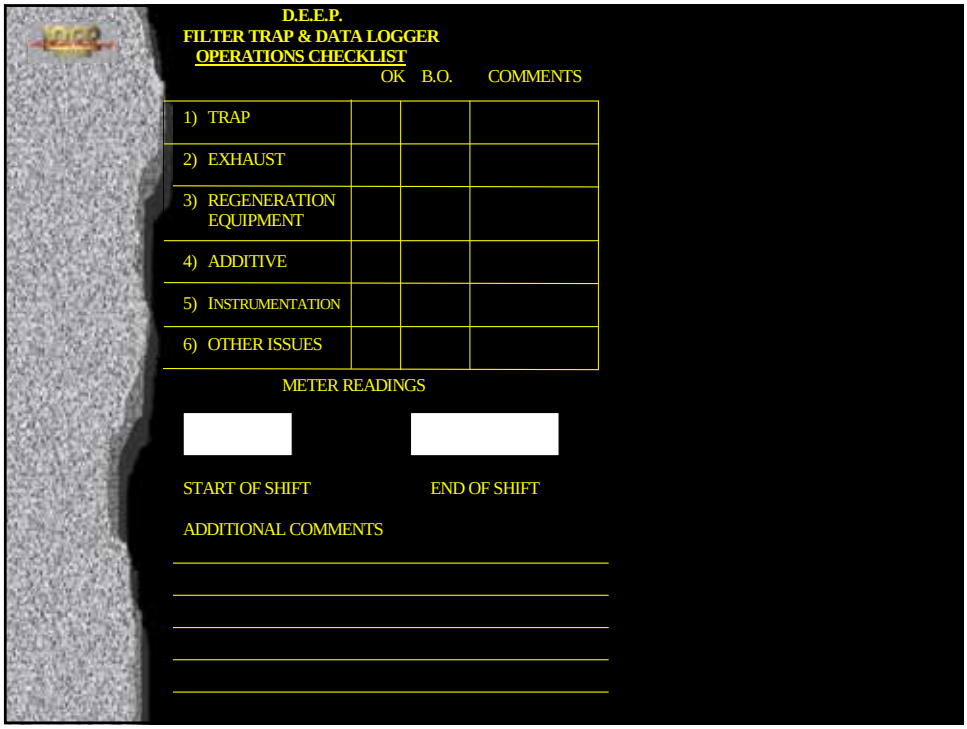
Date _____
Shift _____
Vehicle Number _____
Vehicle Type _____
Data Logger # _____
Operator's Name _____
Operator's Serial # _____
Fuel Reading _____
Oil Reading _____
Oil Leak YES ☐ NO ☐

Out of Use Operations ☐

Out of Use Maintenance ☐

rs of Use +4 hrs. Heavy 2-4 hrs. Mod 0-2 hrs. Light

SEE OTHER SIDE



D.E.E.P.
FILTER TRAP & DATA LOGGER
OPERATIONS CHECKLIST

	OK	B.O.	COMMENTS
1) TRAP			
2) EXHAUST			
3) REGENERATION EQUIPMENT			
4) ADDITIVE			
5) INSTRUMENTATION			
6) OTHER ISSUES			

METER READINGS

START OF SHIFT

END OF SHIFT

ADDITIONAL COMMENTS