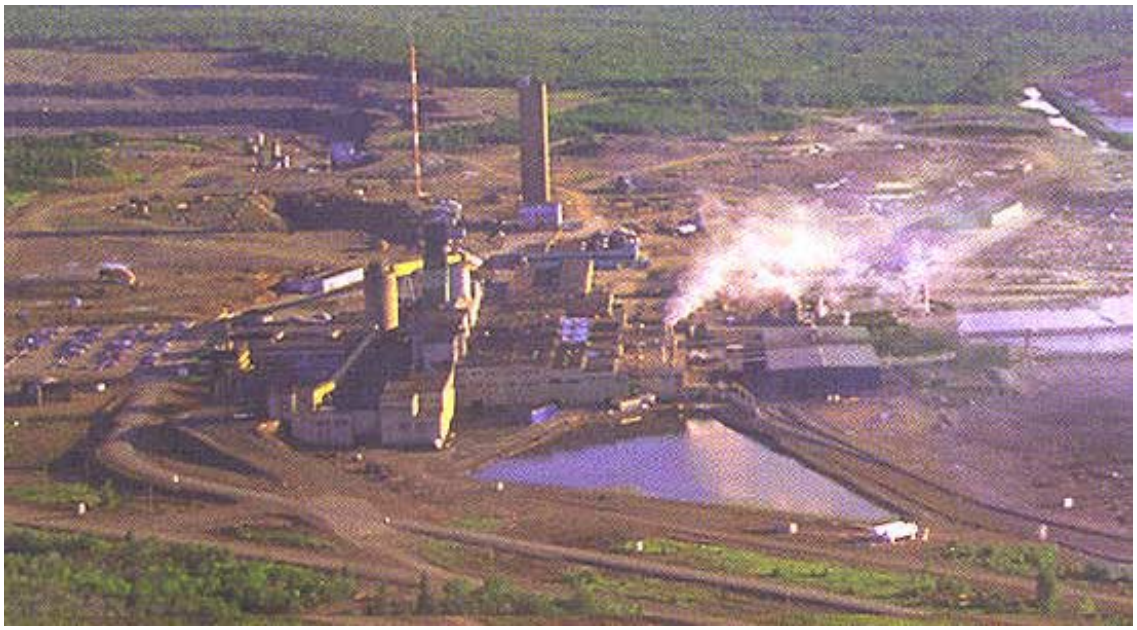
noranda



The Noranda – Brunswick Mine Diesel Particulate Trap Project

Request For Proposals – Trap Manufacturers

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Introduction

The Diesel Emissions Evaluation Program (DEEP) has approved a project to investigate the effectiveness of new developments in particulate trap technologies. Recent studies such as the VERT program in Europe have shown that particulate emissions can be reduced with these trap technologies by as much as 98%. A project to investigate the use of particulate traps is currently underway at Noranda Inc. – Brunswick Mine in Bathurst, New Brunswick, Canada. The purpose is to demonstrate the efficiency and overall effectiveness of these new systems in an underground mining production environment.

Project Overview

The project has been planned for an on vehicle test period of 18 months. This would see the identification and selection of appropriate trap technologies to begin with, followed by the 18-month test period. Four heavy production vehicles will be equipped with the traps along with monitoring instrumentation. This will permit the evaluation of four distinct trap systems. The phases of the project are:

- Engine Datalogging – Trap Evaluation and Selection
- Trap Bench Testing and Installations
- 18 Month Evaluation With Continuous Monitoring
- Trap Removal and Bench Testing
- Analysis and Final Report

Engine datalogging is acquired with on board systems measuring exhaust backpressure and 2 channels for exhaust temperatures. The exhaust temperatures are monitored at two points, immediately after the turbocharger and just before the existing exhaust purifier. This data is gathered to help define the application and assist in identifying the best technology fit.

Once the four systems have been selected they will each be bench tested according to the protocol established during the VERT program. This will serve as a baseline measurement in determining trap performance, efficiency, and deterioration. A Detroit Diesel Series 60 lab engine identical to the engines on the vehicles will be available for the bench testing at CANMET, Bells Corners laboratories. Once the bench testing is complete the traps will be moved to the mine and installed by the project team on all four vehicles.

The systems will be monitored closely over the entire 18 month production run. The majority of the instrumentation, measurement, and maintenance of the systems will be done by personnel of the mine under supervision and training from the project team and trap, engine and vehicle manufacturer representatives. The actual measurement components will include:

- PNE Electronic Dataloggers with continuous measurement and alarm functions for exhaust backpressure and temperatures
- Undiluted Gas Analysis System (UGAS) in place at Brunswick Mine for mechanics to evaluate exhaust emissions as a maintenance tool every 250 hour scheduled PM at a minimum
- Detroit Diesel Diagnostic Link for interfacing and monitoring the datalogger alarms (temperature and backpressure) with the existing DDEC engine controls – also used as a maintenance tool at 250 hour scheduled PM at a minimum
- NanoMet (Matter) particulate analysis system for determining actual trap efficiency and characterization of particulates. Laboratory grade instrument that will be employed at 3 month intervals throughout the entire project by CANMET and project team members
- Operator exposure sampling (shift duration) using the NIOSH 5040 EC/OC method of DPM analysis. Sampling will be done at staggered intervals on operators of the four vehicles in the project,
- Isolated production zone studies at 2 stages of the project. This will determine the DPM contributions in ambient concentrations for each vehicle. An isolated zone will be used to evaluate each vehicle individually using the NIOSH 5040 EC/OC method of DPM analysis.
- Operator and mechanic logbooks will be kept for each of the four vehicles during the entire 18 month period.

At the end of the 18 month production test the trap systems will be removed and sent back for identical bench testing to compare against the baseline. Once bench testing is complete the traps will go back to the manufacturers for final autopsy and evaluation.

The final phase of the project will be to consolidate all of the data from the measurement components and provide an analysis on efficiency and effectiveness. The final report will summarize this analysis as well as serving as a "How To" guide in the selection and implementation of trap technology on underground mobile equipment.

The Project Team

The large scope of a project this size requires active participation from many groups. The success of the project will greatly be effected by the

ability of all groups to work together and share expertise in developing the best possible solution for the application.

Brunswick Mine – The most important players on the team are the actual staff at the mine. Vehicle operators, mechanics, ventilation department and management will all play key roles over the 18 month period in making sure the traps are monitored and maintained properly.

Trap Manufacturers – The manufacturers of the trap systems will be responsible for supplying the complete trap system as well as assisting in the installation on the vehicle and training at the mine. They will be required to assist in the implementation design and planning in advance along with other team members.

Engine Manufacturer – All four vehicles in the project are equipped with Detroit Diesel Series 60 engines. Detroit Diesel will be requested as a team member to assist in the implementation, interfacing and maintenance of the engines in combinations with the trap systems.

Vehicle Manufacturer – All four vehicles in the project are manufactured by Atlas Copco Wagner. As the vehicle supplier, Wagner will be requested to assist in the implementation design and actual installation of the traps on the vehicles. This will ensure the transfer of know how between team players and take a step toward implementing these systems at the factory in the manufacture of future vehicles.

CANMET – As the government agency in Canada that is responsible for setting standards in this area CANMET will be a key member on the project team. They will assist in the monitoring and analysis of DPM for the personal exposure monitoring as well as the isolated zone studies. The NanoMet instrument used for undiluted particulate analysis is the property of CANMET and will involve the sharing of both expertise and the actual hardware for this project.

Primary Technical Consultant – TTM The expertise of Mr. Andreas Mayer and his experience from managing the VERT program will be drawn upon to guide the project team in all phases of this project. In order to achieve similarly impressive results as the VERT program we will need to share some of that know how and put it to work in our project.

Project Leader - Noranda Technology Centre The organization and logistics for the project will be handled by Mr. Sean McGinn from NTC. This would include coordination of all phases, team tasks, budget, implementation, reporting, etc. As a representative for Noranda on the DEEP Technical Committee as well as working within Norandaà mining

operations in mobile maintenance research and support, he is well situated for managing the project.

The Vehicle Applications

There are four heavy production vehicles included in the study. Two of the vehicles are ST8-B scooptrams. These machines are also described as load-haul-dump (LHD) vehicles because of their design application. The LHD is a multi functional design that allows it to operate as a front-end loader to dig into a muck pile and then tram the machine over a considerable distance to a dump transfer point and then return to the load point to repeat the cycle.

The other two vehicles are MT436-B haulage trucks. These machines are designed to haul large loads over longer distances and would be typically loaded either by an LHD or at an overhead chute.

At Brunswick Mine these vehicles are the backbone of the ore transportation process. The broken ore is drawn from an opening to the open stope by the ST8 –B LHD. This loading process is done primarily with the use of vehicle radio remote controls due to ground instability and safety factor. The operator works the remote control from a safety bay within sight of the back end of the machine, typically 25 metres or so. When the loaded LHD reaches the safety bay the operator switches off the remote control, and gets into the operators' seat to drive through the remainder of the cycle. The haul distance from the draw point of the stope to the truck loading point is kept to a minimum, generally within one to two minutes haul time. At the dump point, the LHD will transfer the ore from the bucket to the dump box of the haulage truck. The trucks are usually filled in 2 buckets from the LHD. The truck will haul the load to an ore pass which is a vertical chute that will carry the ore through a network of chutes and bins to a crusher at the bottom of the mine. The haulage distance from loading to dump points for the trucks will vary depending on the area, but is typically several minutes. While the truck is away on a haul cycle the LHD will load another bucket and await the return of the truck. In cases where the distance between the stope draw point and ore pass is close, the scooptram will load, haul and dump directly without the use of a truck.

The mine production and maintenance operations work on a two shift per day basis. Both day and night shifts are the same, starting at 7:00 and finishing at 5:30. This leaves a two to three hour window between shifts twice per day. The mine operates seven days a week. Vehicles normally accumulate approximately 250 operating hours per month.

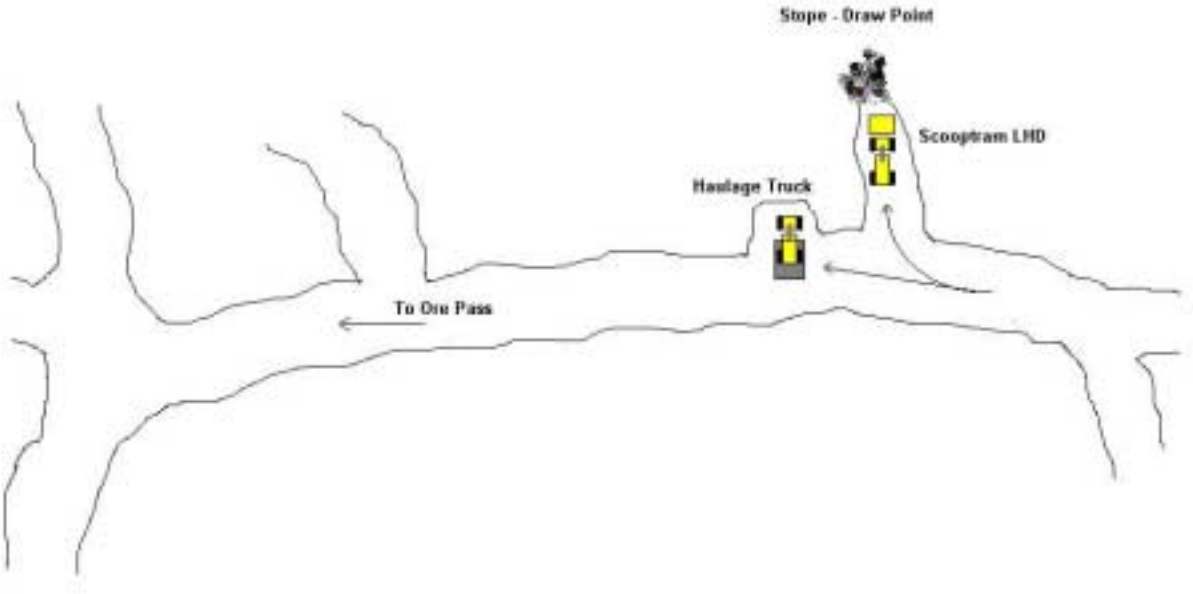


Figure 1 - Load Haul Dump Cycle

Figure 2 - Radio Remote ST8-B At Brunswick Mine

Figure 3 – ST8-B Loading A Haulage Truck

ST8-B Scooptram

The ST8-B scooptrams in this project are both newly acquired units with approximately 500 operating hours on them. Both VL233 and VL234 have been instrumented with the datalogging instrumentation since early August. VL233 has one backpressure sensor immediately after the turbocharger, one temperature sensor immediately after the turbocharger, and the second temperature sensor just before the catalytic purifier. VL 234 has the same 3 sensors with the only difference being that the second temperature sensor is measuring temperatures inside the logger enclosure at the exhaust compartment instead of before the purifier. Both vehicles are equipped with Detroit Diesel Series 60 11.1 litre engines rated at 325 HP.

The exhaust system is located on the left hand or drivers side of the vehicle engine compartment. The current configuration includes a catalytic purifier and silencer in series at the bottom of the exhaust compartment. A span of approximately 1 metre and 2 90° elbows

connects the purifier / silencer to the turbocharger on the engine. This span of exhaust pipe is currently non insulated. A modification to the factory exhaust installation has been done at Brunswick Mine on the ST8-Bs. Instead of a 90° elbow coming out of the silencer a 180° elbow an additional length of tailpipe has been added to port the exhaust flow out the rear side of the vehicle instead of a deflector underneath. This has been done to alleviate problems with agitation of roadway dust from the bottom mounted deflectors. The schematic of this modification is reflected between figures 5 and 8.

Detailed information on vehicle and engine specifications as well as engine duty cycle information and complete spreadsheets of the raw data can be found at the end of this document in the appendix section.

ST8-B Specifications At A Glance

Engine

Detroit Diesel	Series 60
Power Rating @ 2100 RPM	242 kW (325 HP)
Maximum Torque @ 1200 RPM	1559 Nm (1150 ft-lbs)
Cylinders	6 In Line
Displacement	11.1 Liter (677 in^3)
Cooling	Water
MSHA Ventilation	992 m^3/min (35000 cfm)
CSA Ventilation (0.05 % sulphur/fuel)	623 m^3/min (22000 cfm)

Vehicle

Fuel Tank	379 Liters (105 gallon)
Electrical System	24 Volt
Torque Converter	Clark C-8000 Single Stage
Transmission	Clark 5000 Modulated Power Shift
Vehicle Speeds	1^{st} 2^{nd} 3^{rd} 4^{th} 5.3 9.0 15.1 24.6 (km/hr)
Dump & Hoist Hydraulic Pumps	200 +200 lpm (105 gpm) @ 2100 rpm
Steering Hydraulic Pump	200 lpm (52 gpm) @ 2100 rpm
Dump / Hoist System Pressure	13.8 Mpa (2000 psi)
Tramming Capacity	13608 kg (30000 lbs)
Operating Weight (Empty Approx)	39474 kg (87,040 lbs)

Figure 4 - ST8-B At Brunswick Mine

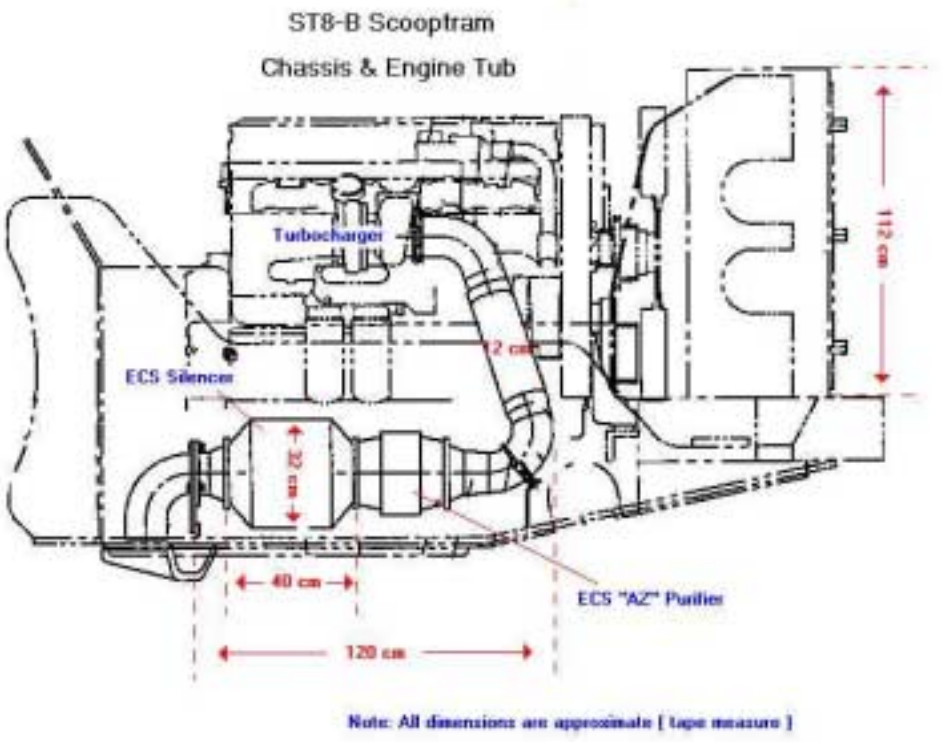


Figure 5 - ST8-B Side Profile

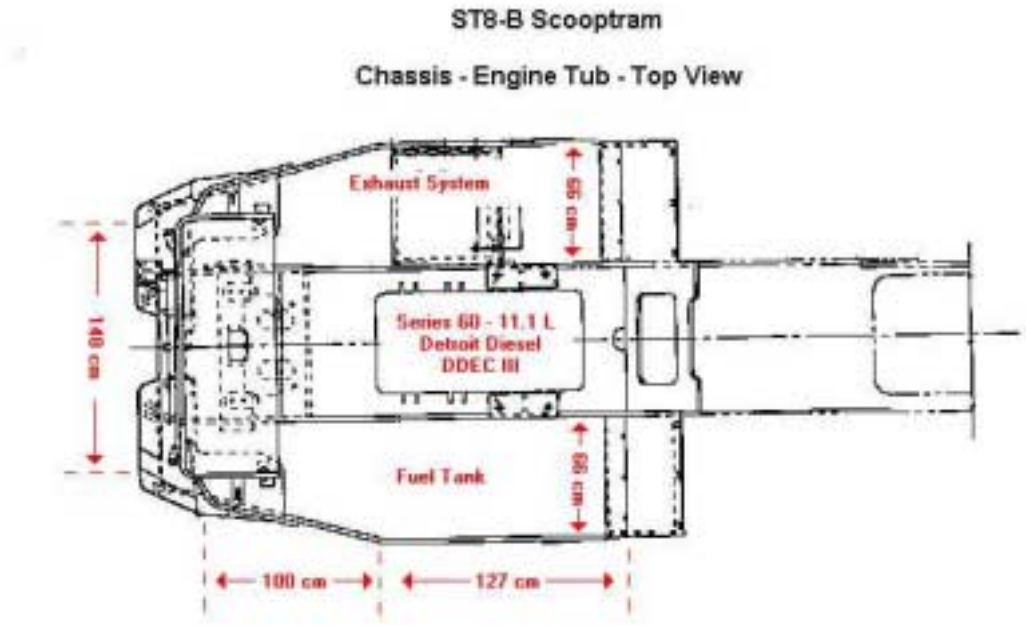


Figure 6 - ST8-B Top Profile

ST8-B Scooptram

Chassis - Engine Tub - Side View

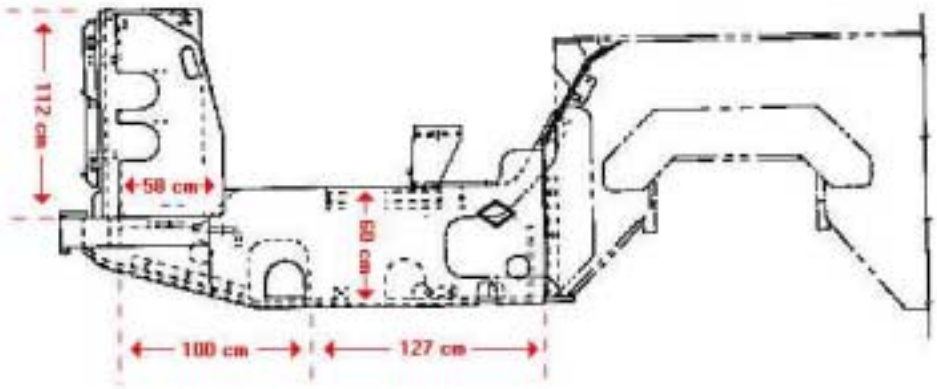


Figure 7 - ST8-B Opposite Side Profile

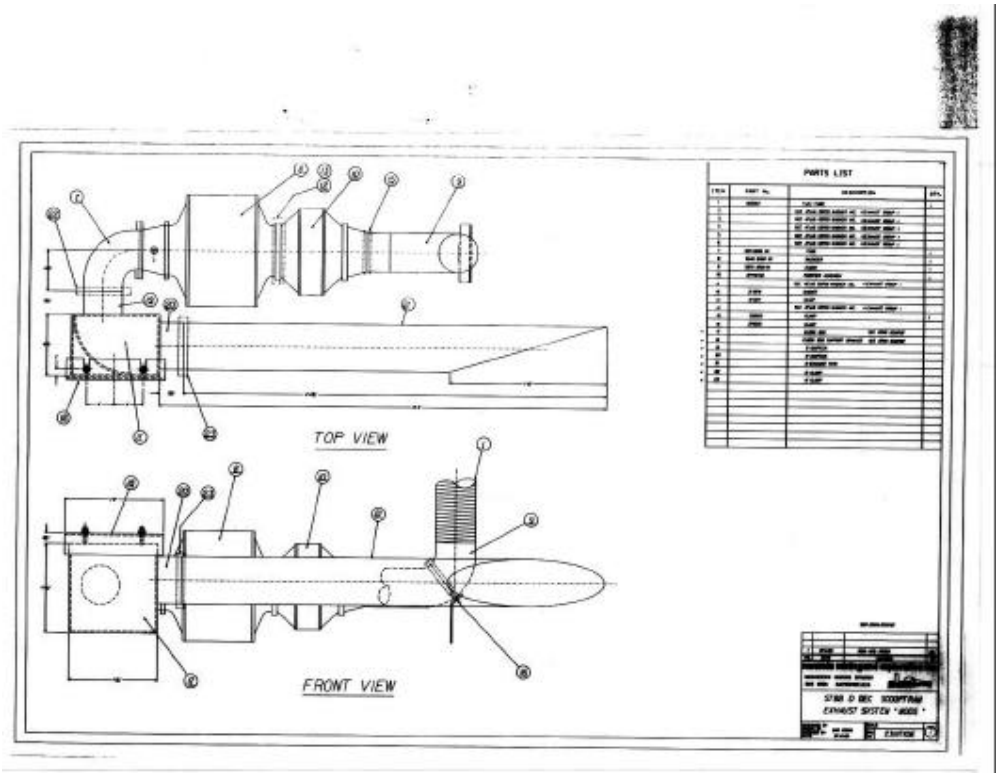


Figure 9 - Exhaust Modification

Figure 10 - Exhaust Modification

MT-436B Mine Truck

The MT-436B trucks in the project are both newly acquired units with approximately 500 operating hours on them as well. Both VH178 and VH179 have been instrumented with the datalogging instrumentation since early August. Each truck has been instrumented identically with backpressure measured immediately after the turbocharger, and temperatures measured immediately after the turbo and before the purifier. Both trucks are equipped with Detroit Diesel Series 60 12.7 liter engines rated at 375 HP.

The exhaust system is located on the right hand side opposite the drivers compartment. The current configuration includes a catalytic purifier and silencer in series at the bottom of the exhaust compartment. A span of approximately 1 meter and 2 90° elbows connects the purifier / silencer to the turbocharger on the engine. This span of exhaust pipe is currently non-insulated. The exhaust compartment is smaller than that of the ST8B and is further complicated by the installation of the Ansul fire suppression system mounted on the fender above the compartment. Unlike the ST8s there has been no modification to the exhaust system and the exhaust flow is directed out of the silencer through a 90° elbow to the deflector underneath.

Detailed information on vehicle and engine specifications as well as engine duty cycle information and complete spreadsheets of the raw data can be found at the end of this document in the appendix section.

MT-436B Specifications At A Glance

Engine

Detroit Diesel	Series 60
Power Rating @ 2100 RPM	278 kW (375 HP)
Maximum Torque @ 1200 RPM	1763 Nm (1300 ft-lbs)
Cylinders	6 In Line
Displacement	12.7 Liter (775 in^3)
Cooling	Water
MSHA Ventilation	1161 m^3/min (41000 cfm)
CSA Ventilation (0.05 % sulphur/fuel)	744.7 m^3/min (26300 cfm)

Vehicle

Fuel Tank	439 Liters (116 gallon)
Electrical System	24 Volt
Torque Converter	Clark CL-6000 Single Stage with Lockup
Transmission	Clark 6000 Full Power Shift
Vehicle Speeds	1st 2nd 3rd 4th 4.8 8.4 14.0 23.0 (km/hr)
Dump Hydraulic Pump	197 + 87 lpm (75 gpm) @ 2200 rpm
Steering Hydraulic Pump	197 lpm (52 gpm) @ 2200 rpm
Steering System Pressure	15.8 Mpa (2300 psi)
Payload	32659 kg (72000 lbs)
Operating Weight (Empty Approx)	31298 kg (69000 lbs)

Figure 11 - MT-436B Truck at Brunswick Mine

Figure 12 - MT-436B Side View

Figure 13 - MT-436B Top View

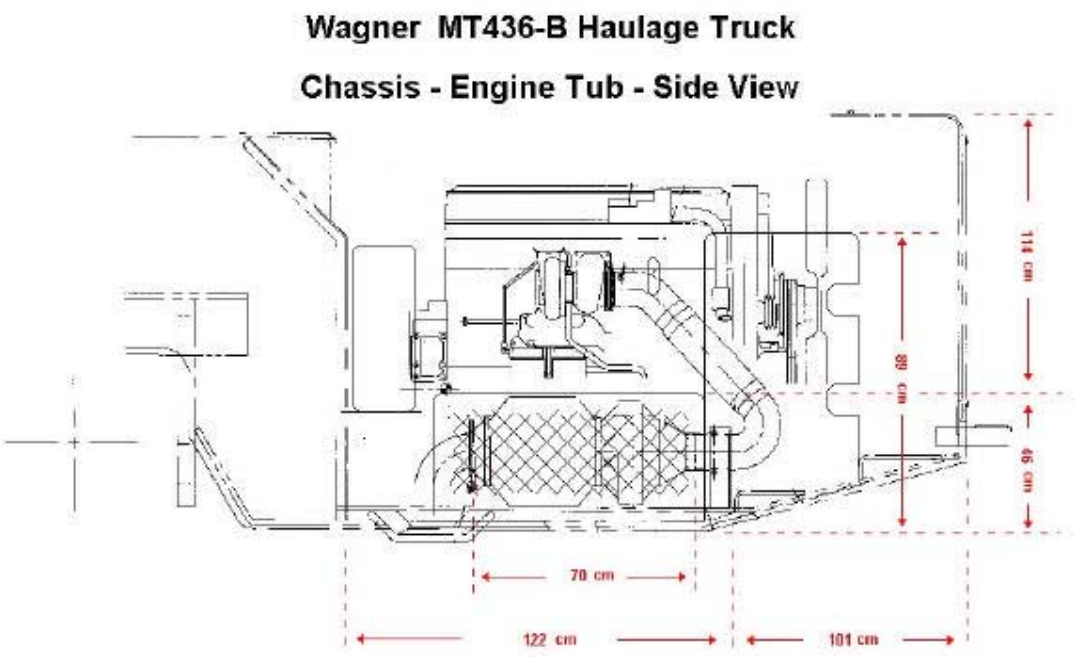


Figure 14 - MT-436B Side Profile

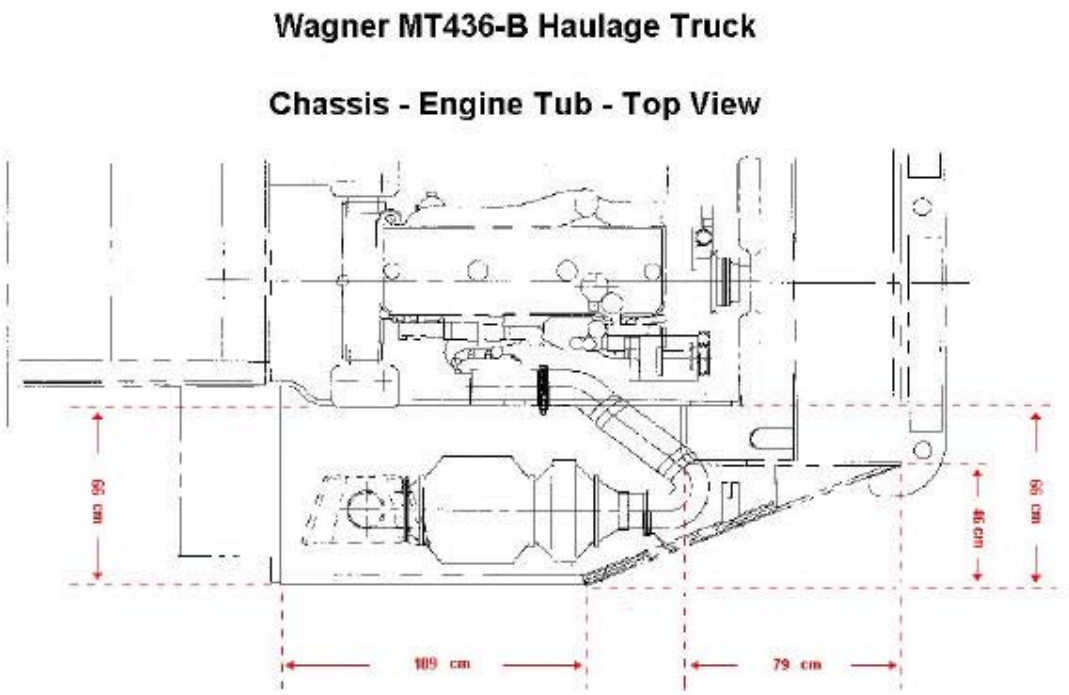


Figure 15 - MT-436B Top Profile

Datalogging – Duty Cycles

The four vehicles have been instrumented with datalogging systems from Paul Nothiger Electronic in Switzerland. Each system is comprised of an electronic logger with display, processor, memory, alarm and communication download capability acquiring data from external sensors. The current loggers are capable of reading 4 channels in total: pressure, temperature (2), and RPM. At present we are only measuring and logging 3 channels, with engine RPM to be added later if required. The alarm digital output capability of the logger unit will be interfaced with the DDEC control system on the engines to display exhaust temperature and backpressure alarms. These signals will be picked up by the DDEC system and provide engine protection through the existing indicators and fault code system.

Figure 16 - Logger Unit and Enclosure

Figure 17 - Logger / PC Download

The interface between the logger unit and a PC is a straight RS2332 connection to the LogLink software application supplied with the system. The software provides capabilities for:

- ➢ Configuration of channels, logging frequency, memory management
- ➢ Real time display of data
- ➢ Graphic display of historical data
- ➢ Ascii converter for data to Excel spreadsheet
- ➢ Integrated email for data transfer

Figure 18 - LogLink Software

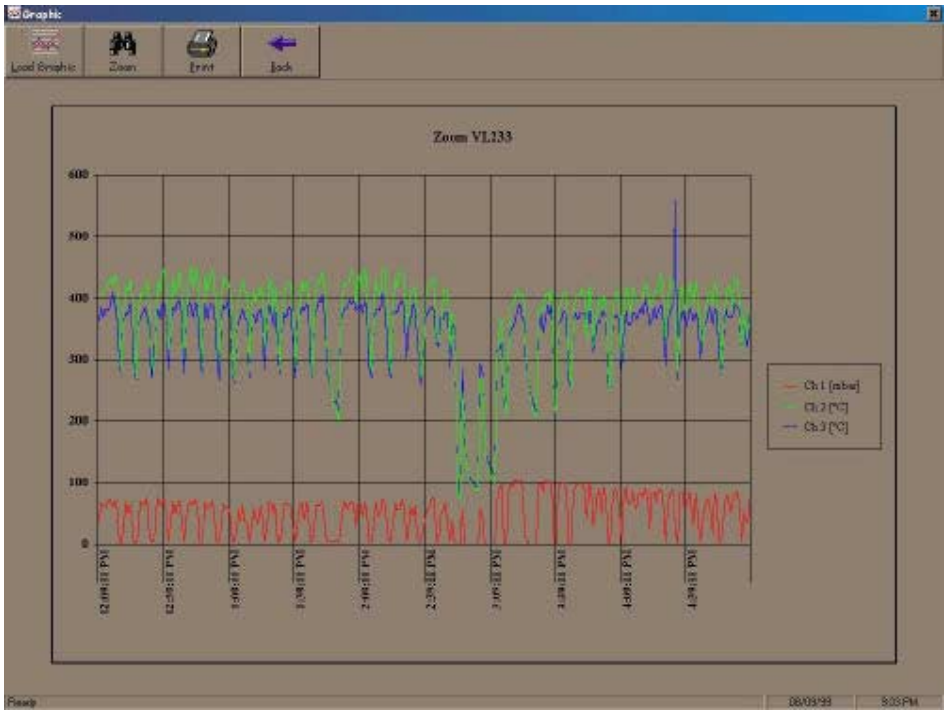


Figure 19 - LogLink Graphic Analysis

Request For Proposals

Based on the information included both above and in the appendix section, the Brunswick Mine Trap Project team is requesting proposals from the manufacturers of trap technologies to match their specific technology to our vehicle applications as described. General guidelines for the composition of the proposal would be:

- Complete technical specifications, drawings, and schematics
- Field test data where possible
- Detailed explanation of all options and scenarios for implementation
- Include information described in targets and data sheets (appendix)
- Avoid "Marketing Proposal" approach

Responsibilities

By agreeing to participate in this project if selected, the trap manufacturer would be expected to:

- Supply 2 complete trap systems (1 spare) for the duration of the project at their cost
- Contribute to the cost of bench testing at start and end of project
- Actively participate from installation onward at the mine with technical staff at regular intervals (3 – 6 months)
- Agree to terms and conditions contract (appendix)

Proposal Submission

Manufacturers should have their proposals submitted by November 2nd, 1999. This date has been chosen because a closed session special meeting is currently being planned at the Embassy Suites in Markham, Ontario to receive the proposals and presentations. This would be similar to last years' meeting at the same location the day before the Mining Diesel Emissions Conference. Manufacturers who choose to attend this meeting will be given 15 – 20 minutes to present their proposal to the group that will include representatives from both the Brunswick Mine Trap Project team and DEEP Technical Committee. The question and answer session following presentations will be between this group and individual manufacturers. The session will not be open to questions and debate amongst the manufacturers. Those who are unable to attend this meeting to submit their proposal by presentation should have a copy of their proposal submitted to the group before this date.

Any questions or inquiries regarding this project and proposal process should be directed to:

Sean McGinn
Project Leader – Brunswick Mine Particulate Trap Project
#3 – 415 Echo Drive
Ottawa, Ontario, K1S 1N5
Tel: (613) 230-7941
Fax: (613) 230-9160
smcginn@fox.nstn.ca

Appendix

- **ST8-B Vehicle Specifications**
- **ST8-B Engine Power /Torque / Fuel Consumption Curves**
- **ST8-B Engine Specifications**
- **ST8-B Engine Duty Cycle Graphic Analysis**

- **MT-436B Vehicle Specifications**
- **MT-436B Engine Power /Torque / Fuel Consumption Curves**
- **MT-436B Engine Specifications**
- **MT-436B Engine Duty Cycle Graphic Analysis**

- **Project Target Values**

- **Trap Datasheet**

- **Terms & Conditions**

WAGNER

TECHNICAL SPECIFICATION – OPTIONAL DDEC

ST-8B

Diesel Scooptram®

Capacity	kg	(lbs)
Breakout Force, Digging	22371	(49,327)
Tramming Capacity	13608	(30,000)

Bucket – S.A.E. Rating	m3	(yd3)
Nominal Heaped	6.5	(8.5)
Struck	5.4	(7.0)
Boom Raising Time	6.8 Seconds	
Boom Lowering Time	8.0 Seconds	
Bucket Dump Time	7.0 Seconds	

Vehicle Speeds – Loaded

Forward or Reverse with 3% Rolling Resistance

Gear	1st	2nd	3rd	4th
Speed in km/h	5.3	9.0	15.1	24.6
Speed in mph	3.3	5.6	9.4	15.3

Gradeability

Maximum ..... See Performance Curve

Engine

Detroit Diesel ..... Series 60
MSHA Power Rating @ 2,100 rpm ..... 242 kW (325 hp)
Maximum Torque @ 1,200 rpm ..... 1559 Nm (1150 ft-lbs)
Number of Cylinders ..... 6 In Line
Displacement ..... 11.1 L (677 in3)
Cooling ..... Water
MSHA Ventilation ..... 992 m3/min (35,000 cfm)

Exhaust Conditioner

Catalytic Purifier Plus Exhaust Silencer

Electrical System

24 Volt Starting, 24 Volt Accessories

Torque Converter

Single Stage, Clark ..... C-8000 Series

Transmission

Modulated Power Shift, 4 Speeds Forward/Reverse
Clark ..... 5000 Series

Axles

Spiral Bevel Differential, Full Floating, Planetary Wheel End Drive
Rock Torque® ..... 508 Series

Standard Brakes

Service ..... SAHR®
Spring Applied Hydraulically Released; Fully Enclosed, Force-Cooled Multiple Wet Discs at Each Wheel End
Parking and Emergency ..... Same (SAHR)

Tires

Tubeless, Nylon, Smooth Tread Design, For Underground Mine Service, On Demountable Rims
Tire Size, Front & Rear ..... 26.5 x 25, 32 Ply, L-5S

Steering

Articulated Hydraulic Power Steering, Pilot Operated, Monostick Control
Turning Angle ..... 85° (42.5° each way)
System Pressure ..... 15.8 MPa (2,300 psi)

Hydraulic System

Dump and Hoist Control ..... Pilot Operated, Single Lever
Cylinders ..... Double Acting, Chrome Plated Stems
Steering Cylinders (2) Diameter ..... 152 mm (6.0 in)
Hoist Cylinders (2) Diameter ..... 228 mm (9.0 in)
Dump Cylinder (1) Diameter ..... 228 mm (9.0 in)
Pumps ..... Heavy Duty Gear Type
Dump/Hoist ..... 200+200 lpm (105 gpm) @ 2,100 rpm
Steering ..... 200 lpm (52 gpm) @ 2,100 rpm
Filtration ..... Pilot Flow: 10 Micron; Suction: 25 Micron
Dump/Hoist System Pressure ..... 13.8 MPa (2,000 psi)

Tank Capacities	liters	(gallons)
Fuel	379	(105)
Hydraulic	360	(95)

Oscillation

Rear Axle, Trunion Mounted, Synthane Bushings
Degree of Oscillation ..... Total 18°

Operator's Arrangement

Side Seating For Bi-Directional Operation and Maximum Visibility

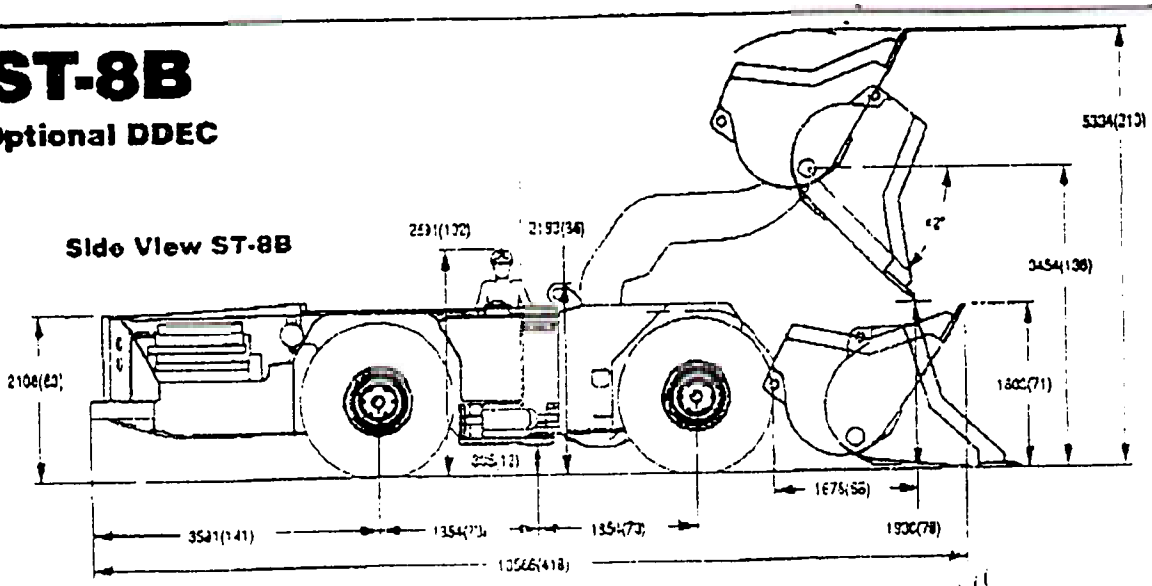
Operating Weight	kg	(lbs)
Empty, Approximate	39474	(87,040)

Manufactured with an MSHA Title 30, Part 32, (Schedule 24) Certified Engine.

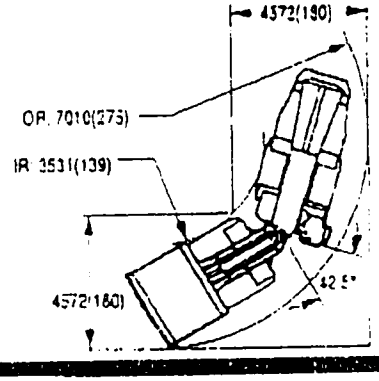
ST-8B

Optional DDEC

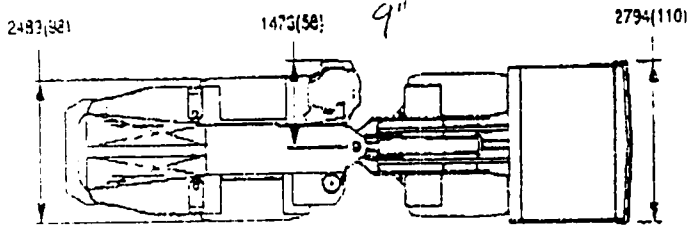
Side View ST-8B



Top Turning View ST-8B



Top View ST-8B



Note: Dimensions shown in millimeters (inches)
Vertical dimensions based on an unloaded vehicle
tire radius of 860 (34)

Standard Features

2101 – Dry Type Air Cleaner(s)
2410 – 24 Volt Electric Start
3201 – Modulated Shift Transmission
3411 – Raised Axle Vents
4002 – Steering Hinge Lock
4401 – Fully Stabilizing Bucket
5221 – Primary & Secondary Fuel Filters
5224 – Fuel / Water Separator
5350 – Converter Oil Cooler
5550 – Hydraulic Pressure Test Ports
5700 – Neutral Start Protection
5801 – SAHR® Brake System
6001 – Seat Belts
7004 – Sealed Electrical System
7100 – Alternator
7200 – Batteries
7300 – Halogen Working Lights
7400 – Electric Warning Horn
8008 – SAHR Brake Override Control
8073 – Engine Hour / Service Meter
8093 – Engine Low oil/High temp. Alarm

Vehicle Configuration

0165 – Bucket 6.5 m3 (8.5 yd3)
0219 – Detroit Diesel Series 60
0321 – Rock Tough™ Purifier & Silencer
0400 – No Canopy
0501 – Conventional Front Differential
0602 – No Spin Rear Differential
0701 – SAHR Brakes
0801 – 26.5 x 25 TOYO L-5S TL
0901 – Monostick Steering Control
1001 – Single Lever Dump Control
1102 – Grammer Seat
7003 – 24 Volt Electrical Accessories

Distributed By:

Atlas Copco Wagner Inc.
P.O. Box 20307 • Portland, Oregon • 97294-0307 • USA
Telephone (503) 255-2840 • Facsimile (503) 255-7175

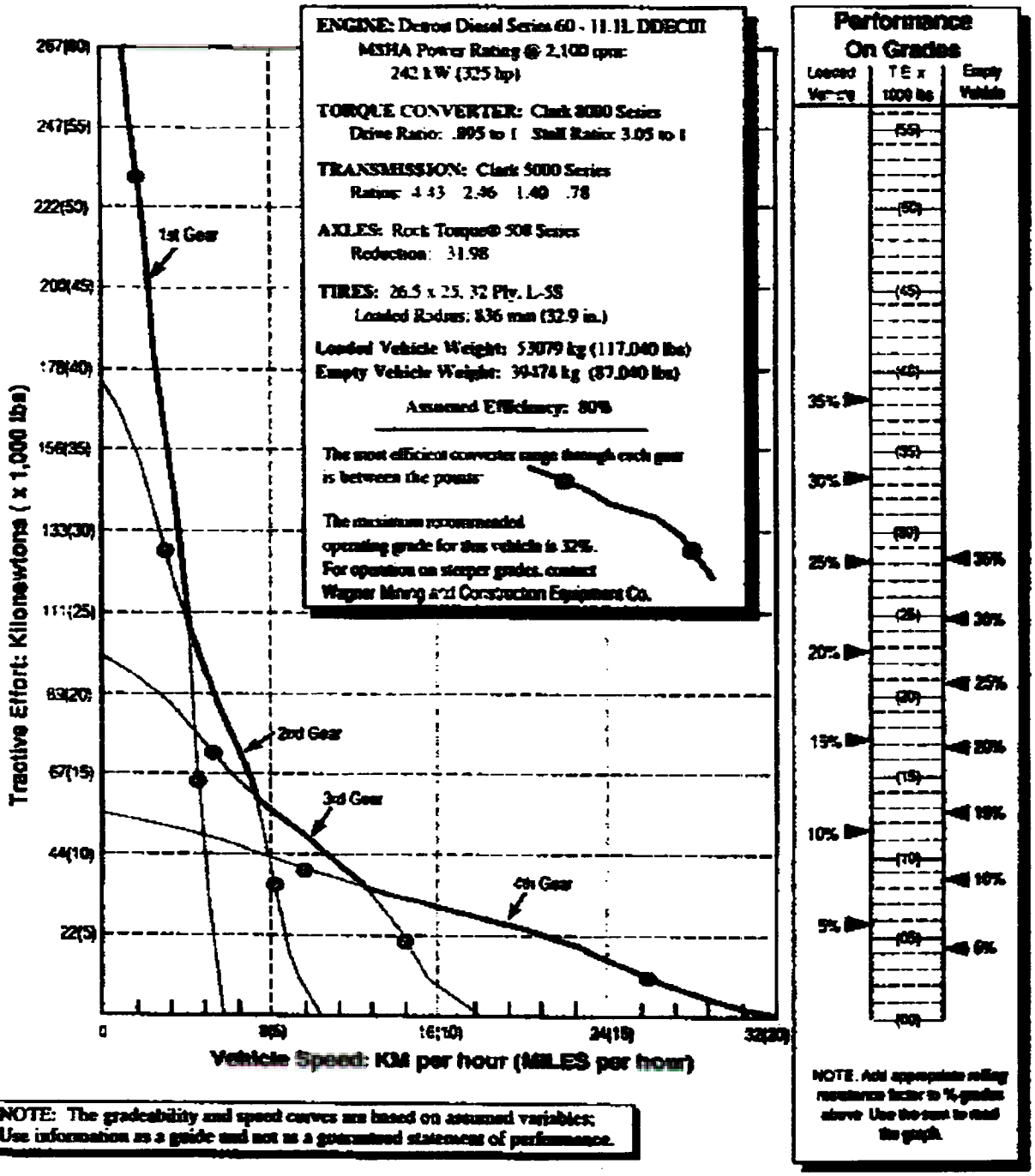
PN #5565 0153 01 10/95 Printed in the USA

WAGNER

Performance Curve – Optional DDEC Engine

ST-8B

Diesel Scooptram®



NOTE: The gradeability and speed curves are based on assumed variables; Use information as a guide and not as a guaranteed statement of performance.

NOTE: Add appropriate rolling resistance factor to % grades above. Use the sum to read the graph.

Atlas Copco Wagner Inc.

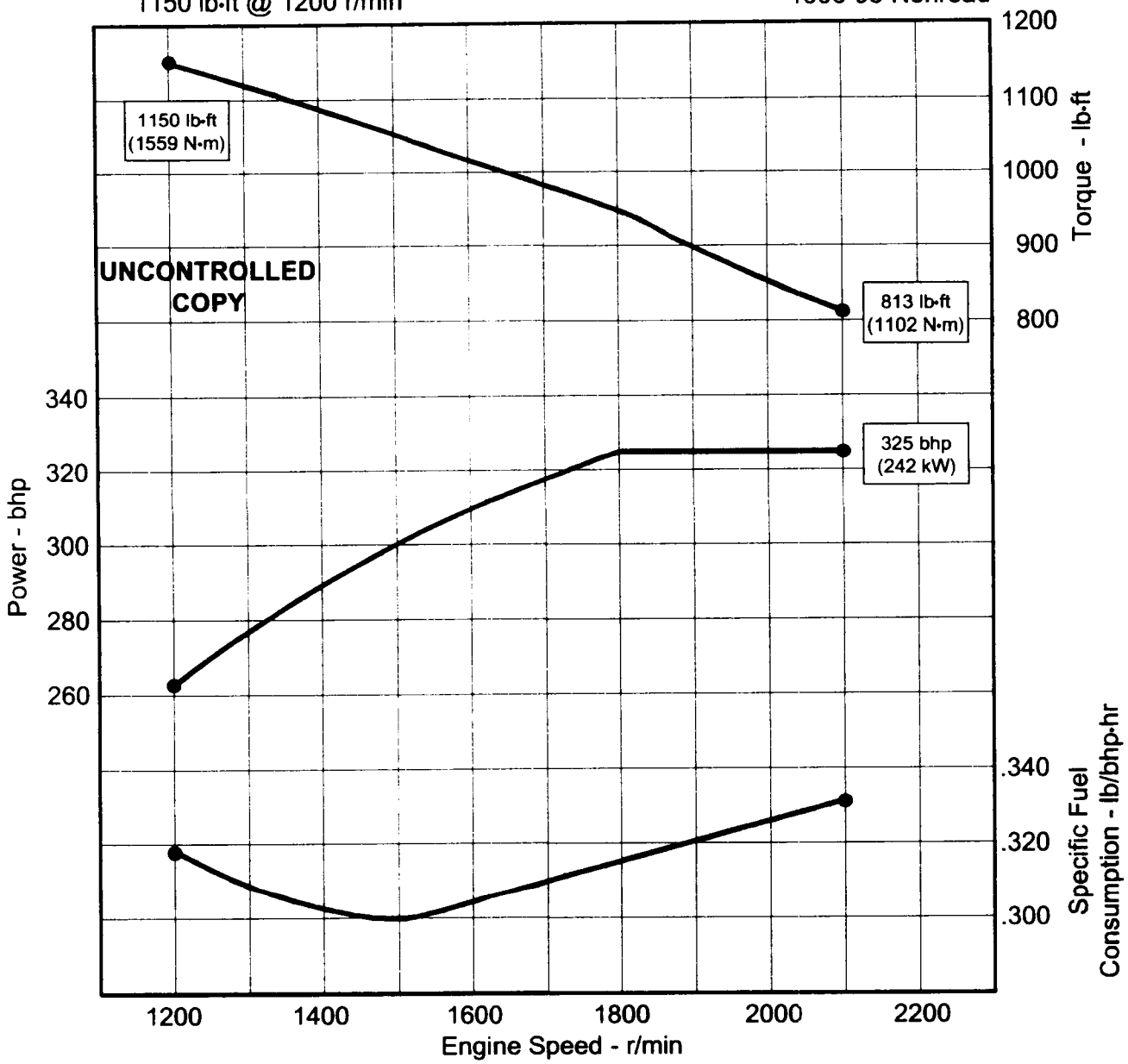
DETROIT DIESEL

Industrial Power

Model: Series 60®

Rating: 325 bhp @ 2100 r/min
1150 lb·ft @ 1200 r/min

Certification:
1996-98 Nonroad



Power output guaranteed within 5% at SAE J1995 conditions: 77°F (25°C) air inlet temperature; 29.31 in. Hg (99kPa) dry barometer; 100°F (38°F) fuel inlet temperature; .653 specific gravity at 60°F (15°C) Charge air cooler system pressure drop: 16 in. H_2O (4 kPa) Charge air cooler system temperature out: 97°F (36°C) Air intake restriction: 10 in. H_2O (2.5 kPa) Exhaust Back Pressure: 15 in. H_2O (3.7 kPa)	*Conversion Factors:* Power: kW = bhp x 0.746 Fuel: kg/kW - hr = lb/bhp - hr x 0.608 Torque: N - m = lb - ft x 1.356	**Turbo:** GT42 (1.15 A/R) **Injector:** 5235605

Certified by: Phil Rumore

Curve No. E4-6063-32-78
Rev. / Date: 3 / 7-16-98
Sheet No. 1 of 2

Performance Curve

CONSTRUCTION AND INDUSTRIAL SPECIFICATION SHEET

General Data

Model	6063-EK33
Number of Cylinders	6
Bore and Stroke – in. x in. (mm x mm)	5.12 x 5.47 (130 x 139)
Displacement – in.^{3} (L)	677 (11.1)
Compression Ratio	16.0:1
Piston Speed – ft/min (m/min)	1915 (583)
Intake Valves Per Cylinder	2
Exhaust Valves Per Cylinder	2
Combustion System	DIRECT INJECTION
Engine Type	INLINE 4 CYCLE
Aspiration	TURBOCHARGED

Configuration

Injection Device	EUI
Turbocharger	GT42 (1.15A/R)
Charge Air Cooling	AIR TO AIR
Low Idle Speed – r/min	600
High Idle Speed – r/min	2225
Engine Crankcase Vent System	OPEN

Physical Data

Size:	
Length – in. (mm)	57.7 (1466)
Width – in. (mm)	34.3 (871)
Height – in. (mm)	50.1 (1273)
Weight, Dry – lb (kg)	2510 (1139)
Weight, Wet – lb (kg)	2632 (1194)
Center of Gravity Distance:	
From R.F.O.B. (x axis) – in. (mm)	22.3 (566)
Above Crankshaft (y axis) – in. (mm)	8.6 (218)
Right of Crankshaft (z axis) – in. (mm)	-1.4 (-35.6)
Installation Drawing	235049165 Ref.

Mechanical Data

Thrust Bearing Load Limit, Continuous – lb (N)	900 (4000)
Thrust Bearing Load Limit, Intermittent – lb (N)	1800 (8000)
Maximum Static Bending Moment at Rear Face of Block – lb·ft (N·m)	1000 (1356)
Additional Mechanical Data	E4-6060-32-1

Fuel System

Fuel Injector	5235605
Injection Timing Height – mm	78.8
Certification Code	5006
Fuel Consumption – lb/hr (kg/hr)	107.6 (48.8)
Fuel Consumption – gal/hr (L/hr)	15.4 (58.3)
Fuel Spill – lb/hr (kg/hr)	513 (233)
Fuel Spill – gal/hr (L/hr)	73.4 (278)
Total Fuel Flow – lb/hr (kg/hr)	621 (282)
Total Fuel Flow – gal/hr (L/hr)	88.8 (336)
Maximum Fuel Inlet Temperature – °F (°C)	140 (60)
Maximum Fuel Pump Suction:	
Clean System – in. Hg (kPa)	6 (20.3)
Dirty System – in. Hg (kPa)	12 (41)
Fuel Filter Size, Primary – microns	25
Fuel Filter Size, Secondary – microns	8
Fuel Spill Restrictive Fitting – in. (mm)	0.08 (2.03

Lubrication System

Oil Pressure at Rated Speed – lb/in.^{2} (kPa)	50 (345)
Oil Pressure at Low Idle – lb/in.^{2} (kPa)	12 (83)
In Pan Oil Temperature – °F (°C)	235 (113)
Oil Flow – gal/min (L/min)	36 (136)
Oil Pan Capacity, High Limit	32 (30)
Oil Pan Capacity, Low Limit	26 (25)
Total Engine Oil Capacity with Filters – qt (L)	38 (36)
Oil Filter, Two Full Flow – Microns	30
Engine Angularity Limits, Front Up – Degrees	27
Engine Angularity Limits, Front Down – Degrees	27
Engine Angularity Limits, Side Tilt – Degrees	21

Electrical System

Recommended Battery Capacity (CCA @ 0°F):	
12 Volt System	1875
24 Volt System	950
Maximum Resistance of Starting Circuit:	
12 Volt System – ohms	0.0012
24 Volt System – ohms	0.002

Cooling System

Engine Heat Rejection to Coolant:	
Rated Speed – Btu/min (kW)	5460 (96.0)
Peak Torque Speed (1200 r/min) – Btu/min (kW)	4975 (87.5)
Charge Air Cooler Heat Rejection:	
Rated Speed – Btu/min (kW)	3787 (66.6)
Peak Torque Speed (1200 r/min) – Btu/min (kW)	1425 (25.1)
Engine Radiated Heat:	
Rated Speed – Btu/min (kW)	1952 (34.3)
Peak Torque Speed (1200 r/min) – Btu/min (kW)	1540 (27.1)
Coolant Flow:	
Rated Speed – gal/min (L/min)	113 (428)
Peak Torque Speed (1200 r/min) – gal/min (L/min)	63 (238)
Thermostat:	
Start to Open – °F (°C)	190 (86)
Fully Open – °F (°C)	205 (96)
Minimum Water Pump Inlet Pressure – lb/in.^{2} (kPa):	0 (0)
Engine Coolant Capacity – qt (L)	24 (23)
Minimum Pressure Cap – lb/in.^{2} (kPa)	7 (48.3)
Maximum Coolant Pressure (Exclusive of Pressure Cap) – lb/in.^{2} (kPa)	17 (117)
Maximum Top Tank Temperature – °F (°C)	210 (99)
Minimum Top Tank Temperature – °F (°C)	160 (71)
Minimum Coolant Fill Rate – gal/min (L/min)	3 (11.4)
Cooling Index (110 °F Ambient w/H_2O @ Sea Level):	
Max Air to Water Diff. @ Rated Speed – °F (°C)	100 (56)
Max Air to Water Diff. @ 1200-1500 r/min – °F (°C)	110 (61)
Deaeration, Air Injection Capacity – ft^3/min (m^3/min)	0.6 (0.017)
Minimum Drawdown Requirement – qt (L)	4 (3.8)

Air System

Maximum Ambient to Turbo Compressor Inlet Temperature Rise – °F (°C)	30 (16.7)
Maximum Air Intake Restriction:	
Clean Air Cleaner – in. H_2O (kPa)	12 (3)
Dirty Air Cleaner – in. H_2O (kPa)	20 (5)
Engine Air Flow: Rated Speed – ft^3/min (m^3/min)	1000 (28.3)
Peak Torque Speed – ft^3/min (m^3/min)	450 (12.7)
Manifold Pressure – in. Hg (kPa)	52.3 (177)
Recommended Intake Pipe Diameter – in. (mm)	5 (127)
Maximum Charge Air Cooler System Total Pressure Drop – in. Hg (kPa)	41.0 (10.2)
Maximum Ambient to Intake Manifold Temp. – °F (°C)	150 (66)
Maximum Crankcase Pressure – in. H_2O (kPa)	3.0 (0.75)

Exhaust System

Exhaust Flow: Rated Speed – ft^3/min (m^3/min)	2040 (57.8)
Peak Torque Speed – ft^3/min (m^3/min)	1250 (35.4)
Exhaust Temperature Rated Speed – °F (°C)	610 (321)
Peak Torque Speed – ft^3/min (m^3/min)	970 (521)
Maximum Back Pressure – in. Hg (kPa)	3.0 (10.1)
Recommended Exhaust Pipe Diameter:	
Single – in. (mm)	5 (127)
Dual – in. (mm)	4 (102)

Performance Data

BMEP – lb/in.^{2} (kPa)	181 (1248)
Friction Power: Rated Speed – fhp (kW)	58 (43)
Peak Torque Speed – fhp (kW)	20 (15)
Altitude Capability – ft (m)	12000 (3660)
Torque Available at 800 r/min – lb·ft (N·m)	750 (1017)

Engine Speed r/min	Rated Power bhp (kW)	Rated Torque lb·ft (N·m)	Rated BSFC lb/bhp·hr (g/kW·hr)
2100	325 (242)	813 (1102)	0.331 (201)
1950	325 (242)	875 (1187)	0.323 (196)
1800	325 (242)	948 (1286)	0.315 (192)
1650	314 (234)	999 (1355)	0.307 (187)
1500	300 (224)	1050 (1424)	0.300 (182)
1350	283 (211)	1101 (1493)	0.305 (186)
1200	263 (196)	1150 (1559)	0.318 (193)

Emissions Data

Certification	1996-98 Nonroad
Smoke, Rated Speed – Bosch Number	0.3
Smoke, Peak Torque Speed – Bosch Number	0.1
Noise – dB(A) @ 1	100.3
Additional Noise Data	Not Available

	2100 r/min g/hr	8 Mode Cycle g/bhp·hr
NO_x	1850	6.61
CO	52	0.45
HC	30	0.11
Particulates	12	6.05

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Curve No. E4-6063-32-78
Rev. / Date: 2 / 7-16-98
Sheet No. 2 of 2

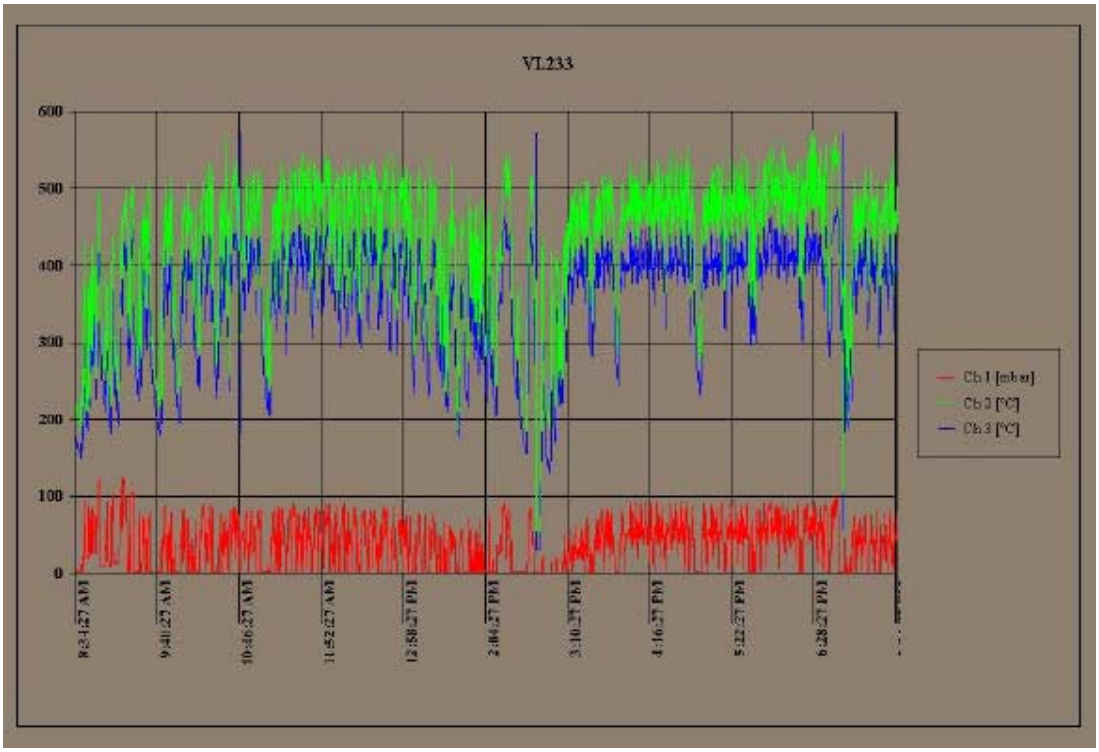
All information subject to change without notice.

ST8-B Engine Duty Cycle Graphic Analysis

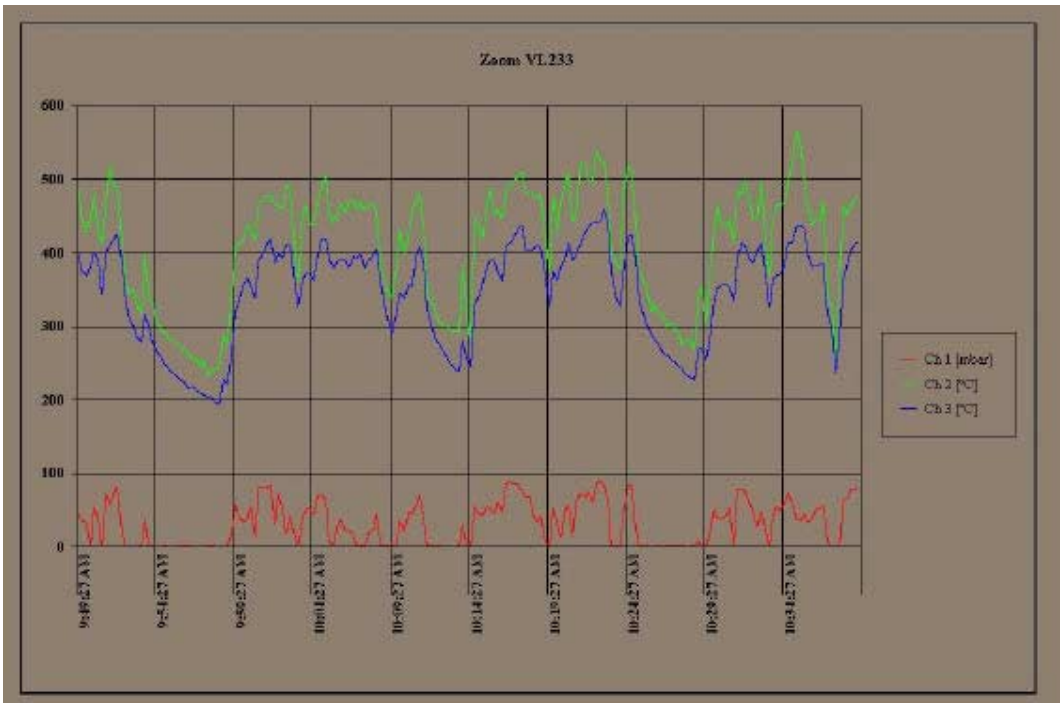
There are two ST8-B scooptrams equipped with dataloggers. Each has three channels, two for temperature and one for backpresure. VL233 has been instrumented with temperature sensors immediately after the turbocharger and the other just before the catalytic purifier assembly. This provides an evaluation of the best possible scenario for maximum temperatures next to the turbo as well as the least ideal scenario at approximately 1 m. downstream from the turbo with two 90° elbows inline as well. The other scooptram, VL234 has been instrumented slightly different for temperatures. The one temperature sensor has been installed next to the turbo but the second has been installed in the logger enclosure. This provides information on ambient temperatures in the exhaust compartment of the vehicle to evaluate operating conditions of electronic control equipment in that area.

The data shown below for these vehicles has been acquired over a period of two months. Although the total operating hours shown for the data in each case is only twelve hours or so it is believed to be as accurate and representative of the vehicle operation as possible. The logging instrumentation has not performed to our expectations but we have made a concerted effort to acquire this information as accurately as possible. At Brunswick Mine the current shift schedule runs two ten and a half hour shifts each day, seven days a week. The twelve hours or so of operating data are ***values measured only when the vehicle is running or the battery master switch has been turned on***. This means that the data represented here would be from one and a half to two full shifts of operation, with different operators on the vehicle for each shift. Any "spikes" in the values either in the graphic or the Excel spreadsheets (included diskette) are due to the switching on and off of the vehicle battery disconnect which also powers the datalogger unit. The time and date stamp cannot be correlated to the actual realtime operation of the vehicle due to a problem with the logger and the switching of the power supply.

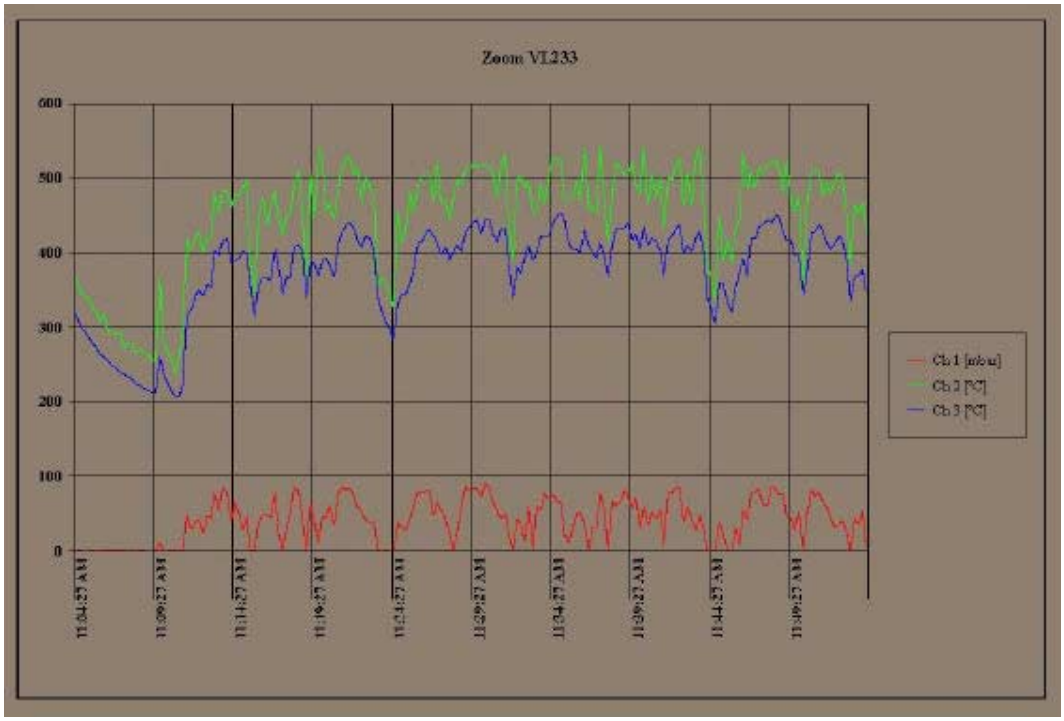
VL233 Scooptram



- VL233 ST8-B Scooptram – Detroit Diesel Series 60 engine – 11.1 L.
- Channel 1 (red) = Backpressure in mbar at turbocharger
- Channel 2 (green) = Temperature in C° after turbocharger
- Channel 3 (blue) = Temperature in C° 1 m. downtream from turbo
- Sampling frequency = 15 seconds



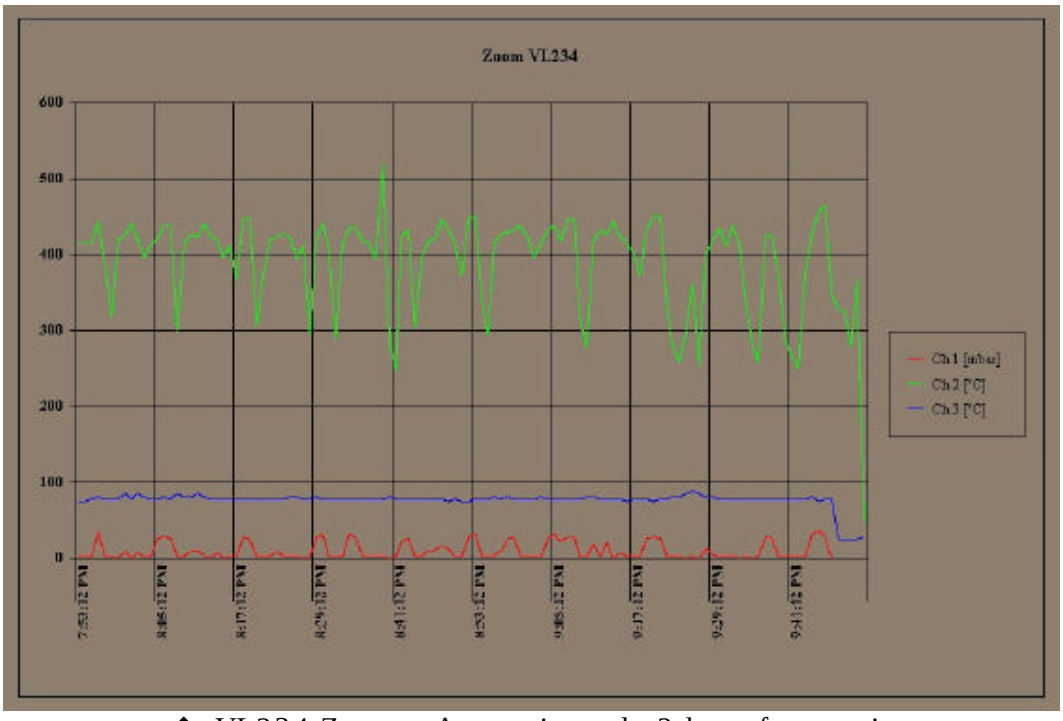
❖ VL233 zoom - approximately 1 hour of operation



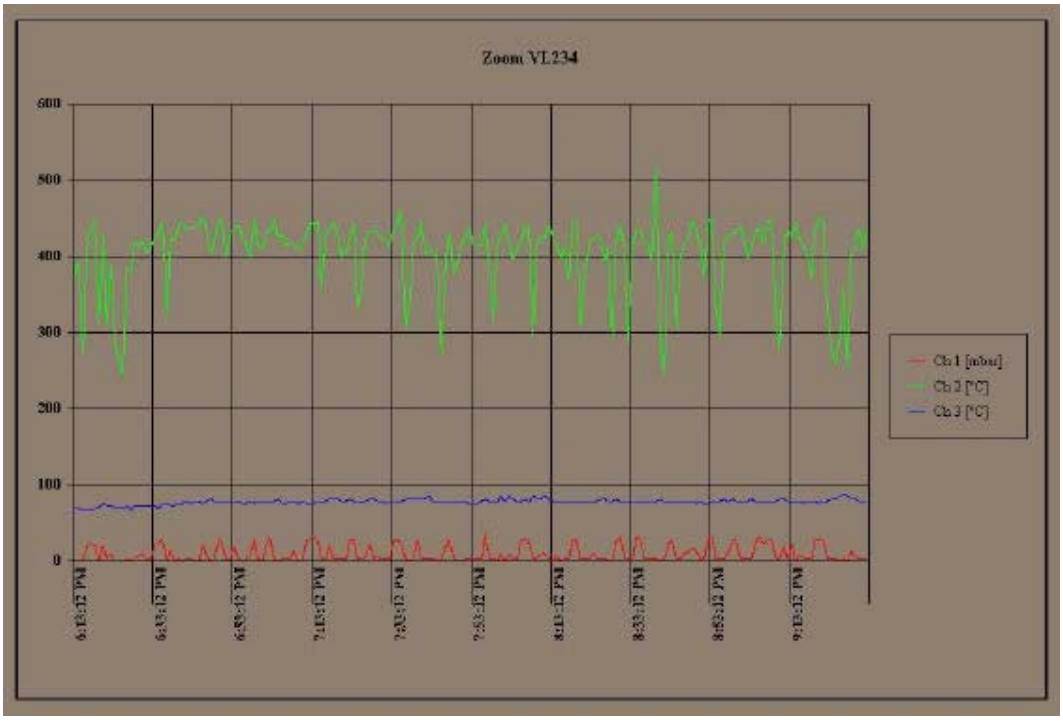
❖ VL233 zoom – approximately 1 hour of operation

VL234 Scooptram

- VL324 ST8-B Scooptram – Detroit Diesel Series 60 Engine – 11.1 L.
- Channel 1 (red) = Backpressure at turbocharger
- Channel 2 (green) = Temperature in C° after turbocharger
- Channel 3 (blue) = Temperature in C° inside logger enclosure
- Sampling Frequency = 60 seconds



❖ VL234 Zoom – Approximately 2 hrs of operation



❖ VL234 Zoom – Approximately 3 hrs of operation

[redacted]

TECHNICAL SPECIFICATION – STANDARD

MT-436B

Diesel Mine Truck

Capacity	kg	(lbs)
Payload	32659	(72,000)
	m3	**(yd3)**
Volume, S.A.E. Heaped	20.0	(26.0)
Volume, S.A.E. Semi-Heaped	18.4	(24.0)
Volume, S.A.E. Struck	16.8	(22.0)

Discharging
Time ..... 14 Seconds

Vehicle Speeds – Loaded
Forward or Reverse with 3% Rolling Resistance

Gear	1st	2nd	3rd	4th
Speed in km/h	4.8	8.4	14.0	23.0
Speed in mph	3.0	5.2	8.7	14.3

Gradeability
Maximum ..... See Performance Curve

Engine
Detroit Diesel ..... Series 60 DDEC III

Converter Drive Rating
Power Rating @ 2,100 rpm ..... 278 kW (375 hp)
Max. Torque @ 1,200 rpm ..... 1763 Nm (1,300 ft.lbs)
MSHA Ventilation ..... 1161 m3/min. (41,000 cfm)

Converter Drive Rating – Lock Up Engaged
Power Rating @ 2,100 rpm ..... 298 kW (400 hp)
Max. Torque @ 1,200 rpm ..... 1695 Nm (1,250 ft.lbs)
MSHA Ventilation ..... 1250 m3/min. (44,000 cfm)
Number of Cylinders ..... 6, In Line
Displacement ..... 12.7 L (775 in3)
Cooling ..... Liquid (Water/Anti-Freeze)
DDEC III System — Electronic Control Module (ECM) and Electronic Unit Injectors (EUI)

Exhaust Conditioner
Catalytic Purifier, Plus Exhaust Silencer

Electrical System
24 Volt Starting, 24 Volt Accessories

Torque Converter
Single Stage with Lock Up, Clark ..... CL-5000 Series

Transmission
Full Power Shift, 4 Speeds Forward/Reverse
Clark ..... 6000 Series

Axles
Spiral Bevel Differential, Full FloatingPlanetary, Wheel End Drive
Rock Torque® ..... 508 Series

Standard Brakes
Service ..... SAHR®
Spring Applied Hydraulically Released; Fully Enclosed, Force-Cooled, Multiple Wet Discs at each Wheel End
Parking and Emergency ..... Same (SAHR)

Tires
Tubeless, Lug Tread Design, Two-Star Rating for Underground Mine Service, On Demountable Rims
Tire Size, Front & Rear ..... 26.5R25, Michelin XKA, L3

Steering
Articulated, Hydraulic Power Steering, Pilot Operated Hydraulic Rotary Servo (Wheel) Control
Turning Angle ..... 85° (42.5° each way)
System Pressure ..... 15.8 MPa (2,300 psi)

Hydraulic System
Cylinders ..... Double Acting with Chrome Plated Stems
Steering Cylinders (2) Diameter ..... 127 mm (5.0 in)
Hoist Cylinders (2) ..... Two Stage
First Stage Diameter ..... 191 mm (7.5 in)
Second Stage Diameter ..... 140 mm (5.5 in)
Pumps ..... Heavy Duty Gear Type
Dump ..... 197 – 87 lpm(75 gpm) @ 2,200 rpm
Steering ..... 197 lpm (52 gpm) @ 2,200 rpm
Filtration ..... Suction Line: 28 Micron
Kidney Loop: 4 Micron

Tank Capacities	liters	(gallons)
Fuel	439	(116)
Hydraulic Oil	230	(63)

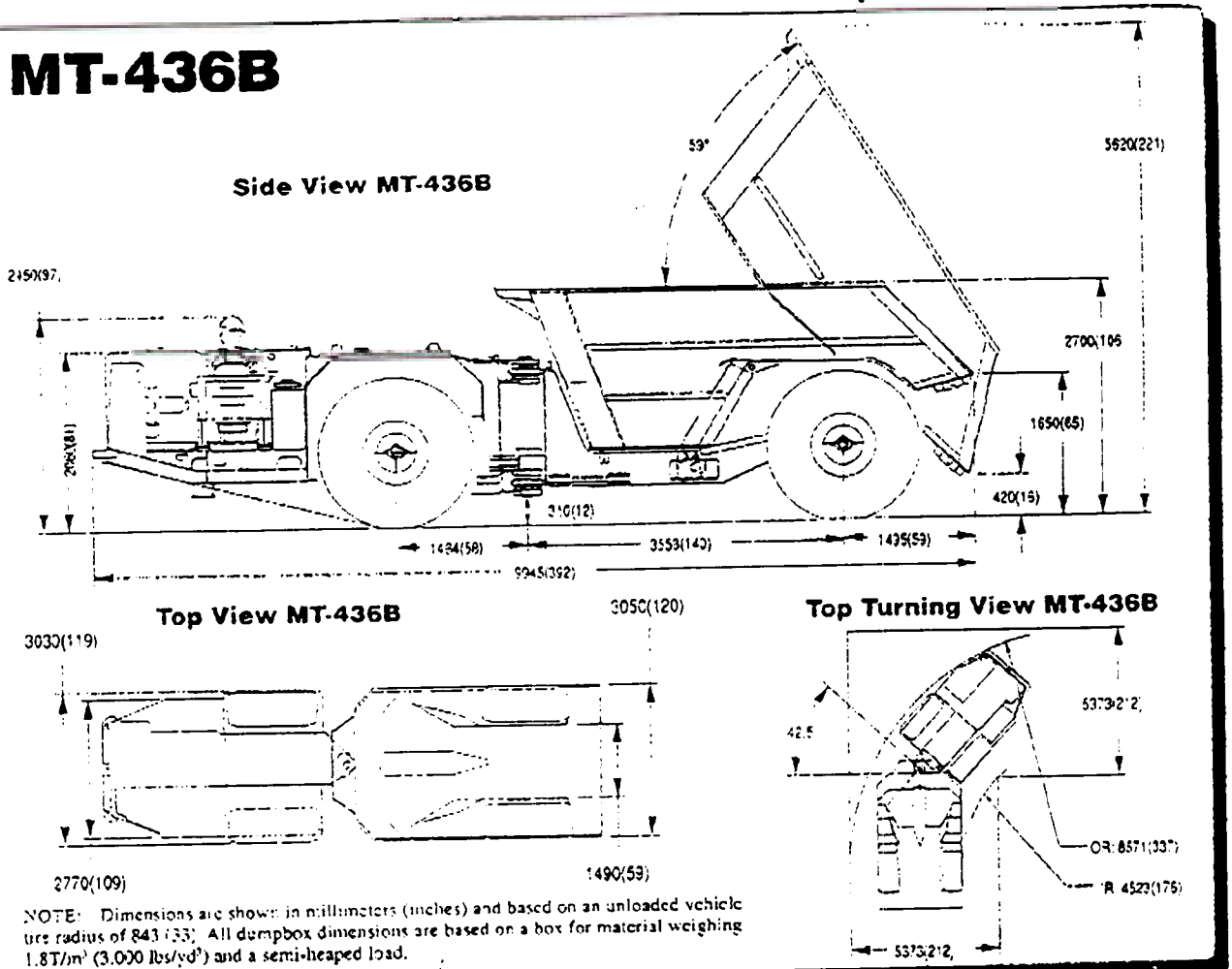
Oscillation
Front Axle, Trunion Mounted, Synthane Bushings
Degree of Oscillation ..... Total 20°

Operator's Arrangement
Side Seating For Bi-Directional Operation and Maximum Visibility

Operating Weight	kg	(lbs)
Empty, Approximate	31298	(69,000)

Manufactured with an MSHA Title 30, Part 32, (Schedule 24) Certified Engine.

MT-436B



NOTE: Dimensions are shown in millimeters (inches) and based on an unloaded vehicle tire radius of 843 (33). All dumpbox dimensions are based on a box for material weighing 1.8T/m³ (3,000 lbs/yd³) and a semi-heaped load.

Standard Features

2101 – Dry Type Air Cleaner(s)
2410 – Electric Start
2701 – Mesabi Radiator
3112 – Flex Plate Drive
4002 – Steering Hinge Lock
5221 – Primary & Secondary Fuel Filters
5350 – Converter Oil Cooler
5550 – Hydraulic Pressure Test Ports
5700 – Neutral Start Protection
5801 – SAHR® Brake System
5810 – Automatic Brake Application
6001 – Seat Belts
7004 – Sealed Electrical System
7100 – Alternator
7200 – Batteries
7300 – Halogen Working Lights
7400 – Electric Warning Horn
7403 – Audio/Visual Back Up Alarm
8008 – SAHR Override Control
8073 – Engine Hour Meter
8061 – Converter Lock Up
8074 – Tachometer
8093 – Engine Low oil/High temp. Alarm

Vehicle Configuration

0155 – Box: 18.4 m3 (24.0 yd3)
0236 – Detroit Diesel Series 60 – 12.7 L
0321 – Rock Tough™ Purifier & Silencer
0400 – No Canopy
0501 – Conventional Front Differential
0601 – Conventional Rear Differential
0701 – SAHR Brakes
0801 – 26.5R25 Michelin XKA TL
0902 – Wheel Steering Control
1001 – Single Lever Dump Control
1102 – Grammer Seat
3407 – Rock Torque® Axles
5401 – Central Lubrication
8067 – Hydraulic Trans Control

Distributed By:

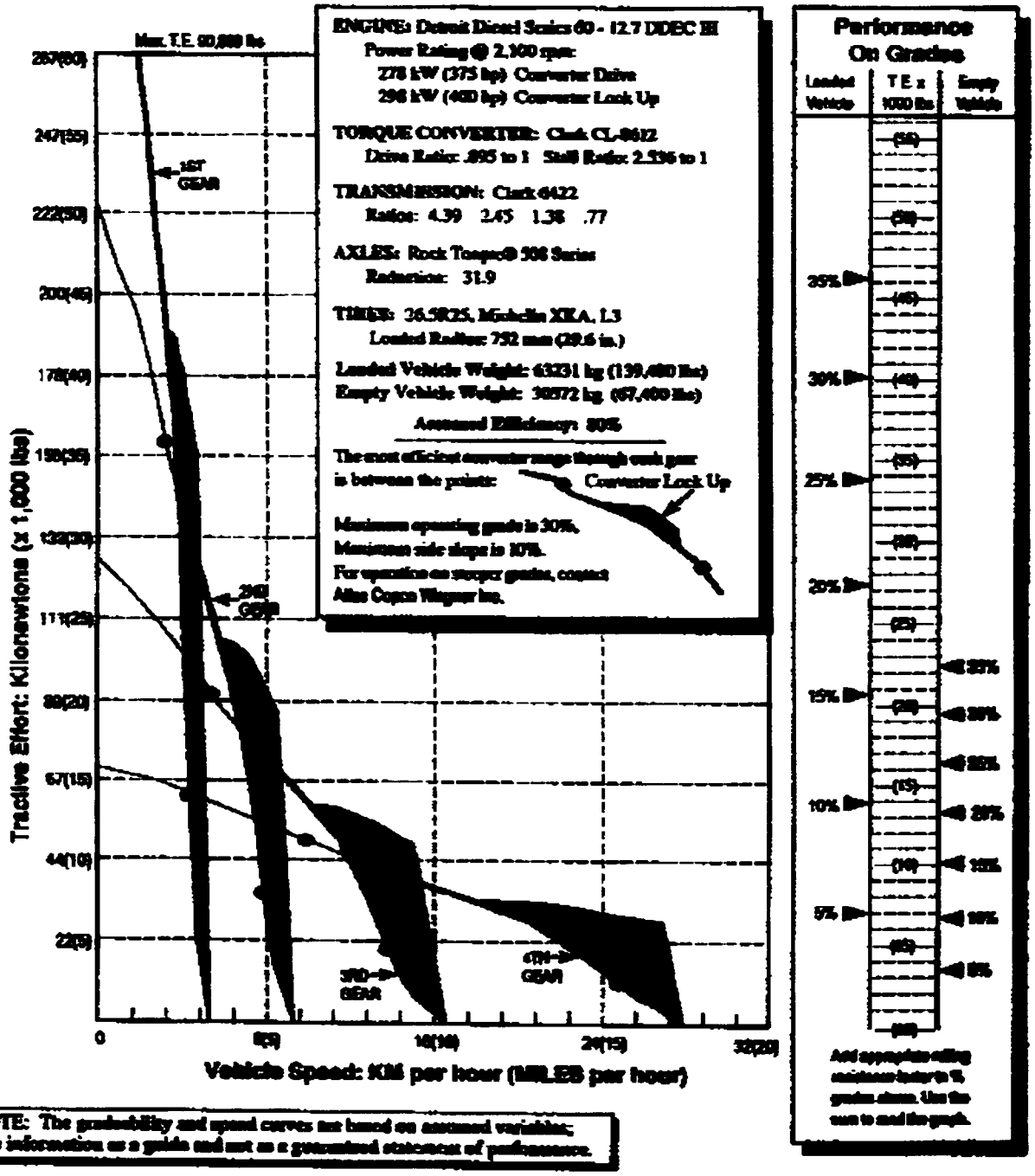
Atlas Copco Wagner Inc.
P.O. Box 20307 • Portland, Oregon • 97220-0307 • USA
Telephone (503) 255-2863 • Facsimile (503) 255-7175

PN #559 60366 01 5/95 Printed in the USA

Performance Curve – Standard

MT-436B

Diesel Mine Truck



NOTE: The gradeability and speed curves are based on assumed variables; Use information as a guide and not as a guaranteed statement of performance.

Atlas Copco Wagner Inc.
P.O. Box [illegible] • Portland, Oregon • [illegible] • USA
[illegible]

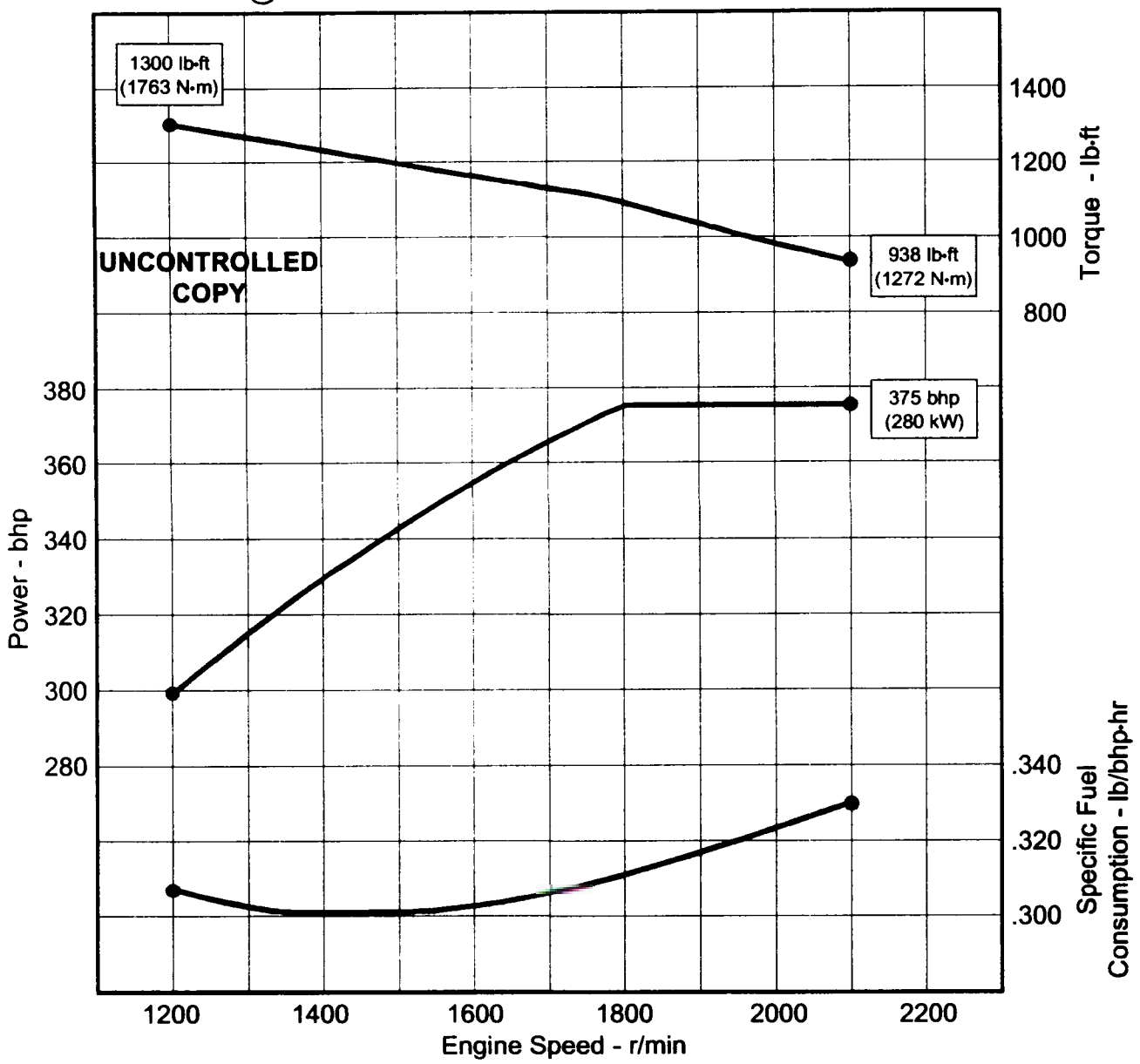
DETROIT DIESEL

Industrial Power

Model: Series 60®

Rating: 375 bhp @ 2100 r/min
1300 lb-ft @ 1200 r/min

Certification:
1996-98 Nonroad



Power output guaranteed within 5% at SAE J1995 conditions: 77°F (25°C) air inlet temperature; 29.31 in. Hg (99kPa) dry barometer; 100°F (38°F) fuel inlet temperature; .853 specific gravity at 60°F (15°C) Charge air cooler system pressure drop: 16 in. H_2O (4 kPa) Charge air cooler system temperature out: 97°F (36°C) Air intake restriction: 10 in. H_2O (2.5 kPa) Exhaust Back Pressure: 15 in. H_2O (3.7 kPa)	*Conversion Factors:* Power: kW = bhp x 0.746 Fuel: kg/kW - hr = lb/bhp - hr x 0.608 Torque: N - m = lb - ft x 1.356	**Turbo:** TMF55 (1.34 A/R) **Injector:** 5235695

Certified by: Phil Rumore

Curve No. E4-6063-32-80
Rev. / Date: 2 / 7-20-98
Sheet No. 1 of 2

Performance Curve

CONSTRUCTION AND INDUSTRIAL SPECIFICATION SHEET

General Data

Model	6063-TK33
Number of Cylinders	6
Bore and Stroke – in. x in. (mm x mm)	5.12 x 6.30 (130 x 160)
Displacement – in.^{3} (L)	778 (12.7L)
Compression Ratio	15.0:1
Piston Speed – ft/min (m/min)	2205 (672)
Intake Valves Per Cylinder	2
Exhaust Valves Per Cylinder	2
Combustion System	DIRECT INJECTION
Engine Type	INLINE 4 CYCLE
Aspiration	TURBOCHARGED

Configuration

Injection Device	EUI
Turbocharger	TMF55 (1.34A/R)
Charge Air Cooling	AIR TO AIR
Low Idle Speed – r/min	600
High Idle Speed – r/min	2225
Engine Crankcase Vent System	OPEN

Physical Data

Size:	
Length – in. (mm)	57.2 (1453)
Width – in. (mm)	35.0 (889)
Height – in. (mm)	54.2 (1377)
Weight, Dry – lb (kg)	2570 (1166)
Weight, Wet – lb (kg)	2692 (1221)
Center of Gravity Distance:	
From R.F.O.B. (x axis) – in. (mm)	22.3 (566)
Above Crankshaft (y axis) – in. (mm)	8.6 (218)
Right of Crankshaft (z axis) – in. (mm)	-1.4 (-35.6)
Installation Drawing	23515495 Ref.

Mechanical Data

Thrust Bearing Load Limit, Continuous – lb (N)	900 (4000)
Thrust Bearing Load Limit, Intermittent – lb (N)	1800 (8000)
Maximum Static Bending Moment at Rear Face of Block – lb·ft (N·m)	1000 (1356)
Additional Mechanical Data	E4-6060-32-1

Fuel System

Fuel Injector	5235695
Injection Timing Height – mm	78.8
Certification Code	5017
Fuel Consumption – lb/hr (kg/hr)	123.8 (56.2)
Fuel Consumption – gal/hr (L/hr)	17.7 (67.0)
Fuel Spill – lb/hr (kg/hr)	483 (219)
Fuel Spill – gal/hr (L/hr)	69.1 (262)
Total Fuel Flow – lb/hr (kg/hr)	607 (275)
Total Fuel Flow – gal/hr (L/hr)	86.8 (329)
Maximum Fuel Inlet Temperature – °F (°C)	140 (60)
Maximum Fuel Pump Suction:	
Clean System – in. Hg (kPa)	6 (20.3)
Dirty System – in. Hg (kPa)	12 (41)
Fuel Filter Size, Primary – Microns	25
Fuel Filter Size, Secondary – Microns	8
Fuel Spill Restrictive Fitting – in. (mm)	0.08 (2.03

Lubrication System

Oil Pressure at Rated Speed – lb/in.^{2} (kPa)	50 (345)
Oil Pressure at Low Idle – lb/in.^{2} (kPa)	12 (83)
In Pan Oil Temperature – °F (°C)	235 (113)
Oil Flow – gal/min (L/min)	36 (136)
Oil Pan Capacity, High Limit	32 (30)
Oil Pan Capacity, Low Limit	26 (25)
Total Engine Oil Capacity with Filters – qt (L)	38 (36)
Oil Filter, Two Full Flow – Microns	30
Engine Angularity Limits, Front Up – Degrees	27
Engine Angularity Limits, Front Down – Degrees	27
Engine Angularity Limits, Side Tilt – Degrees	21

Electrical System

Recommended Battery Capacity (CCA @ 0°F):	
12 Volt System	1875
24 Volt System	950
Maximum Resistance of Starting Circuit:	
12 Volt System – ohms	0.0012
24 Volt System – ohms	0.002

Cooling System

Engine Heat Rejection to Coolant:	
Rated Speed – Btu/min (kW)	5810 (102.2)
Peak Torque Speed (1200 r/min) – Btu/min (kW)	5150 (90.6)
Charge Air Cooler Heat Rejection:	
Rated Speed – Btu/min (kW)	3504 (61.6)
Peak Torque Speed (1200 r/min) – Btu/min (kW)	1700 (29.9)
Engine Radiated Heat:	
Rated Speed – Btu/min (kW)	2260 (39.7)
Peak Torque Speed (1200 r/min) – Btu/min (kW)	1750 (30.8)
Coolant Flow:	
Rated Speed – gal/min (L/min)	113 (428)
Peak Torque Speed (1200 r/min) – gal/min (L/min)	63 (238)
Thermostat:	
Start to Open – °F (°C)	190 (86)
Fully Open – °F (°C)	205 (96)
Minimum Water Pump Inlet Pressure – lb/in.^{2} (kPa):	0 (0)
Engine Coolant Capacity – qt (L)	24 (23)
Minimum Pressure Cap – lb/in.^{2} (kPa)	7 (48.3)
Maximum Coolant Pressure (Exclusive of Pressure Cap) – lb/in.^{2} (kPa)	17 (117)
Maximum Top Tank Temperature – °F (°C)	210 (99)
Minimum Top Tank Temperature – °F (°C)	160 (71)
Minimum Coolant Fill Rate – gal/min (L/min)	3 (11.4)
Cooling Index (110 °F Ambient w/H_2O @ Sea Level):	
Max Air to Water Diff. @ Rated Speed – °F (°C)	100 (56)
Max Air to Water Diff. @ 1200-1500 r/min – °F (°C)	110 (61)
Deaeration, Air Injection Capacity – ft^3/min (m^3/min)	0.6 (0.017)
Minimum Drawdown Requirement – qt (L)	4 (3.8)

Air System

Maximum Ambient to Turbo Compressor Inlet Temperature Rise – °F (°C)	30 (16.7)
Maximum Air Intake Restriction:	
Clean Air Cleaner – in. H_2O (kPa)	12 (3)
Dirty Air Cleaner – in. H_2O (kPa)	20 (5)
Engine Air Flow: Rated Speed – ft^3/min (m^3/min)	1050 (29.7)
Peak Torque Speed – ft^3/min (m^3/min)	550 (15.6)
Manifold Pressure – in. Hg (kPa)	45.0 (152)
Recommended Intake Pipe Diameter – in. (mm)	5 (127)
Maximum Charge Air Cooler System Total Pressure Drop – in. Hg (kPa)	47.6 (11.8)
Maximum Ambient to Intake Manifold Temp. – °F (°C)	150 (66)
Maximum Crankcase Pressure – in. H_2O (kPa)	3.0 (0.75)

Exhaust System

Exhaust Flow: Rated Speed – ft^3/min (m^3/min)	2330 (66.0)
Peak Torque Speed – ft^3/min (m^3/min)	1490 (42.2)
Exhaust Temperature Rated Speed – °F (°C)	700 (371)
Peak Torque Speed – ft^3/min (m^3/min)	940 (504)
Maximum Back Pressure – in. Hg (kPa)	3.0 (10.1)
Recommended Exhaust Pipe Diameter:	
Single – in. (mm)	5 (127)
Dual – in. (mm)	4 (102)

Performance Data

BMEP – lb/in.^{2} (kPa)	182 (1254)
Friction Power: Rated Speed – fhp (kW)	77 (57)
Peak Torque Speed – fhp (kW)	28 (21)
Altitude Capability – ft (m)	12000 (3660)
Torque Available at 800 r/min – lb·ft (N·m)	867 (1175)

Engine Speed r/min	Rated Power bhp (kW)	Rated Torque lb·ft (N·m)	Rated BSFC lb/bhp·hr (g/kW·hr)
2100	375 (280)	938 (1272)	0.330 (201)
1950	375 (280)	1010 (1369)	0.320 (195)
1800	375 (280)	1094 (1484)	0.311 (189)
1650	360 (269)	1146 (1554)	0.304 (185)
1500	342 (255)	1197 (1624)	0.301 (183)
1350	321 (239)	1249 (1693)	0.301 (183)
1200	297 (222)	1300 (1762)	0.307 (187)

Emissions Data

Certification	1996-98 Nonroad
Smoke, Rated Speed – Bosch Number	0.6
Smoke, Peak Torque Speed – Bosch Number	1.2
Noise – dB(A) @ 1	102.8
Additional Noise Data	Not Available

	2100 r/min g/hr	8 Mode Cycle g/bhp·hr
NO_x	2115	6.53
CO	68	0.58
HC	23	0.11
Particulates	15	0.06

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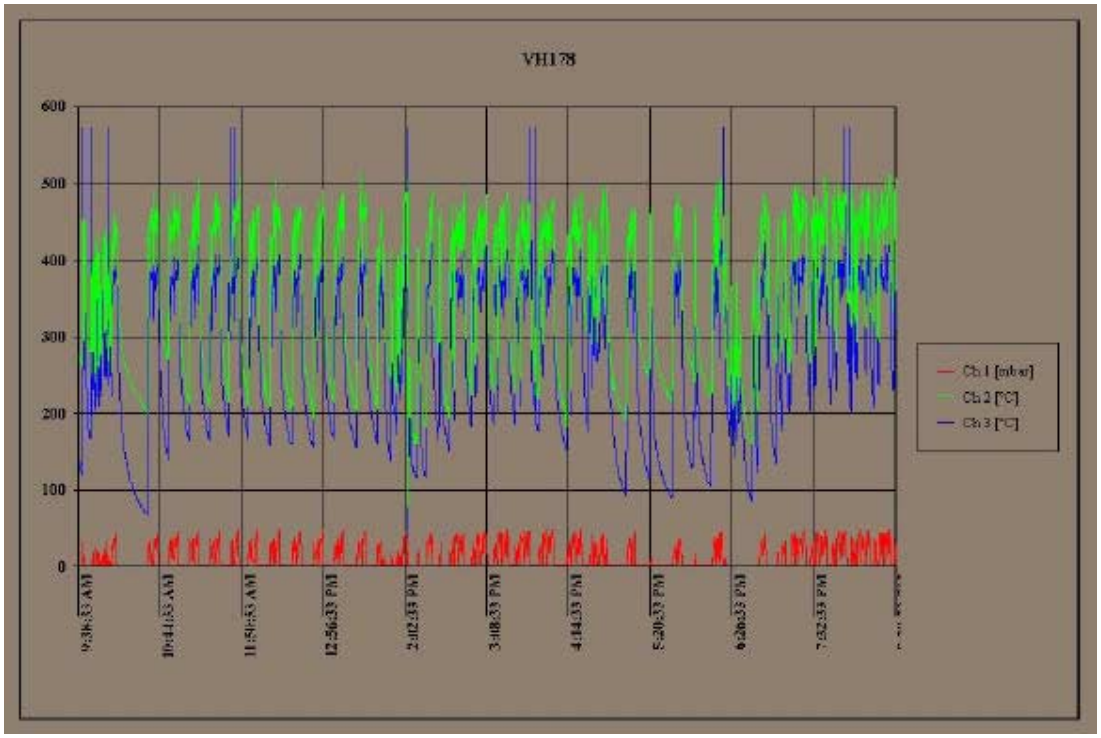
MT436-B Engine Duty Cycle Graphic Analysis

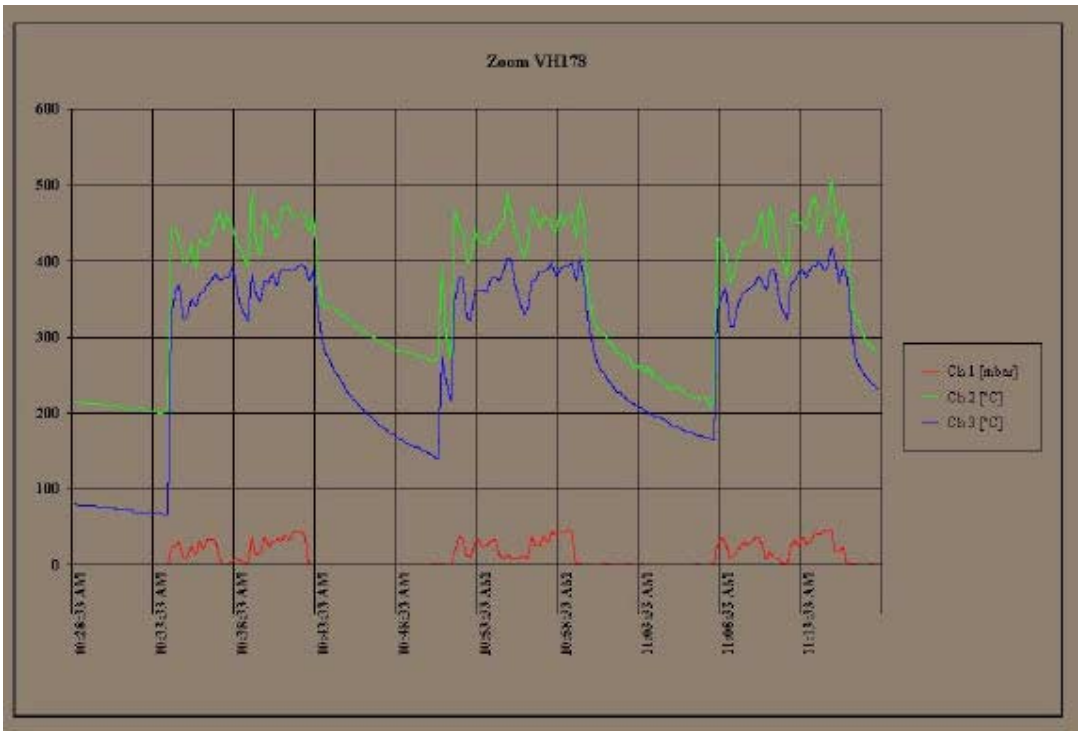
There are two MT436-B haulage trucks equipped with dataloggers. Each has three channels, two for temperature and one for backpresure. Both VH178 and VH179 have been instrumented with temperature sensors immediately after the turbocharger and the other just before the catalytic purifier assembly. This provides an evaluation of the best possible scenario for maximum temperatures next to the turbo as well as the least ideal scenario at approximately 1 m. downstream from the turbo with two 90° elbows inline as well.

As with the scooptrams, the data shown below for these vehicles has been acquired over a period of two months. Although the total operating hours shown for the data in each case is only twelve hours or so it is believed to be as accurate and representative of the vehicle operation as possible. The logging instrumentation has not performed to our expectations but we have made a concerted effort to acquire this information as accurately as possible. At Brunswick Mine the current shift schedule runs two ten and a half hour shifts each day, seven days a week. The twelve hours or so of operating data are ***values measured only when the vehicle is running or the battery master switch has been turned on*** This means that the data represented here would be from one and a half to two full shifts of operation, with different operators on the vehicle for each shift. Any "spikes" in the values either in the graphic or the Excel spreadsheets (included diskette) are due to the switching on and off of the vehicle battery disconnect which also powers the datalogger unit. The time and date stamp cannot be correlated to the actual realtime operation of the vehicle due to a problem with the logger and the switching of the power supply.

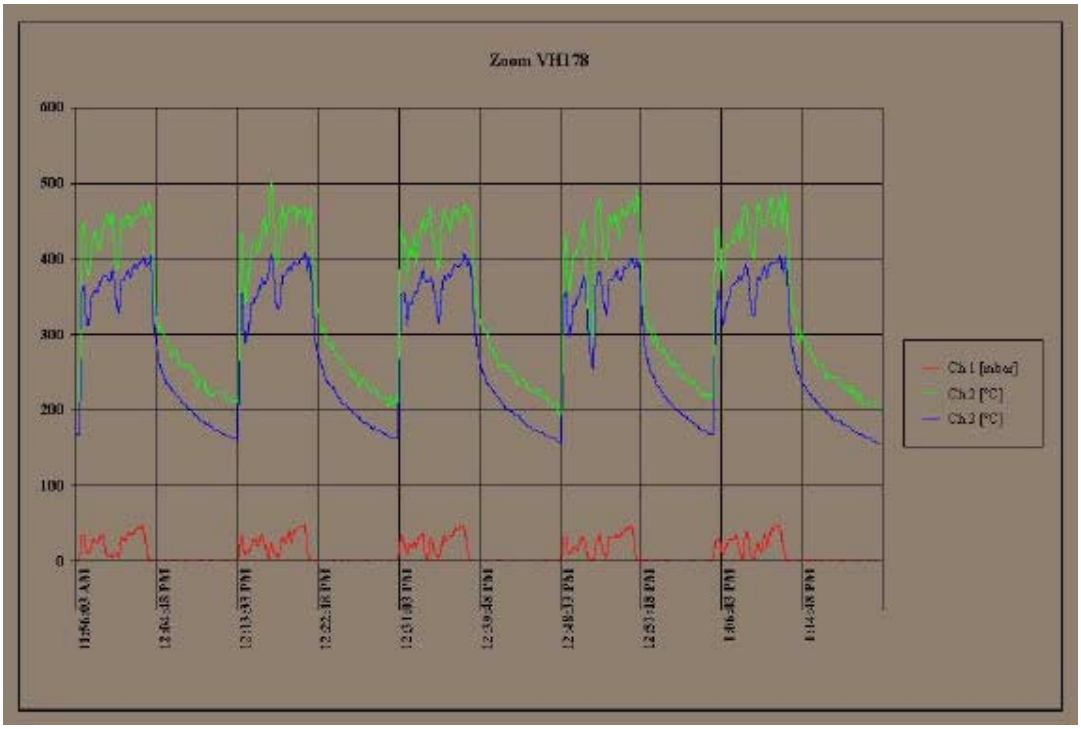
VH178 Haulage Truck



- VH178 Truck – Detroit Diesel Series 60 Engine – 12.7 L.
- Channel 1 (red) = Backpressure at turbocharger
- Channel 2 (green) = Temperature in C° after turbocharger
- Channel 3 (blue) = Temperature in C° 1 m. down from turbo
- Sampling Frequency = 15 seconds
- Note "spikes" are due to switching of power supply
- Note the more transient duty cycle than the scooptram. This reflects the operation cycle of waiting to be loaded by the scooptram and then starting again to haul the load, dump and return.

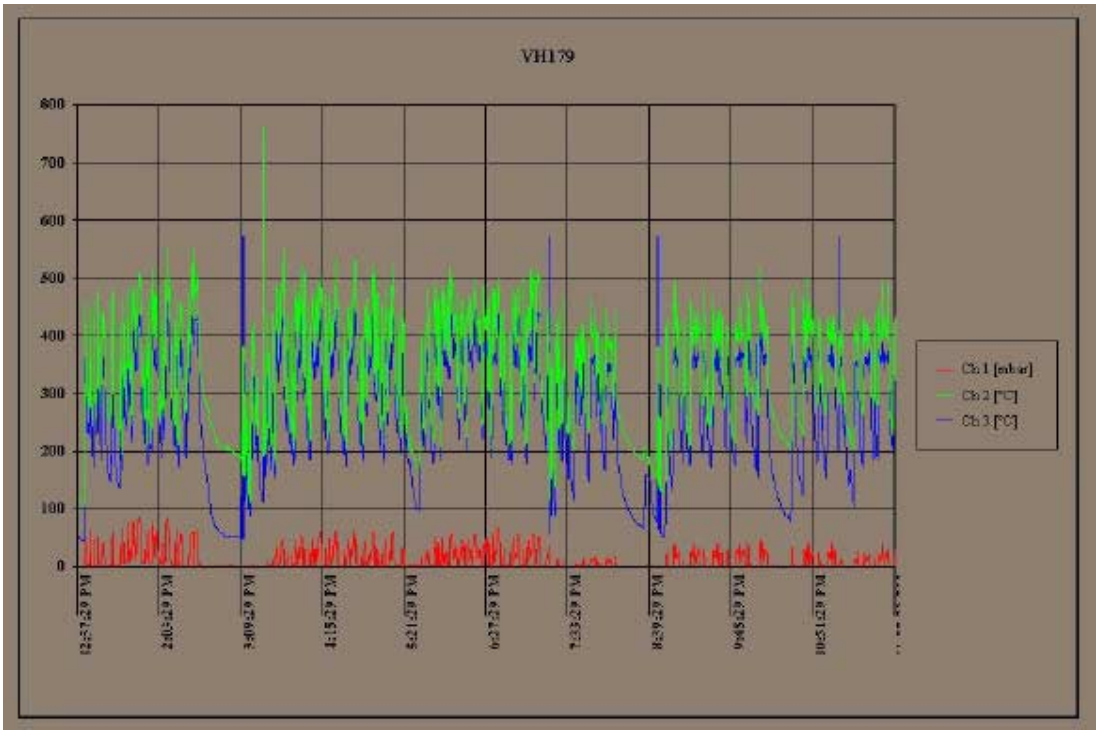


❖ VH178 Zoom – Approximately 1 hour

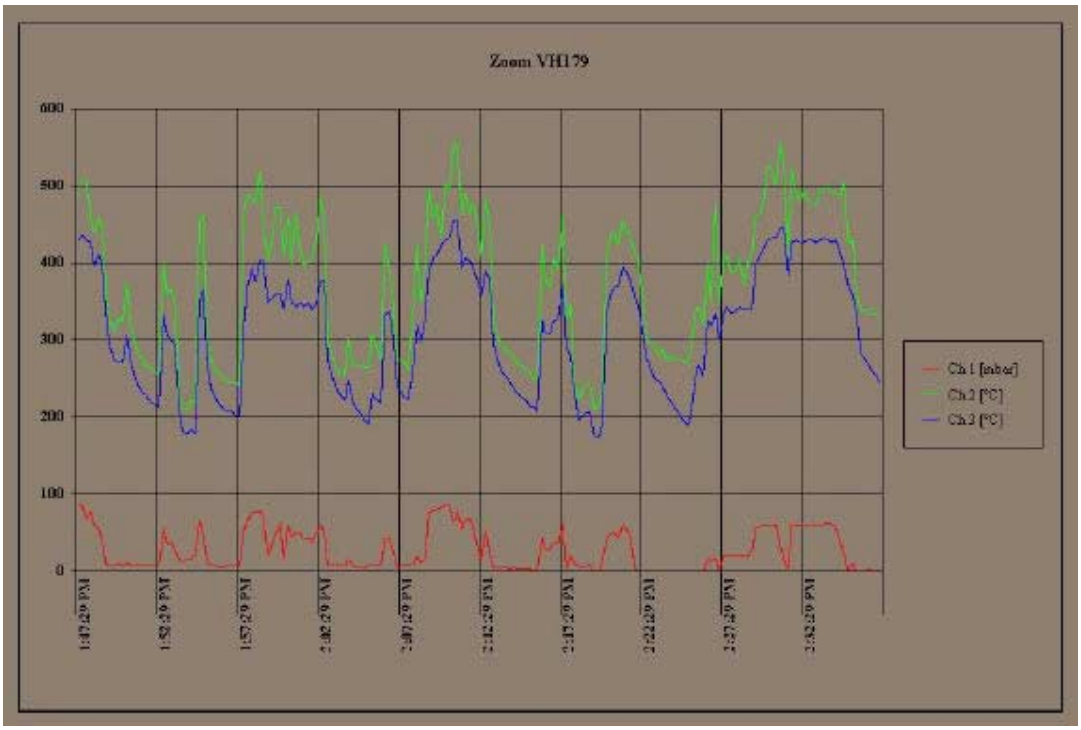


❖ VH178 Zoom – Approximately 1.5 hrs

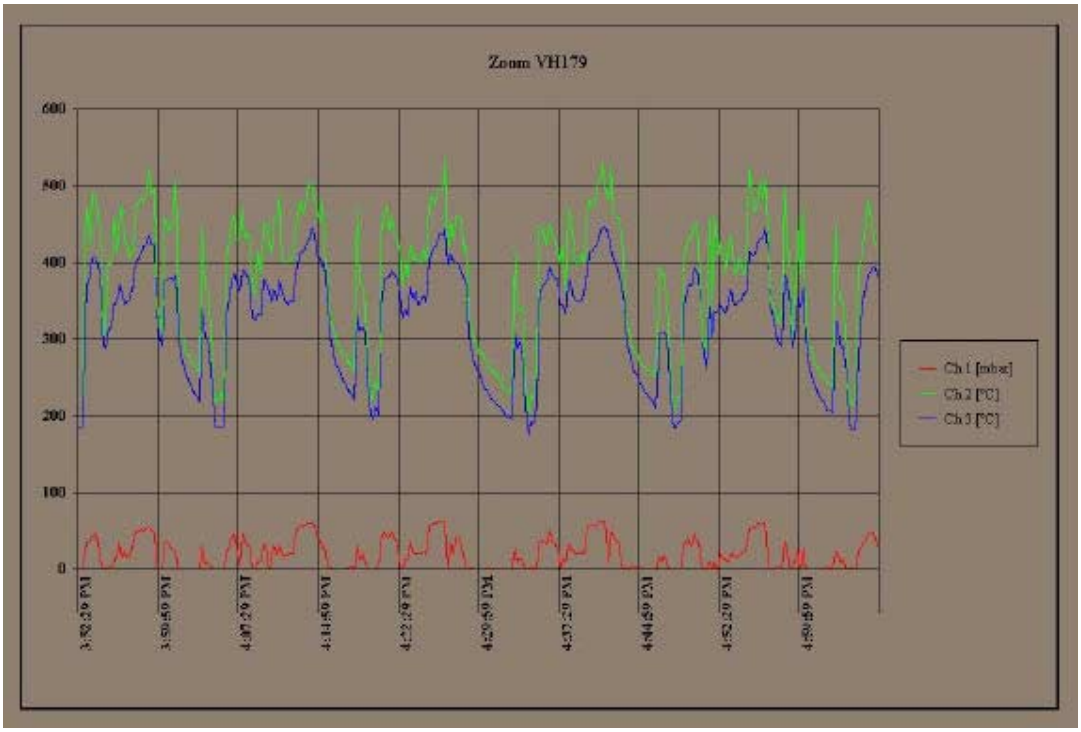
VH179 Haulage Truck



- VH179 Truck – Detroit Diesel Series 60 Engine – 12.7 L.
- Channel 1 (red) = Backpressure at turbocharger
- Channel 2 (green) = Temperature in C° after turbocharger
- Channel 3 (blue) = Temperature in C° 1 m. down from turbo
- Sampling Frequency = 15 seconds
- Note "spikes" are due to switching of power supply
- Note once again the more transient duty cycle than the scooptram, although this units cycles are not as clearly defined as VH178. This reflects the operation cycle of waiting to be loaded by the scooptram and then starting again to haul the load, dump and return.



❖ VH179 Zoom – Approximately 1 hour



❖ VH179 Zoom – Approximately 1.5 hrs

Targets for Brunswick Trap Test

	VERT Specs	Desired DEEP Specs	This Projects requirmts
Pressure loss at rated RPM / full load			
Fresh filter (mbar)	< 50	< 50	< 50
Limit till regeneration (mbar)	< 150	< 150	< 80
Maximum burden (warning) (mbar)	< 200	< 200	< 100
DPM field emissions – (Matter instrument)			
Total carbon (g/kWh)	N/a	< 0.020	< 0.08
Elemental carbon (g/kWh)	N/a	< 0.015	< 0.05
EC nanoparticles (#/cm3) Integral over 10-200 nm	N/a	< 1e4	< 1e6
DPM operator exposure (vehicle mount)			
Total carbon for isolated vehicle (mg/m3)	N/a	< 0.07	< 0.6
Elemental carbon isolated (mg/m3)	N/a	< 0.03 (?)	< 0.2
Costs			
Capital cost ($Cdn /(kW/100)^0.7)	<100	<100	<200
" - simple lifecycle ($Cdn/kWh)	N/a	< 0.03	< 0.04
Operating costs ($Cdn/kWh)	< 0.02	< 0.02	< 0.05
Maintenance per year (VERT % of trap cost, DEEP k$Cdn/y)	<10%	< 2	< 5
Lost production costs ($Cdn/kWh)	N/a		
Total DPFS costs ($Cdn/kWh)	N/a	< 0.06	< 0.15
Reliability and robustness			
Durability or lifetime to replacement (h)	6000	6000	1000
Trap operation until ash removal (h)	2000	2000	1000
Maintenance interval (h)	500	500	250
Lost production time due to DPFS (%)	N/a	< 2%	< 10%
Other concerns			
Additive dosage fully automatic on board	Yes	yes	No

Assumes 1 $Cdn ~ 1 CHF (Swiss franc)
h = engine operating hour
Lost production costs only apply to production vehicles (LHD, trucks not pickups, scissors etc)
200 mbar = 0.2 atm = 0.2 * (33 ft water * 12 "/ft) ~ 80 "water

Particulate trap system datasheet

Manufacturer										
Canadian sales agent										
Filter medium										
Regeneration method										
Monitoring system										
Deployment range From / to:	V(m^3/s)		N (kW)		T exhaust gas (C)		Soot (mg/m^3)			
Trap size / weight Power rating… … … kW	1/kW		1/m^3/s		kg/kW		Kg m^3/s			
Filtration rate, % when Soot laden: Regenerated:	TPM in %		Count in %		Coulom. EC		OC			
Life-cycle: op.h.			Disposal:							
Deployment time: op.h.			Cleaning:							
Experience	Ariz System		Total kW		Total kWh		Longest deploy.			
Deployed in	Stationary engine	Forklift	Auto-mobile		Bus		Truck			
Back pressure (mbar) At rated flow in … m^3/s	New	Laden	Regenerated		Cleaned		Limit			
Service effort	Interval		Time		Cost		Spare parts			
Installation effort	Time				Cost					
Regeneration effort	kWh				Cost					
Muffing (dB)										

DRAFT – 29-09-99

AGREEMENT between

Diesel Emission Evaluation Program ("DEEP")

And

Noranda Inc.-Technology Centre

And

To be determined ("Trap Manufacturers")

And

Detroit Diesel, ("Engine Manufacturer")

And

Atlas Copco Wagner, _____, ("Vehicle Manufacturer")

And

Natural Resources Canada - CANMET

And

The Primary Technical Consultant TTM

Whereas the parties recognize that a Memorandum of Understanding ("MOU") on the Diesel Emissions Evaluation Program ("DEEP") has been executed by Natural Resources Canada - CANMET on February 28, 1997 thereby forming the DEEP Consortium;

Whereas under such MOU the DEEP Management Board has approved on April 30, 1999 the project described in the Project Proposal entitled "Evaluating Diesel Particulate Trap Technology at Noranda – Brunswick Mining Division (the "Project"), to be conducted by Noranda Inc.- Technology Center at its Brunswick Mining operation;

Whereas the parties hereto are participants into the Project, acknowledge their respective responsibilities hereunder, and wish to establish further terms and conditions to it;

Now therefore the parties agree as follows:

1. Object

Noranda shall perform the work described in the Project as described in the Project Proposal. Such work is to be conducted by and under the supervision of Mr. Sean McGinn as the Principal Investigator of the Project (or Project Team Leader).

2. Obligations of the Parties

The Trap Manufacturers will collaborate to the Project with the Principal Investigator and will be closely involved in the In-Mine-Trap-Test with Noranda. In particular, they will:

a) Be members of a "Project Team" as defined in the Project Proposal;
b) Provide in-kind contribution of trap systems;
c) Provide in-kind personnel time of ca. 12 days work to the Project (install, select etc);
d) Provide bench testing at a designated laboratory as per VERT certification process;

All parties hereto recognize and agree to abide by all rules or regulations that Noranda Inc.- Brunswick Mining may adopt from time to time, with respect to the confidential nature of its property or activities, or with respect to health, safety and security, or any other rules or regulations that Noranda Inc. - Brunswick Mining may adopt from time to time for its visitors.

2. Installation of Trap Systems

The parties agree that the trap systems will be selected and installed at Brunswick Mining in cooperation with the Trap Manufacturers, Engine Manufacturer, Vehicle Manufacturer, Noranda Brunswick Mining personnel, Principal Investigator and the Primary Technical Consultant TTM, based on engine data collected with data loggers over a period of 6-8 weeks. The Trap Manufacturer shall appoint some specialists to be available during trap installation and trap removal to provide their collaboration to that effect.

3. Trouble Shooting, Replacement, Repairs

All vehicles being equipped with traps are operating in production areas at very tough schedules. Interruptions due to failures, readjustment or repairs must be shortened to the absolute minimum. Trap manufacturers must either provide spare traps or repair personnel within the shortest possible time. Adequate resolution of these issues must be agreed between trap manufacturer and principal investigator prior to installation date.

4. Intellectual Property

In this paragraph, "Intellectual Property" shall mean any invention, process, method or improvement that can be protected by patents, trade-marks, copyrights, industrial designs, or other proprietary know-how. The parties understand and agree that all background Intellectual Property remains the property of the party who is the owner of it and that no licensing rights are hereby implied from that owner by participating into the Project. All arising Intellectual Property developed under this Project shall be the joint property of all parties, including the DEEP consortium members.

5. Ownership and Disposal of Equipment, Instrumentation and Supplies

Equipment, instrumentation and supplies acquired during the Project remain the property of their original in-kind contributor or purchaser. Particularly, should any Trap Manufacturer withdraw from the Project, it may reclaim and remove its trap from testing with no obligation to the other parties participating to the Project.

6. Confidentiality

The parties understand and agree that Noranda Inc. – Brunswick Mining may disclose some of its scientific, technical and commercial information during the Project ("Confidential Information"), including without limiting the generality of the foregoing information in relation to its general mining operations. Such information is proprietary to Noranda Inc. and may not be disclosed to third parties or used by the parties hereto otherwise than for the purpose of the Project.

7. Term

The term of this Project shall be of eighteen months from the date of installation of the traps at Brunswick Mining.

8. Cancellation or Termination of Participation

Any Trap Manufacturer, or any party to the Project, is free to withdraw from the Project at any time within 30 days prior written notice to the Principal Investigator.

The parties recognize and agree that the withdrawal of any critical party could result in a failure to complete the work under the Project and produce useful results in spite of significant expenditures by the parties, and hereby waive all recourses against any party hereto for that situation.

9. Publications

Results and data gathered by the Principal Investigator under the Project and any report issuing thereof may be published provided that it does not contain any Confidential Information. Also, the parties understand that Trap Manufacturers shall be entitled to use such results and data collected with respect to their traps during the Project for their own purposes.

10. Indemnities, Representations, and Warranties

The parties shall incur no liability arising from their participation to the Project except from liability arising from their negligence. The DEEP or no party hereto shall incur any liability for any damage whatsoever, including loss of profits, due to disclosure of unfavorable results of their trap (unless such results would be erroneous or negligent).

In particular, the Trap Manufacturers shall not be liable for the cost of lost production, test duration, loss of data or results etc, due to the faulty performance of their trap. They do not have to guarantee a minimum performance of the specific trap being used, as it is assumed that generic VERT tests are sufficient proof of potential performance. They are responsible for delivering the traps to the minesite (or bench test) in good condition.

The parties recognize that underground operating environment can be very harsh. Accordingly, neither Noranda – Brunswick Mining nor DEEP stakeholders will be liable for any direct, indirect or consequential damage or any damage whatsoever arising out of the Project, including the wear and tear and physical damage experienced by traps being tested on working vehicles.

11. Open Exchange of Information

All information relating to the traps will be forwarded from Principal Investigator or the Primary Technical Consultant TTM to the Trap Manufacturers as soon as they are available in order to receive feedback at the earliest possible date.

It is also expected that all information regarding the trap condition after test will be forwarded from the Trap Manufacturer to Principal Investigator and the Primary Technical Consultant TTM without major delays.

We hereby agree to these terms and conditions:

FOR THE MINE:
Brunswick Mining

_____

_____
Signature Date

FOR THE TRAP MANUFACTURERS:
Name of Company

_____

_____
Signature Date

FOR THE VEHICLE MANUFACTURER:

Atlas Copco Wagner

_____
Signature Date

FOR THE ENGINE MANUFACTURER:

Detroit Diesel

_____
Signature Date