

# DPM-RT

## Operating Manual

Version 1.1



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# **DPM-RT Real-Time Diesel Particulate Analyser**

## **Operating Manual**

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# 1 Chapter 1 : Safety

## 1.1 Introduction

Thoroughly read this manual before operating the equipment and comply with the instructions.

Always display the manual in a conspicuous location.

Personal injury and property damage incurred due to non-compliance with these safety instructions are not covered by the product liability regulations.

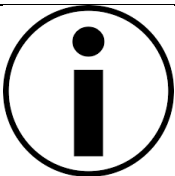
## 1.2 Symbols



Failure to comply with instructions could result in personal injury.



Failure to comply with instructions could result in property damage.



Important information.



Class 3B Laser radiation when open. 3B lasers are hazardous for eye exposure. Do not dismantle or modify unit.

No user serviceable parts in side. Refer servicing to authorised personnel.

## 1.3 Intended Use

- This testing device is a technical piece of equipment that is to be used exclusively for its intended purpose.
- The testing device may not be modified without the express written consent of the manufacturer.

## **1.4 Safety Instructions for Operation**

The accident prevention regulations of the country in which the Particle Measurement Unit is being operated apply.

The Particle Measurement Unit may not be installed and operated in hazardous locations or washing bays.

The Particle Measurement Unit may only be used for its intended purpose and within its stated performance limits.

The Particle Measurement Unit may only be operated by trained personnel.

All parts of the Particle Measurement Unit must be protected from moisture and corrosive substances.

The Particle Measurement Unit and the surrounding work area must be kept clean.

Running vehicle engines in closed rooms represent potential carbon monoxide poisoning. The operator/owner is responsible for providing sufficient air ventilation.

## **1.5 Safety Instructions for Servicing**

Repair work of any kind (other than routine servicing explicitly covered in this operator manual) may only be done by authorized service technicians. In case of non-compliance the warranty becomes void.

## 2 Chapter 2 : Description

## Chapter

# 2

The dPM-RT is a self-contained maintenance tool which continuously measures the concentration of fine particulate matter (PM) in the exhaust of diesel engines, using standardized tests developed in joint government/mining industry projects.

The measurement principle is based on well-established laser light-scattering technologies, which are widely accepted and used for measurement of particle concentrations in numerous laboratory and industrial applications.

The dPM-RT takes this technology several steps further, by adding sophisticated automated data processing capabilities and by ruggedizing the design to withstand the harsh operating conditions. Simple and accessible user maintenance greatly reduces the need for inconvenient "back-to-base" servicing.

Ensuring the accuracy and consistency of measurement is vitally important. As well as performing an auto-zero at the start of each test, the instrument's calibration can be checked by the operator in less than a minute, using the supplied Calibration-Check Plug.

A single HEPA grade filter is used to remove over 99.9% of particles before releasing the measured sample stream into the atmosphere. The filter unit is a standard screw-off housing design with a disposable filter element. No tools are required to change the filter element. A second disposable HEPA filter\* is located inside the case to continuously filter a stream of ambient air which protects the optical elements from contamination by soot or moisture in the sample.

\*Note: this filter is only serviced annually when returned to your local service centre or manufacturer.

Unlike other DPM measurement methods which require off-line analysis or manual interpretation, the dPM-RT continuously displays DPM concentration, and provides an immediate overall test result at completion of a test. This means that maintenance decisions can be made without delay, and the effectiveness of any maintenance action can be confirmed prior to releasing the equipment back to the workplace.

Weighing approximately 3kg (including its integral battery), the instrument is self-contained and is designed for stand-alone operation. With around ~ 3 hours continuous testing on a single charge, most operators prefer to use the instrument on battery power.

Designed specifically for operation in the harsh environments typically associated with mobile and stationary diesel engines, the instrument incorporates a number of features that enhance its usefulness in "real-world" situations, including:

- simple "one button" operation
- rugged construction for on-site applications
- user-maintainable with minimal tools
- very wide measurement range (0.1...420 mg/m<sup>3</sup> elemental carbon)
- automatic instrument zero setting prior to every test
- field calibration check in less than 1 minute using supplied calibration-check plug

## 3 Chapter 3 : Setting Up the DPM-RT

### Chapter

# 3

### 3.1 Unpacking

The dPM-RT instrument and its accessories are shipped from the factory in a single box. The box contents are as follows:

- dPM-RT instrument
- Tail pipe probe
- Sample hose
- Battery charger (100 -- 240 V, 50/60 Hz)
- Calibration-Check Plug (requires external software – contact supplier)
- 5 x Spare filter elements (external filters)
- Operator manual
- Remote 'Enter' button with 7m cable
- Heavy duty portable carry case (w/- wheels, carry handle)

### 3.2 Instrument Setup

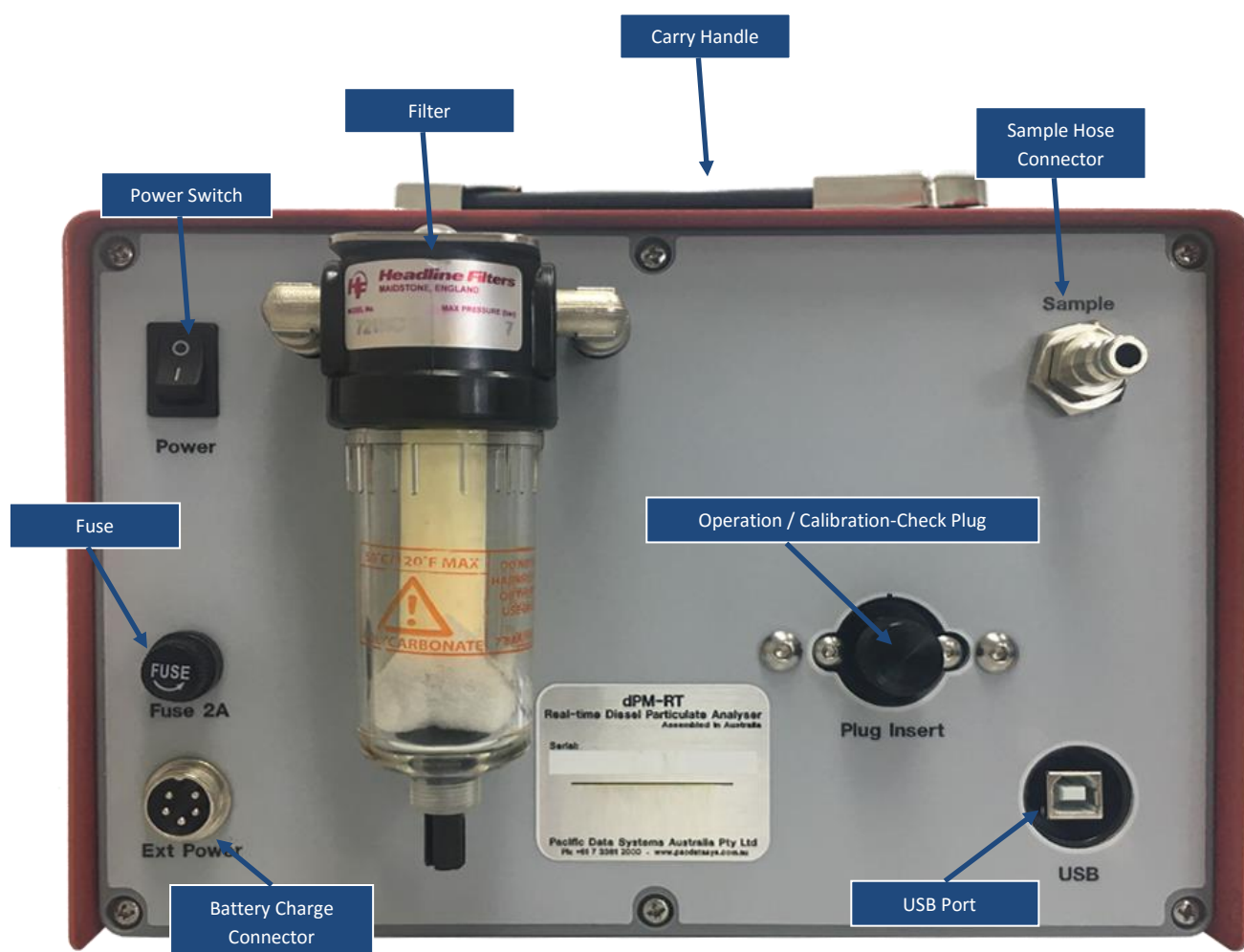


Fig. 1: Rear Panel (Standard Instrument)



### 3.3 Power Supply

The Particle Measurement Unit is powered by its internal NiMH battery and may be operated while the battery is being charged with the supplied battery charger.

### 3.4 Sample Hose Connector

For easy storage, the sample hose is removable from the tail pipe probe, and the dPM-RT instrument.

To separate, simply disconnect the hose by pulling back on the knurled connector.  
To reconnect, push the connectors together until the sample hose clicks into place.

### 3.5 USB Port

Only accessed by authorised service centre or manufacturer.

### 3.6 Remote Control

The wired remote-control button may be connected to the 6mm jack connector at the lower right-hand corner of the front panel. The function of the remote control is to duplicate the **ENTER** key on the front panel, facilitating one-person testing by allowing the instrument to be operated from the driving position of the vehicle or equipment under test.

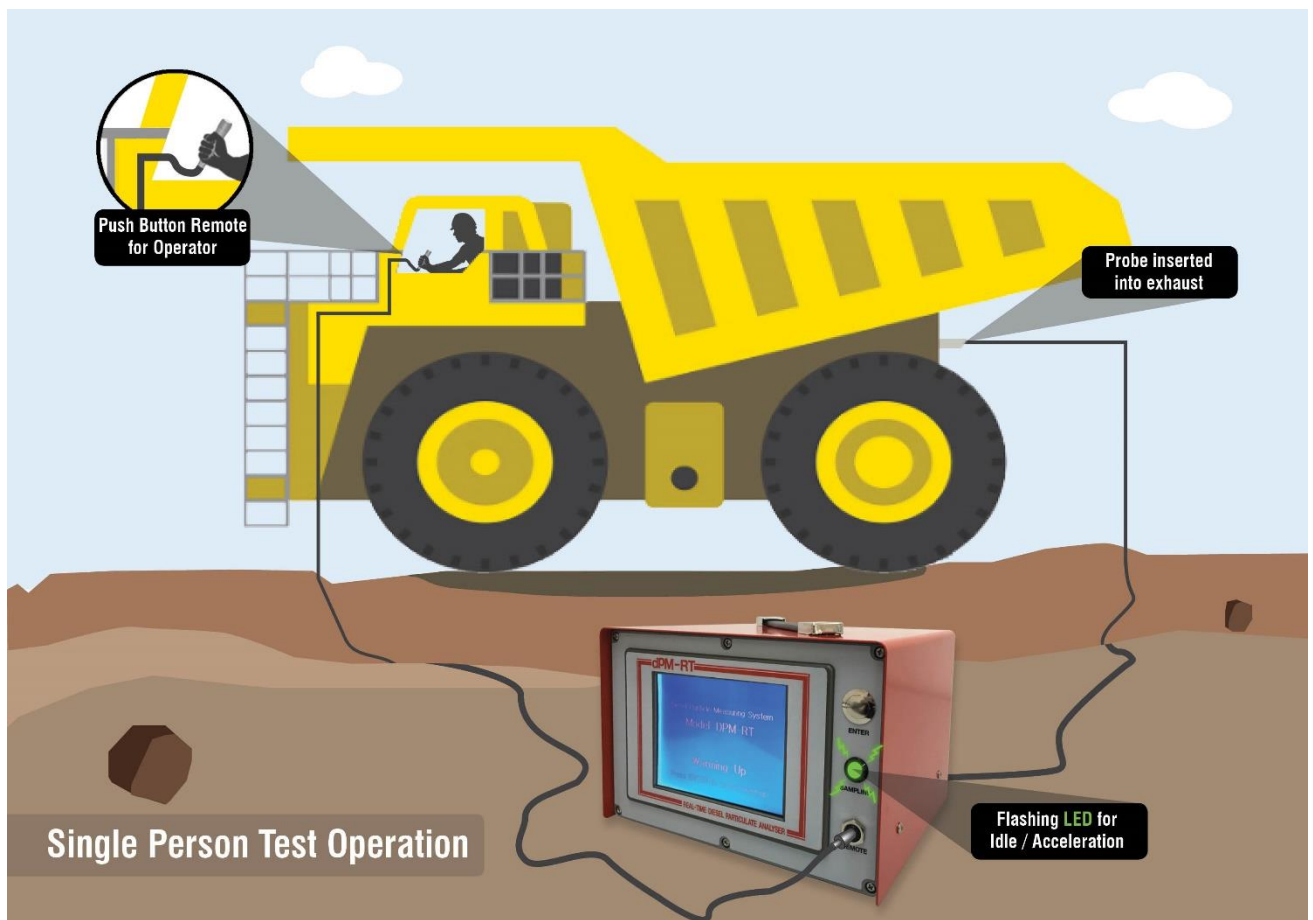


Fig. 2: Single-person operation via remote control

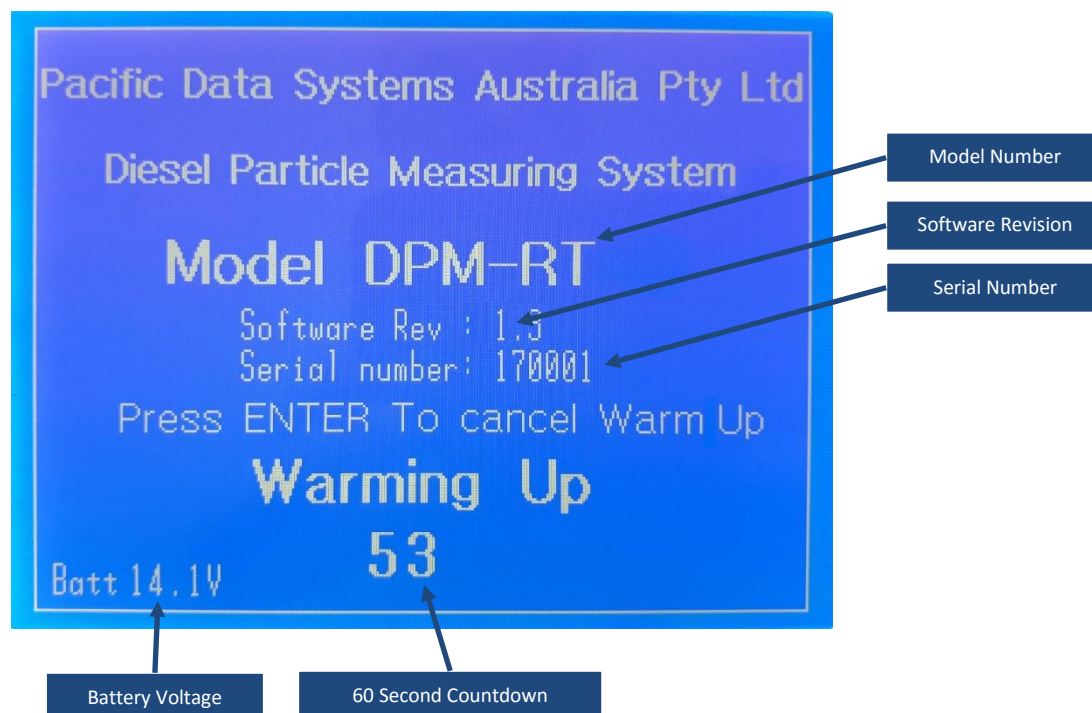
## 4 Chapter 4 : Operation

### Chapter

# 4

### 4.1 Warm up

The warm-up screen provides information regarding the unit including serial number and software revision. This screen also allows the sampling chamber to get to operating temperature.



The warm-up screen can be exited by pressing the “ENTER” button.

## 4.2 Test Selection

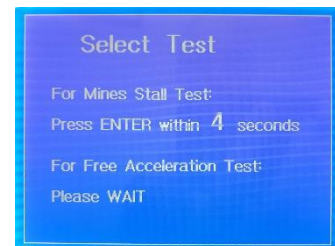
The dPM-RT is pre-programmed to lead the operator through one of two standardised test procedures; either a **Stall Test** for vehicles and plant with a torque converter, and a **Free Acceleration Test** for other types of equipment, such as vehicles with a manual clutch.

Pressing the **ENTER** button during the 5 second countdown will initiate a **Stall Test**.

If the **ENTER** button is not pushed during the countdown, the instrument will automatically initiate a **Free Acceleration Test** routine.

See the note (next page) for an introduction to the available tests.

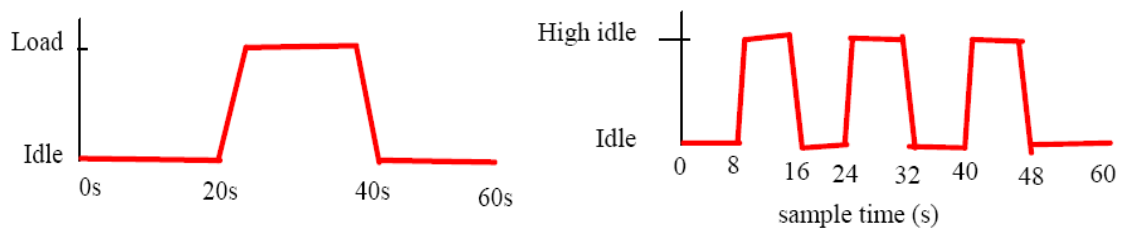
For **continuous measurement**, (for instance while testing for longer periods under actual operating conditions) hold down the **ENTER** button while turning on the power switch. This operating mode also allows calibration checks to be done more quickly and conveniently.



### NOTE

Appendix A to this document contains an extract from the MDG 29 guidelines relating to the stall and free acceleration tests. The full MDG 29 document covers a wide range of additional material relevant to management of air quality in underground mines. A hyperlink to the full MDG 29 document is also in Appendix A.

Each of the pre-programmed tests has a duration of 60 seconds, and both have two engine modes: for the stall test these are idle and full power; for the free acceleration test they are idle and full throttle governed engine speed (no load). See Figures 3 and 4 below.



Stall and Free Acceleration Tests

## 4.3 Auto-Zero Adjust

Prior to any test, the instrument initiates an auto-zero procedure, prompting the operator to ensure that the sample probe is located in relatively clean air (for instance, not directly downstream from the exhaust of an operating engine). This procedure ensures the exhaust paths into the machine are clear from exhaust fumes.

The auto-zero procedure is completed in approximately 10 seconds but if the machine detects diesel particles it will restart the Auto-Zero test.

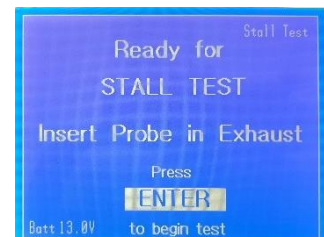


## 4.4 Stall Test

The Stall Test consists of 20s Idle, 20s Full Power and 20s Idle. Total time: 60 seconds.

### 4.4.1 Insert Probe

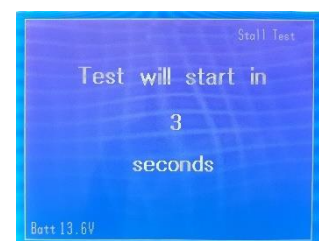
Insert the supplied sample probe fully into the exhaust of the vehicle or plant under test, using the spring wire retainers to secure the probe in position. Confirm that the engine is running and at normal operating temperature, with the transmission engaged in accordance with the MDG 29 procedures.



### 4.4.2 Initiate Test

After inserting the probe, check that the vehicle or plant under test is chocked or braked to prevent movement and ensure that all personnel are clear. With the test operator at the controls, check for clear line of sight to the dPM-RT screen. When ready, press the ENTER push button.

The green LED on the front panel will illuminate (steady) and a 5 second countdown will start, allowing the operator to anticipate the time when measurements will commence.



### 4.4.3 Run Test

Immediately after the countdown, the instrument will start measuring and storing PM concentration measurements, and the display will change to the following "IDLE" screen.

To assist the operator, the green LED will flash slowly, indicating measuring is ON and the engine should be at normal idle speed (with the transmission engaged).



After 20 seconds the green LED with start to flash quickly, indicating the “Full Power” mode of the test. At this point the operator should rapidly apply full throttle and hold the engine at full throttle.

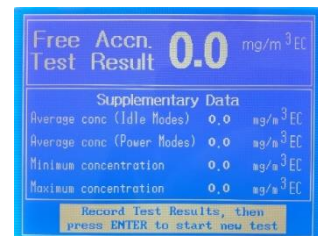
The screen changes to show “FULL POWER” and updates the exhaust PM concentration every second.



After 20 seconds at full throttle the green LED once again flashes slowly, indicating a return to normal idle speed. The operator should rapidly return the throttle to the idle position.



After 20 seconds at idle, measurements are terminated. At this point the LED is turned off and the screen flashes a brief “TEST COMPLETED” message. The screen then displays the overall test result in bold characters, together with some other test data which may aid maintenance personnel to identify any emission-related faults in the engine or fuel management system.



To retain the simplicity of the test procedure, manually record the test result, the date/time and the vehicle or plant identification information.



## 4.5 Free Acceleration Test

The format of the **Free Acceleration Test** is similar to that of the **Stall Test**, but there are some important differences, notably:

- testing is performed with the transmission in neutral
- there are three acceleration peaks, compared with just one in the Stall Test.

The test consists of: 8s idle, 8s full power, 8s idle, 8s full power, 8s idle, 8s full power, 12s idle.  
For completeness, the full test procedure follows.

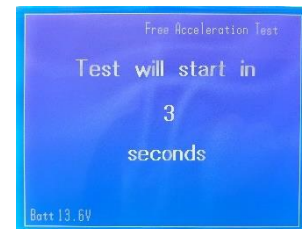
### 4.5.1 Insert Probe

Insert the supplied sample probe fully into the exhaust of the vehicle or plant under test, using the spring wire retainers to secure the probe in position. Confirm that the engine is running and at normal operating temperature, with the transmission disengaged in accordance with the MDG 29 procedures.



### 4.5.2 Initiate Test

After inserting the probe, check that the vehicle or plant under test is chocked or braked to prevent movement and ensure that all personnel are clear. With the test operator at the controls, check for clear line of sight to the dPM-RT screen. When ready, press the ENTER push button. The green LED on the front panel will illuminate (steady) and a 5 second countdown will start, allowing the operator to anticipate the time when measurements will commence.



### 4.5.3 Run Test

Immediately after the countdown, the instrument will start measuring and storing PM concentration measurements, and the display will change to the following "IDLE" screen.

To assist the operator, the green LED will flash slowly for 8 seconds, indicating measuring is ON and the engine should be at normal idle speed (with the transmission engaged).



The green LED will then flash quickly for a further 8 seconds, indicating the first "Full Throttle" (Regulated Speed) mode of the test. At this point the operator should rapidly apply full throttle and hold the engine at full throttle. The screen changes to show "FULL POWER" and updates the exhaust PM concentration every second.



Subsequently, every 8 seconds the LED flashing speed and screen display alternate between Idle and Full Power Modes.



Full Power (8 seconds).....



Idle (8 seconds).....



Full Power (8 seconds).....

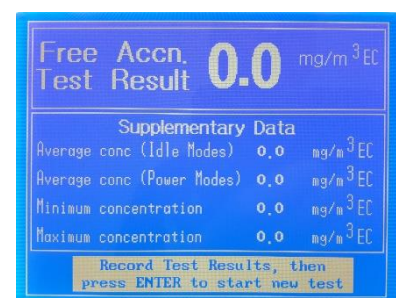


Idle (12 seconds).....



After the final 12 seconds at Idle, measurements are terminated.

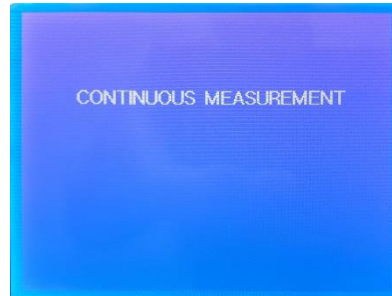
At this point the LED is turned off and the screen flashes a brief "TEST COMPLETED" message. The screen then displays the overall test result in bold characters, together with some additional test data which may aid maintenance personnel to identify any emission-related faults in the engine or fuel management system.



## 4.6 Continuous Measurement

The dPM-RT also has a capability to continuously measure and record DPM concentration. This feature is very useful if you wish to record DPM over an extended period, such as on-vehicle monitoring during normal work activities.

To initiate the continuous measuring mode, turn the dPM-RT **OFF**, then, while holding down the **ENTER** button, switch the dPM-RT back **ON**. The following screen will be displayed.



Alternatively, the **ENTER** button may be held down while the unit displays the 'Restarting' screen which will give you 5 seconds to hold the **ENTER** button down. The machine will then restart and continuous measurement will be selected.



When the **ENTER** button is released, the zeroing screen will appear which will prompt you to hold the tail pipe probe in clean air and press **ENTER**.

After setting the probe in the tailpipe of the equipment under test, press **ENTER** once again and continuous measurement will commence, after a 5 second countdown.



Running vehicle engines in closed areas represents a risk of potential carbon monoxide poisoning.

➤ The operator/owner is responsible for providing sufficient air ventilation.

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## 5 Chapter 5 : Calibration

### Chapter

# 5

### 5.1 Using the Calibration-Check Plug

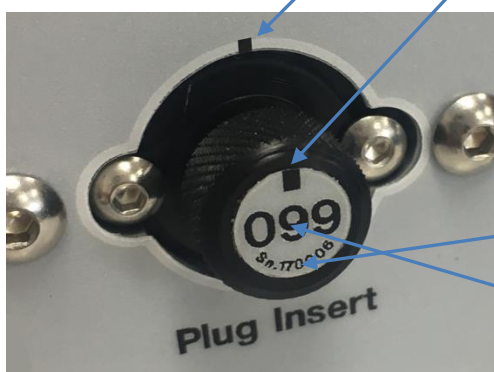
The analyser has been factory calibrated to deliver a linear output directly proportional to the concentration of PM. Given the linearity of response, a simple “Zero and Span” check provides an excellent and rapid confirmation of calibration status. The supplied calibration-check tool generates the span response. The procedure follows:

- Perform the "Warm up" and "Zero Set" procedures above.
- Put the instrument in “Continuous Measuring” mode (see Section 4.6), with the sample probe resting in relatively clean air (i.e. not downstream of any vehicle exhaust).
- Remove the Operating Plug from the rear panel of the analyser by rotating it counter-clockwise and then pulling directly from its socket. If the plug has not been removed for some time, it may require a firm pull to overcome O-ring friction. Occasional light application of silicon grease will help to avoid this.



Calibration-Check Plug (left) and Operating Plug (right)

- After carefully cleaning the calibration plug using a lint-free cloth (**DO NOT use paper tissue**), insert the Calibration-Check Plug and rotate clockwise until it is firmly engaged on the stop pins. Ensure that the plug is oriented so that black indicator / mark on the back face of the Calibration-Check Plug is aligned with the black indicator / mark on the instrument case.



Back Face of Calibration-Check Plug.

Note: Serial # shown on Calibration-Check Plug is unique to each instrument

- Confirm that the numerical reading on the screen is approximately the same ( $\pm 5\%$ ) as the number labelled on the Calibration-Check Plug.
- If the displayed reading is still not  $\pm 5\%$  of the number labelled on the Calibration-Check Plug supplied with the instrument (number on Calibration-Check Plug is unique to each instrument), some further adjustment will be required using specialist calibration software. In this instance, the dPM-RT instrument will need to be returned to your local service centre for further analysis.

## 6 Chapter 6 : Technical Specifications

### Chapter

# 6

<b>Measurement Method</b>	Laser light-scattering photometry
<b>Particle Size Range</b>	<100nm to 10 microns
<b>Particle Concentration Range</b>	0.1 to 420 mg/m <sup>3</sup> (Elemental Carbon)
<b>Resolution</b>	0.1 mg/m <sup>3</sup>
<b>Sample Flow</b>	2.0 lpm (nominal)
<b>Accuracy</b>	+/-18% of reading
<b>Range Selection</b>	Auto-Ranging
<b>Zero Check</b>	Auto-Zero prior to every test
<b>Field Calibration</b>	One minute span check (Calibration-Check Plug supplied)
<b>PC Connection</b>	USB
<b>Display</b>	320 x 240 blue/white graphic LCD display.
<b>Operating Voltage</b>	12V DC (via external 240/12V adapter), or internal NiMH battery
<b>Battery Operation</b>	~3 hr continuous operation per charge
<b>Operating Current</b>	2.0 amp (max)
<b>Analyser Mass</b>	4kg (approx)
<b>Supplied Accessories</b>	Tail pipe probe, high-temperature sample hose, Battery charger (100 -- 240 V, 50/60 Hz), Calibration-Check Plug (requires external software - contact supplier), 5 x Spare filter elements (external filters), remote 'Enter' button with 7m cable, Heavy duty portable carry case (w/- wheels, carry handle), Operator manual.
<b>Temperature</b>	- 20 °C to + 50 °C

# **7 Chapter 7 : Appendix A – MDG 29**

## **Test Procedures (Extract)**

### **Chapter**

# **7**

The following text is an extract from the MDG 29 document (full title “**Guideline for the management of diesel engine pollutants in underground environments**”). The complete document can be downloaded from:

[http://www.resourcesandenergy.nsw.gov.au/\\_data/assets/pdf\\_file/0011/419465/MDG-29.pdf](http://www.resourcesandenergy.nsw.gov.au/_data/assets/pdf_file/0011/419465/MDG-29.pdf)

### **6.3.2 Procedures for Monitoring Raw Diesel Particulate Emissions**

#### **6.3.2.1 Standard Method**

All diesel particulate testing shall be carried out using the following method unless the diesel engine cannot be held in the load condition for 20 seconds in which case testing shall be carried out in accordance with clause 6.3.2.2 below.

- a) Testing equipment shall comply with clause 8.2 *Diesel Particulate Monitoring Equipment*.

**Note:** It is not possible to use the Bosch Smoke Meter for the above tests due to its inability to measure over a 60 second sampling period.

- b) Exhaust sampling and analysis shall be carried out by a person competent to the satisfaction of the mine mechanical engineer to carry out such test or by a licensed laboratory.
- c) The diesel engine shall be operated until the engine temperature stabilises. Exhaust particulate sampling and analysis shall be performed when the diesel engine is at normal operating temperature.
- d) The vehicle must be safely chocked and the vehicle brakes must be applied.

#### **Important Safety Notice**

As engines must be tested in the load condition requiring the drive train to be engaged during testing it is important the vehicle is adequately chocked or restrained and the brakes applied to ensure it cannot “jump” or run away while the diesel engine is under throttle during the test.

- e) Place vehicle in third gear or other gear as specified by the equipment manufacturer to carry out the test.
- f) Run the engine at idle speed.
- g) Insert sensor probe into the undiluted raw exhaust before any particulate treatment.

**Note:** This may be downstream of catalytic converters and water based scrubbers but must be before any particulate filter.

- h) Testing shall be carried out over a 60 second cycle and on the undiluted raw exhaust as indicated in **Figure 1** below.

**Notes:**

1. It is important that the timing of the idle and full throttle settings is as accurate as possible. To ensure good repeatability, it is advisable for the operator to practice the procedure several times prior to collecting a sample.
  2. Sampling should commence in the first idle period and continue until the final idle period.
  3. Engines with a constant load, such as a diesel generator or pump should be analysed with the load applied over the full 60 seconds.
- i) Start sampling timer on analyser.
- j) After 20 seconds have an operator quickly apply full throttle to engine (still in third gear) and hold for 20 seconds.
- k) Quickly release throttle and allow engine to decay to idle while sampling for 20 seconds.
- l) Stop sampling timer on analyser.
- m) The total sampling time is 60 seconds. The sampling must pick up rise and decay of the engine from idle to full throttle and return to idle.
- n) Remove the probe if no further testing is required.
- o) Record the mean (average) engine exhaust diesel particulate concentration in (mg/m<sup>3</sup>).

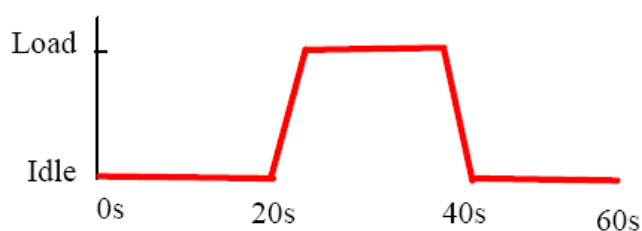


Figure 1 – Diesel particulate load cycle – Standard method

### 6.3.2.2 Alternative Method

Where testing in accordance with clause 6.3.2.1 above is not practicable (such as engines fitted with manual clutches) diesel particulate testing of the undiluted raw exhaust of diesel engines shall be carried out as follows:

- a) Testing equipment shall comply with clause 8.2 *Diesel Particulate Monitoring Equipment*.

**Note:** It is not possible to use the Bosch Smoke Meter for the above tests due to its inability to measure over a 60 second sampling period.

- b) Exhaust sampling and analysis shall be carried out by a person competent to the satisfaction of the mine mechanical engineer to carry out such test or by a licensed laboratory.
- c) The diesel engine shall be operated until the engine temperature stabilises. Exhaust particulate sampling and analysis shall be performed when the diesel engine is at normal operating temperature.
- d) The vehicle must be safely chocked and the vehicle brakes must be applied.

#### *Important Safety Notice*

As engines must be tested in the load condition requiring the drive train to be engaged during testing it is important the vehicle is adequately chocked or restrained and the brakes applied to ensure it cannot “jump” or run away while the diesel engine is under throttle during the test.

- e) Place vehicle in third gear or other gear as specified by the equipment manufacturer to carry out the test.
- f) Run the engine at idle speed.
- g) Insert sensor probe into the undiluted raw exhaust before any particulate treatment.

**Note:** This may be downstream of catalytic converters and water based scrubbers but must be before any particulate filter.

- h) Testing shall be carried out over a 60 second cycle and on the undiluted raw exhaust as indicated in **Figure 2** below.

#### **Notes:**

1. It is important that the timing of the idle and full throttle settings is as accurate as possible. To ensure good repeatability, it is advisable for the operator to practice the procedure several times prior to collecting a sample.
  2. Sampling should commence in the first idle period and continue until the final idle period.
  3. Engines with a constant load, such as a diesel generator or pump should be analysed with the load applied over the full 60 seconds.
- i) Start sampling timer on analyser.
  - j) Continue to idle until timer indicates 8 seconds.
  - k) Have an operator quickly apply full throttle, hold until timer indicates 16 seconds and quickly release throttle.
  - l) Idle engine until timer indicates 24 seconds.
  - m) Quickly apply full throttle again, hold until timer indicates 32 seconds and quickly release throttle.

- n) Idle engine until timer indicates 40 seconds.
- o) Quickly apply full throttle again, hold until timer indicates 48 seconds and quickly release throttle.
- p) Idle engine until timer indicates 60 seconds then stop sampling timer on analyser.
- q) The total sampling time is 60 seconds. The sampling must pick up rise and decay of the engine from idle to full throttle and return to idle for each cycle.
- r) Remove the probe if no further testing is required.
- s) Record the mean (average) engine exhaust diesel particulate concentration in ( $\text{mg}/\text{m}^3$ ).

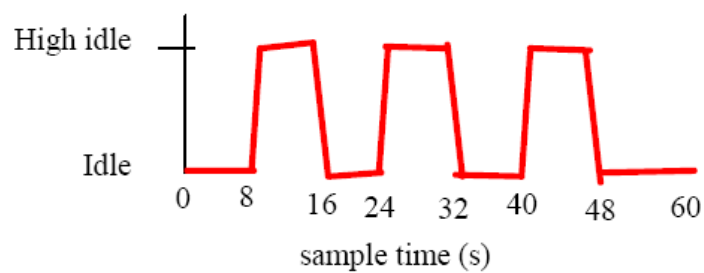


Figure 2 - Diesel particulate load cycle – Alternative method

## 8 Chapter 8 : Company Information

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### Chapter

# 8

#### DOCUMENT

Document №: Version 1.1

Approval Date: 24.11.2017

#### SALES AND TECHNICAL SUPPORT (AUSTRALIA)



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