

DPM-RT-2 – Real-Time Diesel Particulate Analyser

DPM-RT-2

Operating Manual

Version 3.3



PACIFIC DATA SYSTEMS AUSTRALIA

DPM-RT-2 Real-Time Diesel Particulate Analyser

Operating Manual

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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.

When viewing a digital version of this manual there are selectable links to other sections in the manual contents and where sections are referred to throughout. To select the link hold CTRL and click the section number with your mouse. Sections are also collapsible.

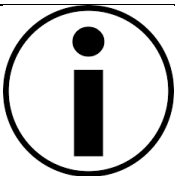
1.2 Symbols



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 inside. 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.

The DPM-RT-2 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-2 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 approximately 5 minutes, 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-2 continuously displays DPM concentration and provides an immediate test result during and 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 5kg (including its internal battery), the instrument is self-contained and is designed for stand-alone operation. With around ~2 hours continuous testing on a single charge, most operators prefer to use the instrument on battery power. Unit should be placed on charge when not in use.

Designed specifically for operation in the harsh environments typically associated with mobile and stationary diesel engines, the instrument incorporates several 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
- wide measurement range (0 ... 200 mg/m³ elemental carbon)
- automatic instrument zero setting prior to every test
- field calibration check in approximately 5 minutes using supplied calibration-check plug

3 Setting Up the DPM-RT-2

3.1 Unpacking

The DPM-RT-2 instrument, and its accessories are shipped from the factory in a single box. The box contents are as follows:

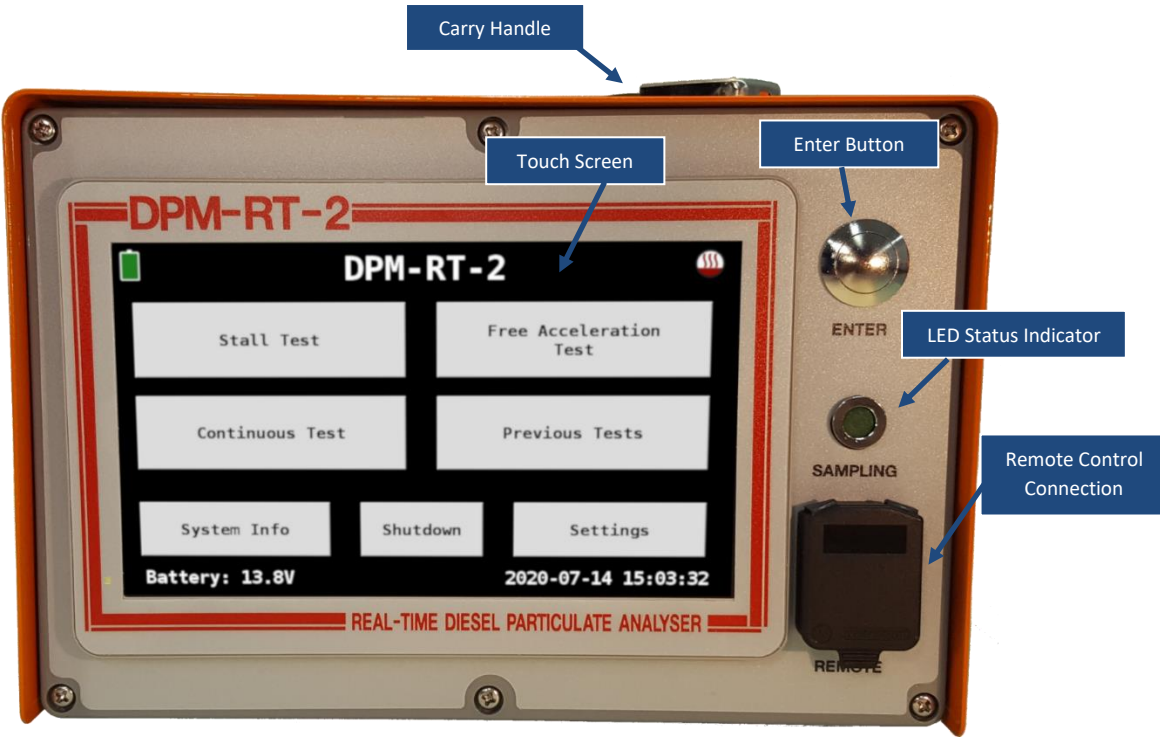
- DPM-RT-2 instrument
- Tail pipe probe
- Sample hose
- 24V / 2.5A DC Plug Pack
- Calibration-Check Plug
- 5 x Spare filter elements (external filters)
- Operator manual
- Remote ENTER button and LED with 7m cable
- Heavy duty portable carry case (w/- wheels, carry handle)
- USB flash drive

3.2 Instrument Setup

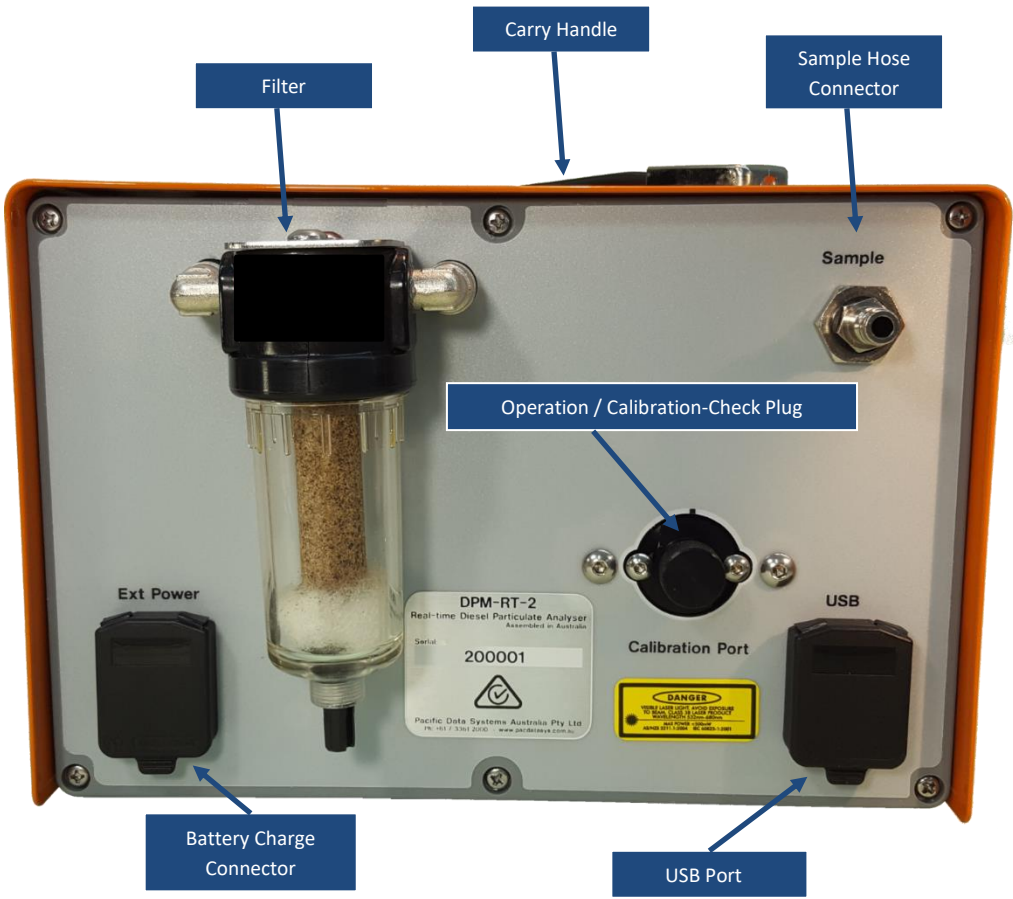
****IMPORTANT NOTE**** When you receive your DPM-RT-2 please put it on charge for at least 5 hours. It doesn't need to be turned on for the battery to charge.

The DPM-RT-2 must be placed on charge when not in use.

Front View



Rear View



3.3 Power Supply

The DPM-RT-2 is powered by its internal NiMH battery and may be operated while the battery is being charged. The unit can be charged with a 60W DC power source between 9V – 36V when the unit is powered off, or between 12V – 36V when the unit is powered on. The unit is shipped with a DC plug pack that can source 24V @ 2.5A, product code DPM-RT-2-AC-LEAD. A 12V @ 5A source can also be used which can be obtained from a cigarette lighter in a car or truck using the optional cable available from Pacifica Data Systems Australia or your local distributor, product code DPM-RT-2-DC-LEAD.



DPM-RT-2-AC-LEAD: 110V-240V 50/60Hz Power Lead



DPM-RT-2-DC-LEAD: Cigarette Lighter Power Lead

3.4 Sample Hose Connector

For easy storage, the sample hose is removable from the tail pipe probe, and the DPM-RT-2 instrument.

To separate, simply disconnect the hose by pulling back on the knurled connector.

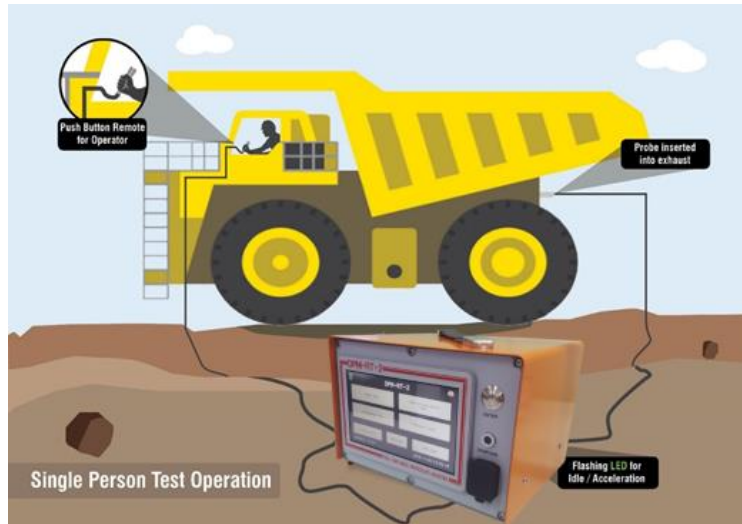
To reconnect, push the connectors together until the sample hose clicks into place.

3.5 USB Port

The USB port can be used to download historical test data to the USB drive supplied. *See Section 5.1 Previous Tests.*

3.6 Remote Control

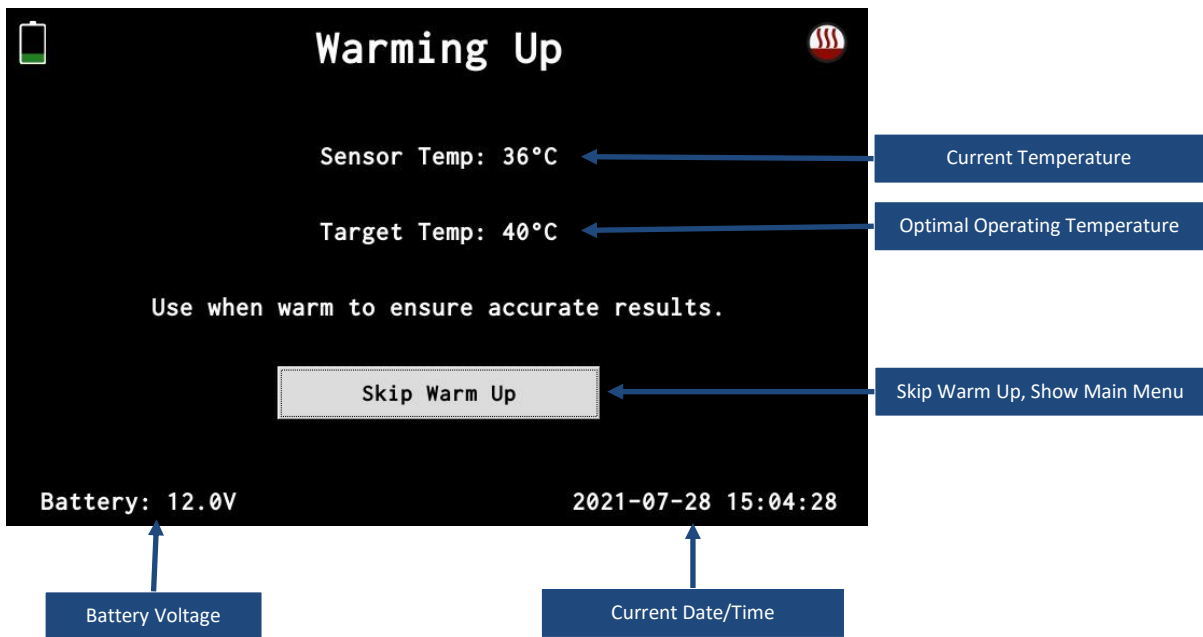
The wired remote-control button/LED may be connected to the 6mm jack connector at the lower right-hand corner of the front panel. The function of the remote control is to duplicate the **ENTER** key and **LED** on the front panel, facilitating one-person testing by allowing the instrument to be operated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



4 Operation

4.1 Warm up

The warm-up screen allows the sampling chamber to get to reach its optimal operating temperature after the unit is powered on. Performing tests before the unit is warm can introduce errors in your readings. When the sampling chamber is lower than 40°C it will read slightly lower and will slowly increase until the target temperature is reached.



4.2 Common Buttons and Icons

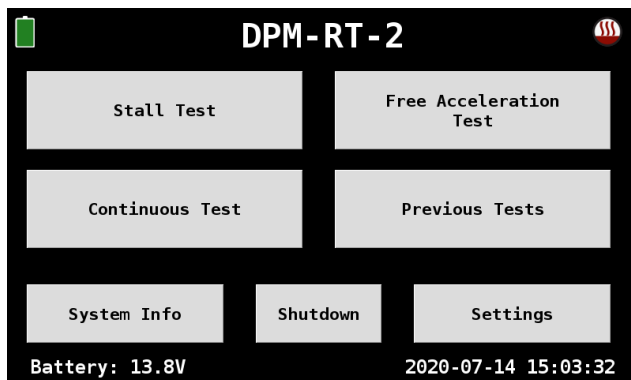
In the top corners on every screen on the DPM-RT-2, two icons will be displayed, one to indicate the battery voltage and the other to indicate the status of the **Sampling Chamber's Heater**. When the heater is on and currently heating the chamber, the icon in the top right-hand corner will go red, otherwise it will be grey.

On all screens except for the Main and Warm Up screens there will be either a **Cancel Button** and/or a **Submit Button**. If the **Cancel Button** is tapped, then all data entered in the current screen is discarded and the screen is closed. If the **Submit Button** is tapped, then all data entered in the current screen is saved and the screen is closed.



4.3 Main Screen

When the DPM-RT-2 boots up, it will show the system's Main Screen which allows the user to start a test, view previous test results, view the unit's status, configure the unit or shutdown/power off the unit.



The DPM-RT-2 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. See Sections 4.6 Stall Test and 4.7 Free Acceleration Test.

The **Continuous Test** can be used when testing for longer periods such as under actual operating conditions. This operating mode also allows calibration checks to be done more quickly and conveniently while logging the results. See Section 4.8 Continuous Measurement.

The **Previous Tests** screen can be used to view overall results as well as chart the PM value over test's timespan for a graphical representation of the test results. Raw CSV data of the test results can be downloaded over Wi-Fi. See Section 5 Data Logging / Previous Tests.

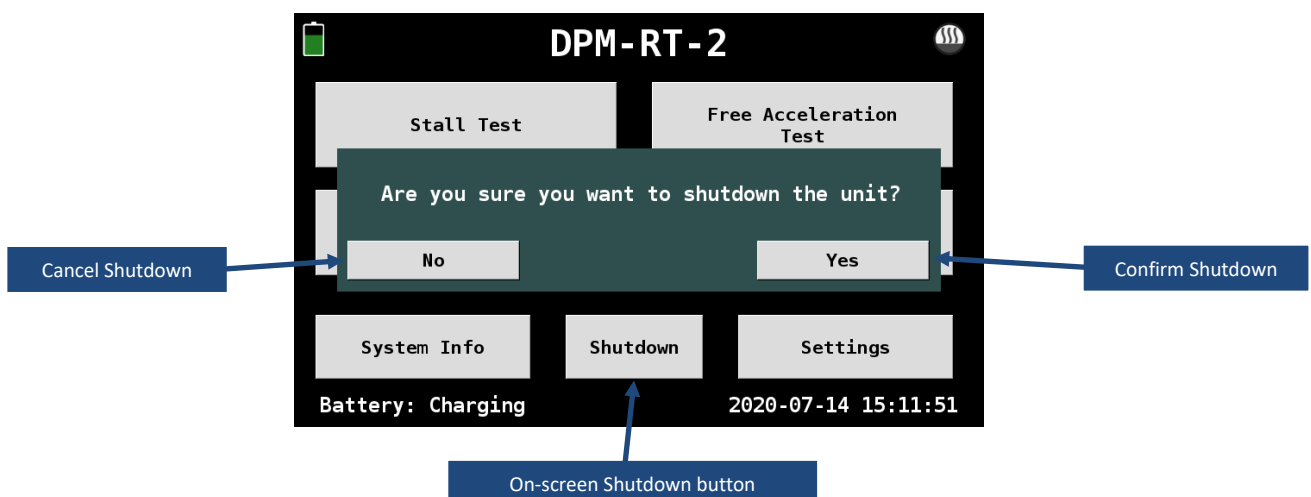
The system's calibration and Wi-Fi status can be accessed via the **System Info** button, these settings are described in Section 4.5 System Info.

The system's settings can be accessed via the **Settings** button, these settings are described in Section 6 Settings.

4.4 Shutdown / Power Off

The DPM-RT-2 operates like any other computer system, in that it needs to be shutdown to avoid potential data corruption on its internal disk. This can be done via the **Shutdown** button on the Main Screen.

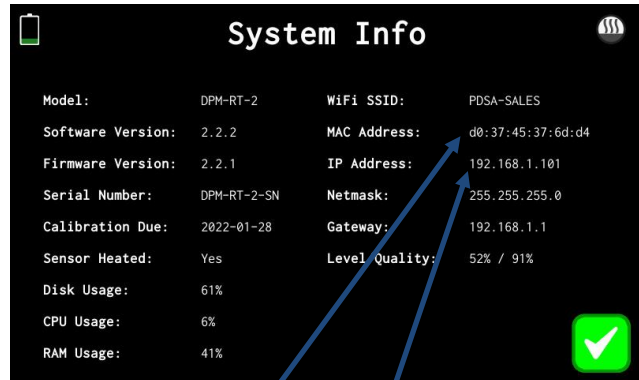
If the **ENTER** Button is held in for 10 seconds, then the unit will power off instantly without shutting down. Powering off the DPM-RT-2 via this method is not recommended as it risks data corruption on the unit. This should only be used if the on-screen **Shutdown** button **cannot** be used for some reason.



4.5 System Info

The **System Info** screen provides a brief overview of the DPM-RT-2 and includes the following information:

- Model Number
- Software Version
- Serial Number
- Calibration Due Date
- If the sensor is at optimal temperature (40°C)
- WiFi Connection Status
- System disk, CPU and memory usage.



WiFi Adapter MAC Address

WiFi IP Address for accessing the unit's internal web portal.

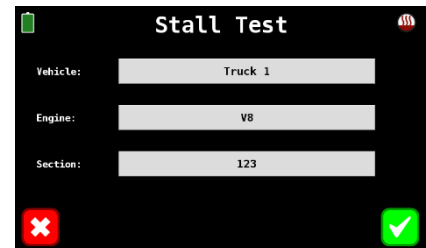
4.6 Stall Test

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

4.6.1 Test Details

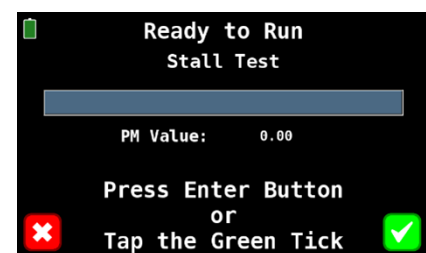
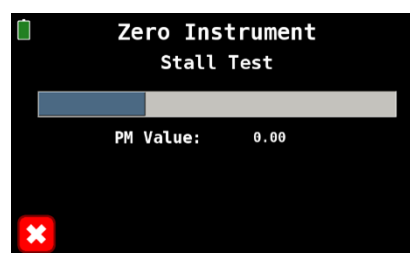
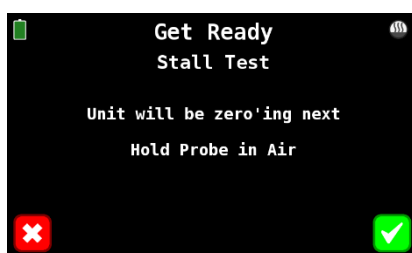
The test's details are a set of text parameters that allow you identify this test in the list of previous results. It also allows the user to associate a piece of equipment with the test.

Tapping on the buttons will bring up an on-screen keyboard for the user to enter in the required information.



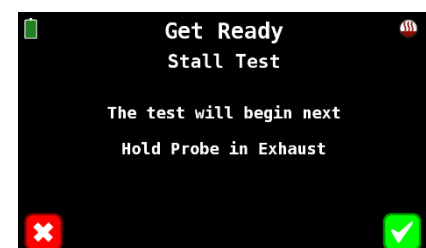
4.6.2 Zero Instrument

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



4.6.3 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, *see Appendix A: MDG 29 Test Procedures (Extract)*.



4.6.4 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-2 screen or remote. When ready, press the **ENTER** button or tap the **Green Tick** button.

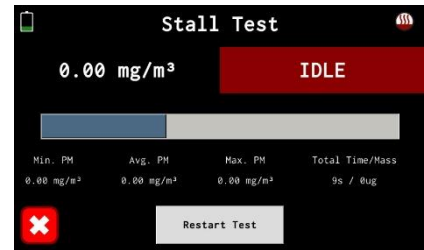
The green **LED** on the front panel will **illuminate** (steady) and a **5 second countdown** will start, allowing the operator to anticipate the time when measurements will commence.



4.6.5 Run Test

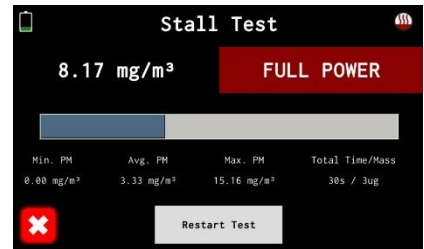
Immediately after the countdown, the instrument will start measuring and storing PM concentration measurements, and the display will change to the following **IDLE** screen.

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).



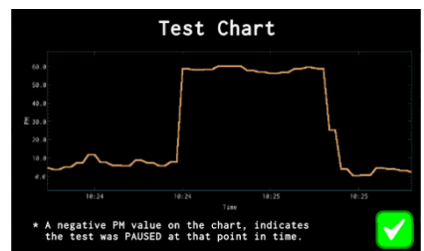
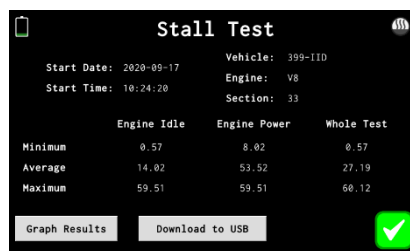
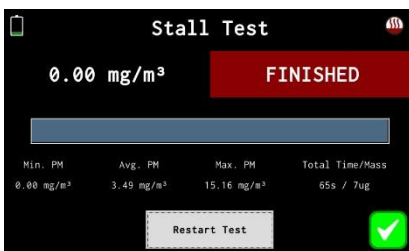
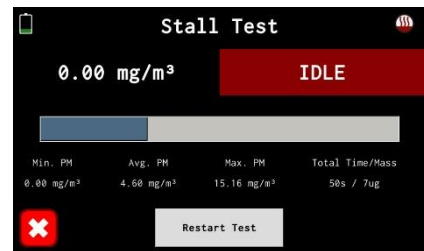
After 20 seconds the green **LED** will start to **flash quickly**, indicating the **Full Power** mode of the test. At this point the operator should rapidly apply full throttle and hold the engine at **full throttle**.

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 **FINISHED** message. The screen then displays the overall test result together with some other test data which may aid maintenance personnel to identify any emission-related faults in the engine or fuel management system.



4.7 Free Acceleration Test

The format of the Free Acceleration Test is like the Stall Test, but there are some important differences, notably:

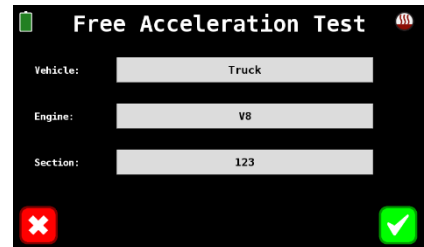
- testing is performed with the transmission in neutral
- there are three acceleration peaks, compared with just one in the Stall Test.

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.

4.7.1 Test Details

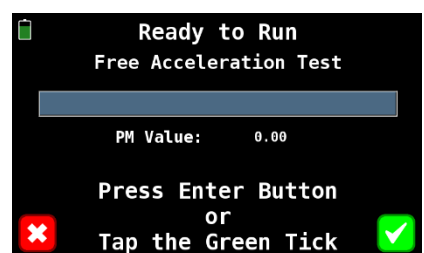
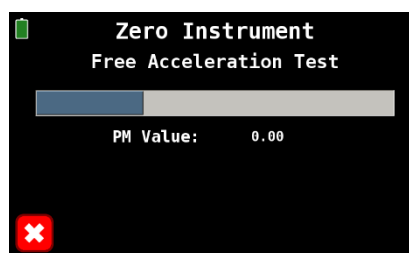
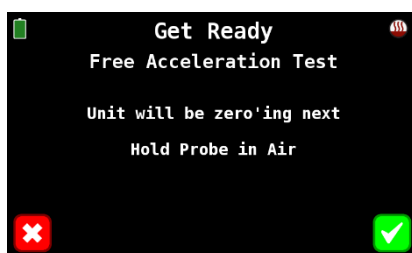
The test's details are a set of text parameters that allow you identify this test in the list of previous results. It also allows the user to associate a piece of equipment with the test.

Tapping on the buttons will bring up an on-screen keyboard for the user to enter in the required information.



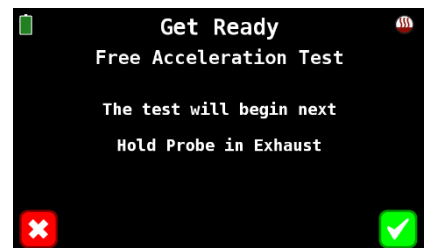
4.7.2 Zero Instrument

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



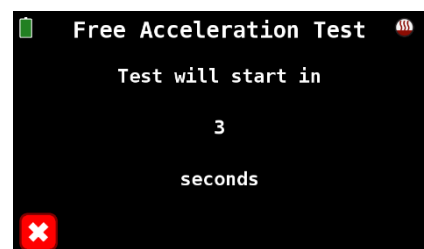
4.7.3 Insert Probe

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, see *Appendix A: MDG 29 Test Procedures (Extract)*.



4.7.4 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-2 screen or remote. When ready, press the **ENTER** button or tap the **Green Tick** button.

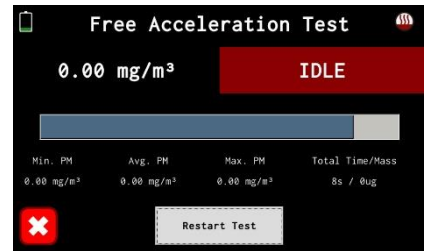


The green LED on the front panel will **illuminate** (steady) and a **5 second countdown** will start, allowing the operator to anticipate the time when measurements will commence.

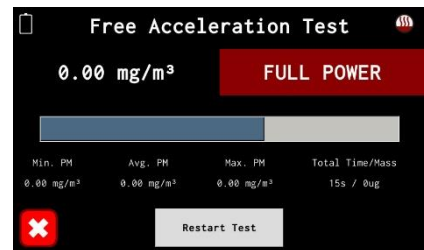
4.7.5 Run Test

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

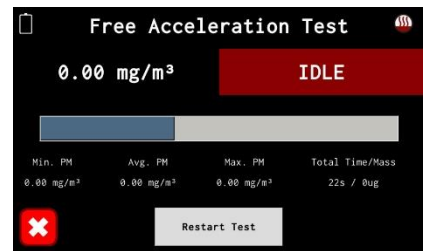
To assist the operator, the green LED will **flash slowly** for 8 seconds, indicating measuring is ON and the engine should be at **normal idle speed** (with the transmission engaged).



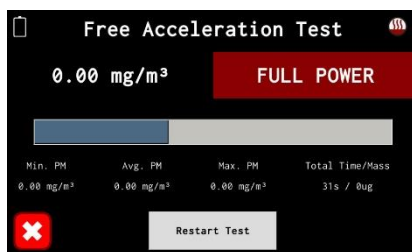
The green LED will then **flash quickly** for a further 8 seconds, indicating the first **Full Throttle** (Regulated Speed) mode of the test. At this point the operator should rapidly apply full throttle and hold the engine at **full throttle**. The screen changes to show **FULL POWER** and updates the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



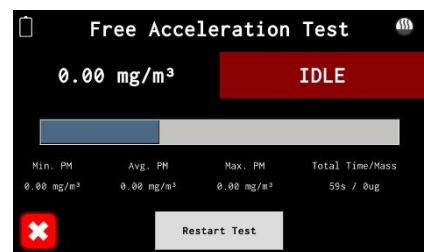
Subsequently, every 8 seconds the LED flashing speed and screen display **alternate** between **Idle** and **Full Power Modes**.



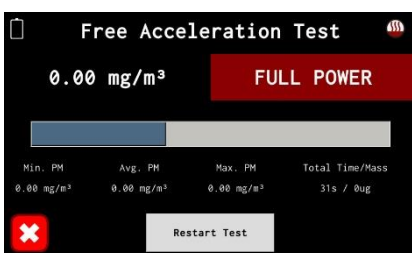
Full Power
(8 seconds)



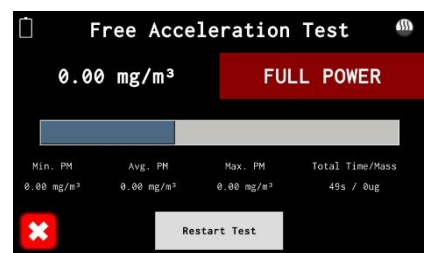
Idle
(8 seconds)



Full Power
(8 seconds)

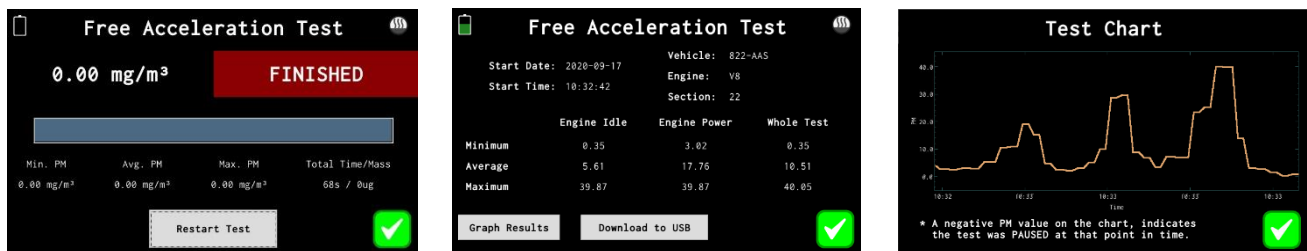


Idle
(8 seconds)



After the final 12 seconds at Idle, measurements stop, and the test is finished.

At this point the **LED** is **turned off** and the screen flashes a **FINISHED** message. The screen then displays the overall test result. After the **Green Tick** is tapped some additional test data is displayed which may aid maintenance personnel to identify any emission-related faults in the engine or fuel management system.



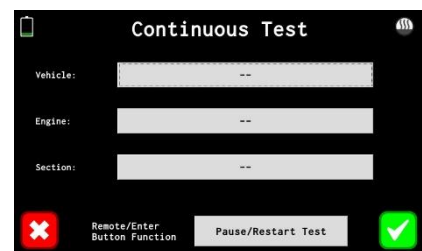
4.8 Continuous Measurement

The DPM-RT-2 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-equipment monitoring during normal workloads.

4.8.1 Test Details

The test's details are a set of text parameters that allow you identify this test in the list of previous results. It also allows the user to associate a piece of equipment with the test.

Tapping on the buttons will bring up an on-screen keyboard for the user to enter in the required information.

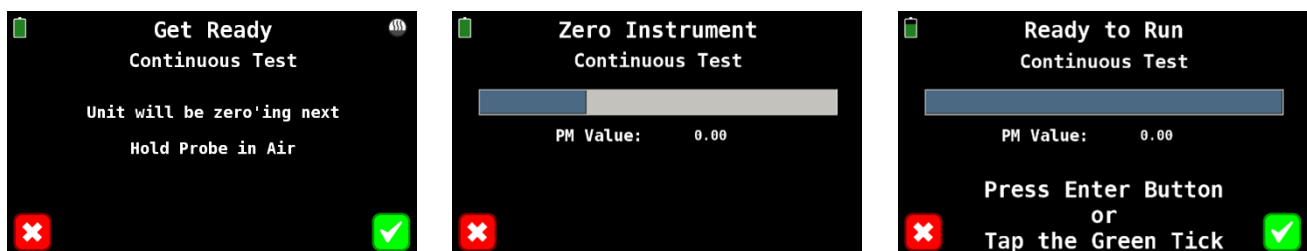


When running a Continuous Test, the ENTER Button can perform either of two functions, the default option can be overridden on this screen and can be one of the following:

- **Stop Test:** When the ENTER button is pressed, the test will stop.
- **Pause/Restart Test:** When the ENTER button is pressed it will either pause or restart the test.

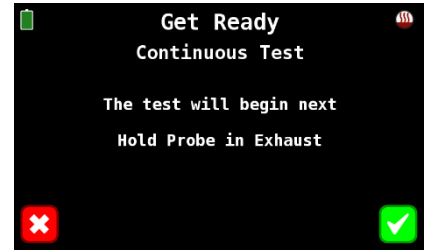
4.8.2 Zero Instrument

Prior to any test, the instrument initiates an auto-zero procedure, prompting the operator to ensure that the sample probe is 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.



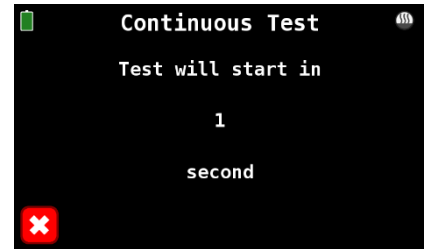
4.8.3 Insert Probe

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 within the desired operating conditions for the test. When ready, press the **ENTER** button or tap the **Green Tick** button.



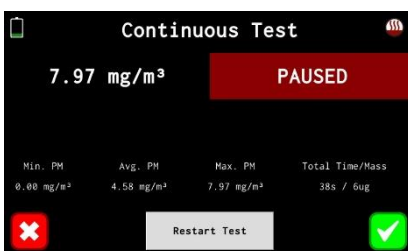
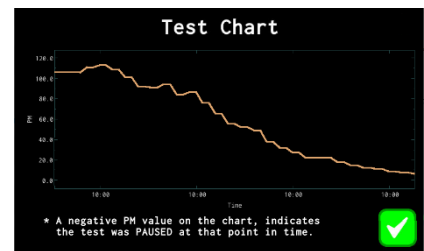
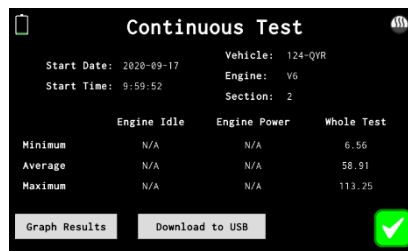
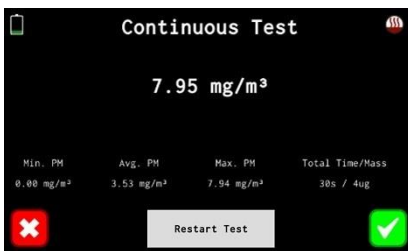
4.8.4 Initiate Test

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.



4.8.5 Run Test

The DPM-RT-2 will now run in continuous mode until the test is either cancelled for finished via the **Red Cross** and **Green Tick** buttons respectively. If the test is cancelled, then the test data will not be available under the previous tests screen, otherwise if the **Green Tick** button is tapped, then the test will appear under the previous tests screen.



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

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

5 Data Logging / Previous Tests

Chapter

5

5.1 Previous Tests

The Previous Tests screen allows the user to recall previous test results and plot the PM over the testing time for graphical representation of the results. Tests are listed with the most recent test at the top of the list and will show 11 results per page. The previous/next buttons at the bottom of the screen allow the user to navigate through the various pages of test results.

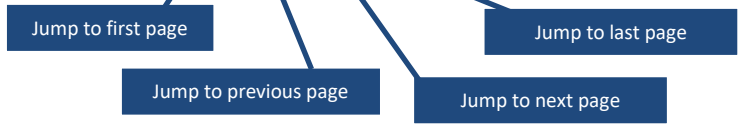
When the **Filters** button is tapped it will bring up a screen to search for tests results.

The **Download to USB** button will be greyed out if there is no USB drive inserted into the unit. Otherwise, if the button is active and is tapped, then all tests that match the current search filters will be download to the USB drive.

Note: The USB Flash Drive must be formatted with FAT32.

Date/Time	Vehicle	Test	Result
2020-12-10 9:25	--	Stall	0.0 (Idl: 0.0 / Pwr: 0.0)
2020-09-17 10:37	345-MIT	Stall	50.9 (Idl: 50.0 / Pwr: 52.6)
2020-09-17 10:34	--	Continuous	51.8 (Min: 45.7 / Max: 57.3)
2020-09-17 10:32	822-AAS	Acceleration	10.5 (Idl: 5.6 / Pwr: 17.8)
2020-09-17 10:30	AIR TEST	Continuous	2.4 (Min: 0.0 / Max: 7.4)
2020-09-17 10:27	882-JJH	Acceleration	63.4 (Idl: 64.2 / Pwr: 62.3)
2020-09-17 10:24	399-IID	Stall	27.2 (Idl: 14.0 / Pwr: 53.5)
2020-09-17 10:21	936-AAT	Acceleration	80.8 (Idl: 81.2 / Pwr: 80.3)
2020-09-17 10:19	742-DJU	Continuous	3.1 (Min: 0.0 / Max: 6.7)
2020-09-17 10:13	926-BAK	Continuous	17.8 (Min: 0.0 / Max: 103.2)
2020-09-17 9:59	124-QYR	Continuous	58.9 (Min: 6.6 / Max: 113.3)

Navigation buttons: [Close], [First], [Previous], [Next], [Last], [Filters], [Download to USB], [View Details]



There are a variety of filters to allow users to search for test results, these include:

- Start Date/Time
- End Date/Time
- Test Type
- Vehicle
- Section
- Engine

Search Filters

Date/Time Range

Start: 2020-12-10 0:00 [Hour Adjust] [Min Adjust] [Clear]

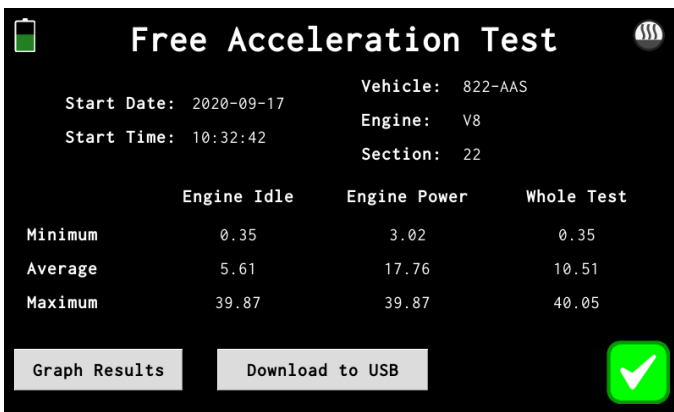
End: 2020-12-11 0:00 [Hour Adjust] [Min Adjust] [Clear]

Test Type: Stall Vehicle: --

Section: -- Engine: --

[Close] Today This Week Last Week This Month Last Month [Checkmark]

To speed up searching for test results the buttons at the bottom of the screen when tapped will prefill the start and end date/times to the period stated on the button.



Once a test is selected via tapping on it, the row will be highlighted. If the user, then taps the **View Details** button they will be shown the standard test results screen. From this screen the user can plot the test results in chart for a graphical representation of the results via the **Graph Results** button or this single test can be downloaded via the **Downloaded to USB** button.

5.2 Printer

A thermal printer is available as an option (DPM-RT-PRN) for DPM-RT-2 instruments loaded with the latest software. It is supplied with spare paper reels, USB lead and battery. The printer option is enabled for each DPM-RT-2 at the time of service or upon purchasing.

The software version can be checked on the System Info screen. Contact your supplier for the latest software.



Fit the battery and paper reel as pictured.

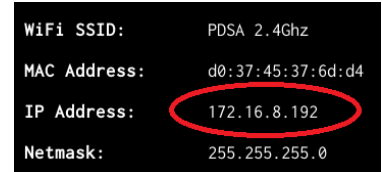
At any time, you can connect the printer via the supplied USB lead to the USB connector on the back of the instrument.

5.3 Data Download over Wi-Fi

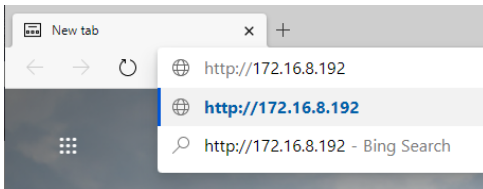
When the user logs into the web portal hosted by the DPM-RT-2 they will be presented with a list of tests that were conducted on the unit. From here they will be able to view a graph of the test results or download a CSV file which can be opened in Excel. This CSV file contains 1 second PM data points, which can then be plotted or analysed further on a laptop, PC, smartphone, or tablet.

5.3.1 Accessing the DPM-RT-2's Internal Web Portal

The DPM-RT-2's Internal Web Portal can be accessed from any computer, laptop, phone or tablet that is connected to the same network as the DPM-RT-2. Once both devices are connected to the network, the IP Address of the DPM-RT-2 must be retrieved from the unit, this can be done via the **System Info** screen, See Section 4.5 System Info.



WiFi SSID:	PDSA 2.4Ghz
MAC Address:	d0:37:45:37:6d:d4
IP Address:	172.16.8.192
Netmask:	255.255.255.0



Then on a browser on the remote device computer, smartphone, or tablet type in the IP Address of the DPM-RT-2 prefixed with "http://" and followed by the enter or return key, in this example the address of the DPM-RT-2 would be:

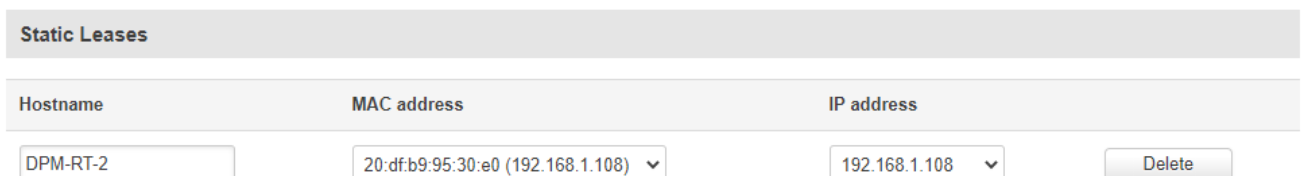
`http://172.16.8.192`

5.3.2 Router Settings for a Persistent IP Address

The DPM-RT-2 will fetch an IP Address for use on the Wi-Fi network using a standard network protocol called DHCP which stands for Dynamic Host Configuration Protocol. Basically, once your unit authenticates itself on the Wi-Fi network the next step is to lease an IP Address from the network's DHCP server. The DHCP server owns all the IP addresses, and the DPM-RT-2 is just borrowing it. This means that each time your unit connects it can get a different IP Address which can make remote connections to the unit problematic.

This DHCP server is generally just a service running on your Wi-Fi Router, unless you have a more complicated network configuration in which case you will need to speak to your IT department.

Log into your router using web browser and navigate to the DHCP settings on your router, you may need to consult your router's documentation for configuring a persistent IP Address for your DPM-RT-2. In the DHCP settings there will be a section for creating Static Leases. The MAC Address is the physical address of the Wi-Fi adapter in your DPM-RT-2, this can be obtained from the **System Info** screen. To ensure your unit gets the same IP Address every time it connects to the network a Static Lease must be created so that the DHCP server will always lease the same IP Address to your unit. This is done by mapping a MAC Address to an IP Address. Below is an example of such a configuration, which tells the router to always give the IP Address of 192.168.1.108 to the DPM-RT-2 with MAC Address 20:df:b9:95:30:e0.



Static Leases			
Hostname	MAC address	IP address	
DPM-RT-2	20:df:b9:95:30:e0 (192.168.1.108)	192.168.1.108	Delete

5.3.3 Login / Enter PIN Code

The DPM-RT-2's internal web portal is protected by a PIN Code which must be entered before accessing the data stored on the unit. The PIN Code can be changed on the DPM-RT-2 via the on-screen menu, *See Section 6.4.1 Client Mode*

To connect the unit to a network, the user must first select a Wi-Fi network by tapping on the **Wi-Fi SSID** button, which will scan for available networks and display them to the user so they can select one. Next the Wi-Fi password must be entered in by tapping on the **Wi-Fi Password** button.

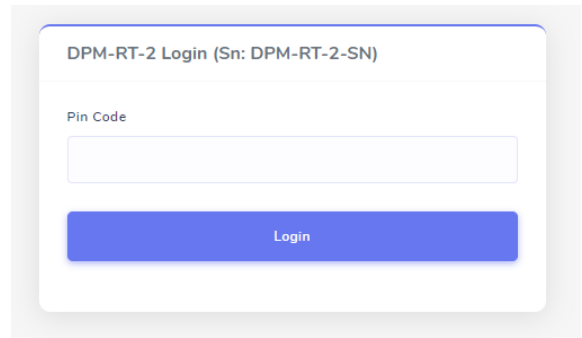
Once a Wi-Fi network has been configured, the DPM-RT-2 will attempt to connect to the network whenever it is in range.

The Wi-Fi network must have a DHCP server on the network to lease an IP Address to the DPM-RT-2. For configuring your router to provide a persistent IP Address to your unit, *See Section 5.2.2 Router Settings for a Persistent IP Address.*

5.3.4 Access Point Mode

When in Access Point mode the DPM-RT-2 will generate its own Wi-Fi network like a Wi-Fi router does, although there will be no internet access available. This Wi-Fi network can only be used for remotely connecting to the DPM-RT-2 using a smartphone, tablet, or laptop/computer.

If required, the Wi-Fi network's range can be increased by using standard Wi-Fi Range Extender or Repeater devices. The Wi-Fi **Channel** and **Mode** can also be set on this screen.



5.4 SSL Certificate for Internal Portal

There are a several options related to the internal web portal around using SSL certificates to encrypt all the traffic to/from the internal web portal. Since the DPM-RT-2 will connect to your local WiFi network, your company's security policies may require encryption to be used.

The DPM-RT-2 can either create a self-signed SSL certificate or your IT department can create/obtain one and it can be loaded into the unit.

- **Domain/Common Name:** The Domain name for the web portal, this is also the Common Name for the self-signed SSL certificate. This does not perform any DNS resolution.
- **Enable HTTP:** Enable the web portal over HTTP on port 80.
- **Redirect to HTTPS / Host site on HTTP:** Sets the function for the HTTP (unencrypted) web portal, it can either redirect the HTTPS (encrypted) web portal or host the portal unencrypted.
- **Enable HTTPS:** Enable the web portal over HTTPS on port 443.
- **Generate Self-Signed CA Certificate:** Tapping on this will generate a self-signed certificate authority (CA), which you can download to USB and upload into other DPM-RT-2 units, so they all use the same self-signed CA.
- **Generate Self-Signed Server Certificate:** Tapping on this will generate a self-signed certificate for the web portal using the self-signed CA certificate.
- **Copy Self-Signed CA Cert & Key (PEM) from USB:** Copy a self-signed CA from a USB drive, and onto the DPM-RT-2. It must be in the root directory of the USB and have the filename 'dpmrt2-ca.pem'.
- **Copy Server Cert & Key (PEM) from USB:** Copy a certificate for the web portal from a USB drive, and onto the DPM-RT-2. It must be in the root directory of the USB and have the filename 'dpmrt2-server.pem'.
- **Copy Self-Signed CA Cert & Key (PEM) to USB:** Copy the self-signed CA certificate onto a USB drive. It can then be uploaded onto other DPM-RT-2 units, so they all use the same self-signed CA.

Pin Codes. There is only one PIN Code to access the portal, multiple PIN Codes or user accounts are not supported, although multiple users can access the portal simultaneously using the same PIN Code.

5.4.1 List of Test Results

Once a user has logged into the DPM-RT-2's internal web portal they will be presented with a paged list of all test results stored on the unit. At the top of the page there are a set of buttons that allow the user to quickly download all tests within the defined period.

There are also a set of filters which allows the user to search for test results in a particular time range, test type or vehicle.

Each test result has three buttons associated with the record:

DPM-RT-2 (On DPM-RT-2-95)

Quick Download
 Today Yesterday This Week Last Week This Month Last Month

Search Test Results
 Start Date/Time: End Date/Time:
 Test Type: Vehicle:
 Engine: Section:

Clear Search

Test Results (12 records found)

<input type="checkbox"/>	Date/Time	Vehicle	Engine	Section	Test	Result	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	2020-12-10 10:29:31	---	---	---	Stall Test	0.0 (Std: 0.0 / Pass: 0.0)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	2020-09-17 10:37:00	345-MT	VB	34	Stall Test	50.9 (Std: 50.0 / Pass: 52.6)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	2020-09-17 10:34:35	---	---	---	Continuous Test	51.8 (Min: 45.7 / Max: 57.4)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	2020-09-17 10:32:42	822-AAS	VB	22	Free Acceleration Test	10.5 (Std: 9.6 / Pass: 17.8)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	2020-09-17 10:30:08	AIR TEST	---	---	Continuous Test	2.4 (Min: 0.0 / Max: 7.4)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	2020-09-17 10:27:32	882-DH	VB	2	Free Acceleration Test	63.4 (Std: 61.2 / Pass: 62.3)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	2020-09-17 10:24:20	399-ID	VB	33	Stall Test	27.2 (Std: 14.0 / Pass: 53.5)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	2020-09-17 10:21:33	936-AAT	VB	8	Free Acceleration Test	80.8 (Std: 81.2 / Pass: 80.3)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	2020-09-17 10:19:20	742-DLU	VB	5	Continuous Test	3.1 (Min: 0.0 / Max: 6.7)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	2020-09-17 10:13:59	926-SAK	4Cyl	3	Continuous Test	17.9 (Min: 0.0 / Max: 103.2)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	2020-09-17 09:59:52	124-QHR	VB	2	Continuous Test	58.9 (Min: 6.6 / Max: 113.3)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	2020-09-17 09:57:51	123-ABC	VB	1	Stall Test	44.2 (Std: 54.0 / Pass: 24.6)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Download Selected Download All

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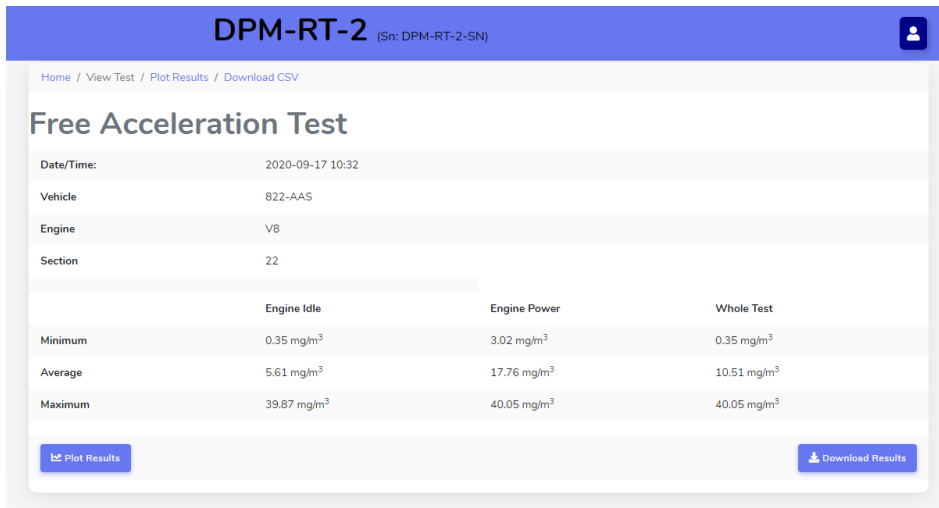
- **Graph Results:** Clicking this will present the user with the graph of the PM value over time for the test. See section 5.3.3 *Graph Test Results*.
- **Download Results:** Clicking on this will download a CSV file to the user's device. See section 5.3.4 *Download Test Results*.
- **View Results:** Clicking on this will present the unit with a summary of the test results. There are checkboxes on each record which allows the user to select multiple Test Results for downloading in a single zip file. Once the Test Results are selected and the **Download Selected** button is clicked the zip file is downloaded.

The **Download All** button when clicked will download all the test results that match the current filters as a single zip file.

5.4.2 View Test Results

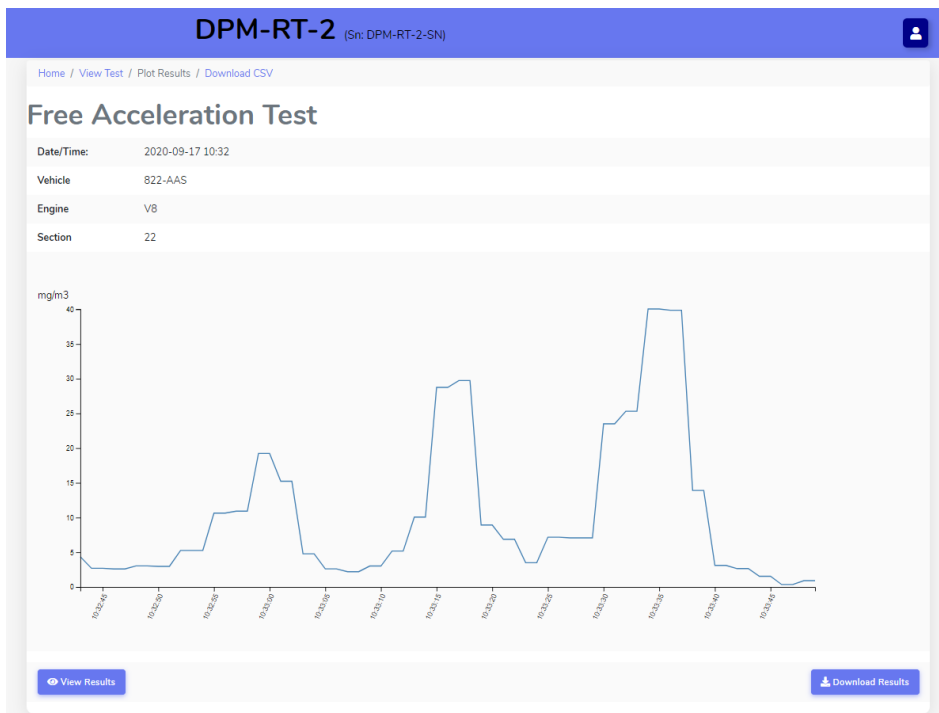
Viewing a Test Result will present the user with a summary of the test results, this includes any vehicle information associated with the results as well as the minimum, average and maximum values for the separate periods within the test.

During a **Stall Test** or **Free Acceleration Test**, the operator is required to operate the piece of equipment under test and move the throttle from the idle position to the full throttle position and back again. In the Stall Test this is only done once, but in the Free Acceleration Test this is done multiple times. The **Continuous Test** does not have these idle and full throttle periods, therefore it will only show results under the **Whole Test** column.



5.4.3 Graph Test Results

Graphing a Test Result will present the user with a plot of the test results as well as any vehicle information associated with the results. This gives the operator a quick visual representation of the test results to allow them to make decisions on the requirement maintenance of the piece of equipment on the spot or from a remote location via WiFi.



5.4.4 Download Test Results

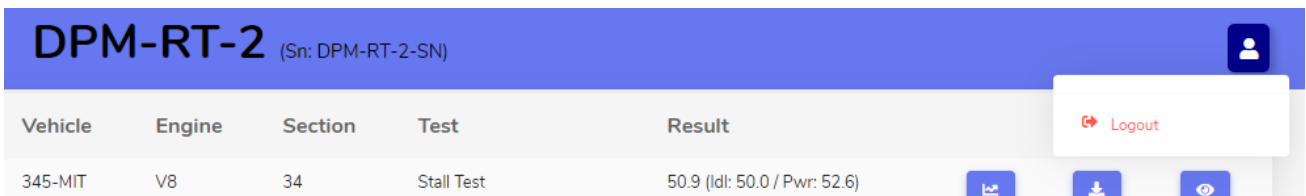
	A	B	C	D
1	DPM-RT-2 Test Result			
2				
3	Date/Time	17/09/2020 10:32		
4				
5	Vehicle	822-AAS		
6	Engine	V8		
7	Section		22	
8				
9	Date/Time	Type	Value	
10	17/09/2020 10:32	Idle	4.35	
11	17/09/2020 10:32	Idle	2.69	
12	17/09/2020 10:32	Idle	2.69	
13	17/09/2020 10:32	Idle	2.6	
14	17/09/2020 10:32	Idle	2.6	
15	17/09/2020 10:32	Idle	3.04	
16	17/09/2020 10:32	Idle	3.04	
17	17/09/2020 10:32	Idle	2.97	
18	17/09/2020 10:32	Idle	2.97	
19	17/09/2020 10:32	Power	5.27	
20	17/09/2020 10:32	Power	5.27	
21	17/09/2020 10:32	Power	5.27	
22	17/09/2020 10:32	Power	10.64	
23	17/09/2020 10:32	Power	10.64	
24	17/09/2020 10:32	Power	10.92	
25	17/09/2020 10:32	Power	10.92	
26	17/09/2020 10:32	Power	19.24	
27	17/09/2020 10:33	Power	19.24	
28	17/09/2020 10:33	Idle	15.23	
29	17/09/2020 10:33	Idle	15.23	
30	17/09/2020 10:33	Idle	4.78	
31	17/09/2020 10:33	Idle	4.78	
32	17/09/2020 10:33	Idle	2.61	
33	17/09/2020 10:33	Idle	2.61	
34	17/09/2020 10:33	Idle	2.2	
35	17/09/2020 10:33	Idle	2.2	
36	17/09/2020 10:33	Idle	3.02	
37	17/09/2020 10:33	Power	3.02	
38	17/09/2020 10:33	Power	5.17	

The results of a test can also be downloaded in CSV format via the DPM-RT-2's internal web portal. CSV is a common text format for spreadsheets which is supported by almost every spreadsheet application including Microsoft Excel and Google Sheets.

The downloaded CSV file will contain any vehicle information associated with the test as well as the PM values from the test taken at 1 second intervals. This data can be used for more extensive review of the results, archiving for future access or even importing into another application that manages your QA processes.

5.4.5 Logout

An authenticated session on the DPM-RT-2's web portal will time out after a period of inactivity for security purposes. But the user can also manually log out and un-authenticate their session via the *Logout* link located under the **User Icon** in the top right hand corner of the page.



6 Settings

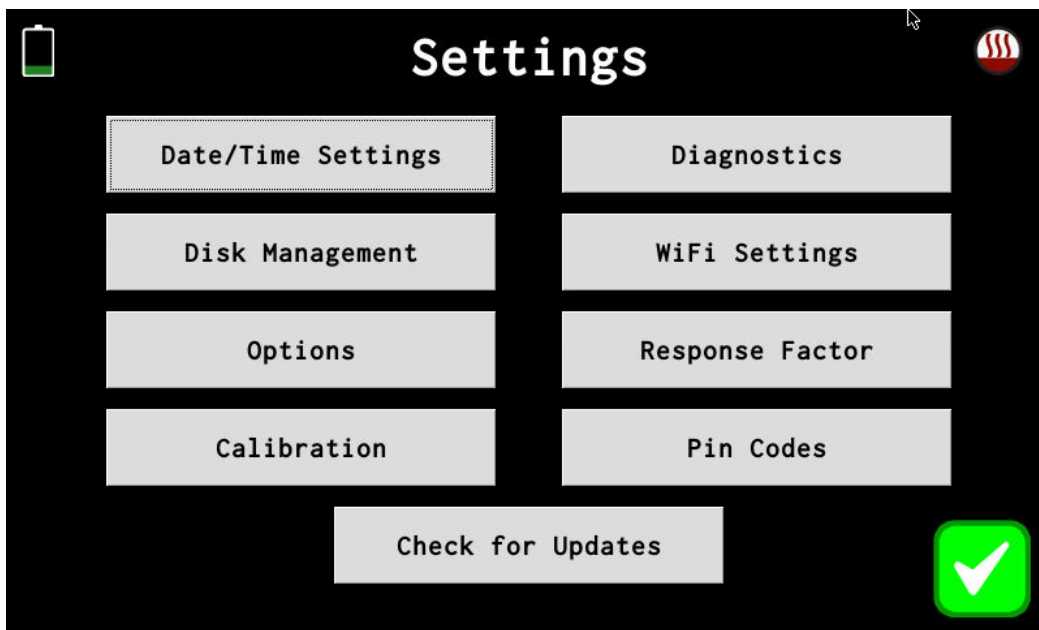


The DPM-RT-2 can be configured via the on-screen menu, the user editable settings include:

- **Date/Time Settings:** For configuring the current date and time, as well as the time zone. If a time zone with daylight saving is used, the unit will automatically shift the time forward or back when required. See *Section 6.1 Date and Time*.
- **Diagnostics:** This screen will show the user the status of the unit. See *Section 6.2 Diagnostics*.
- **Disk Management:** This screen will allow you to purge out old data from the DPM-RT-2. See *Section 6.3 Disk Management*.
- **Wi-Fi Settings:** These settings can be used for connecting to a network or for the unit to generate its own. See *Section 6.4 Wi-Fi*.
- **Options:** This screen contains some general options the user can change. See *Section 6.5 Options*.
- **Response Factor:** This is pin code protected screen, that allows the user to change the response factor of the unit. See *Section 6.8 Response Factor*.
- **Check for Updates:** Check for updates over the internet, requires an active Wi-Fi connection. See *Section 6.4 Software Updates over the Internet*.

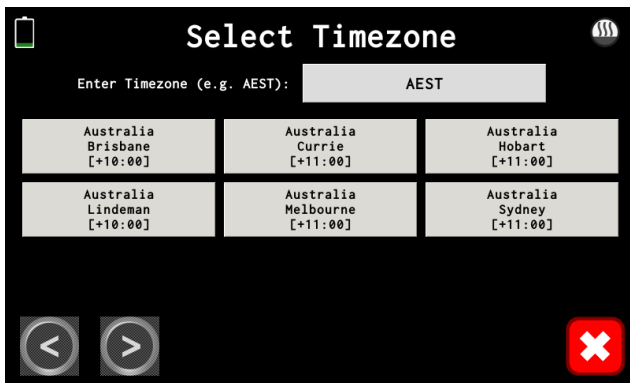
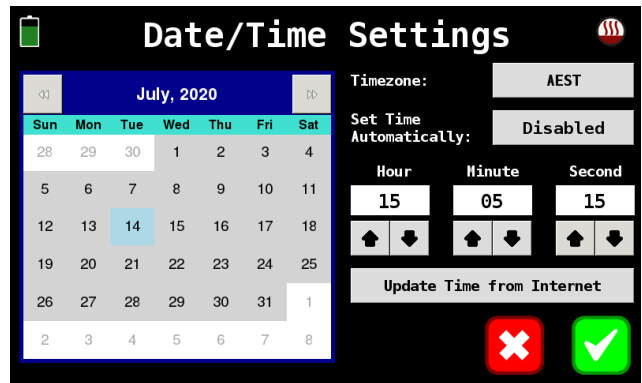
The **Calibration** and some **Pin Codes** settings are pin code protected and can only be accessed by DPM-RT-2 technicians at your local service center or distributor. You can edit the **Internal Web Portal** and **Response Factor** PIN codes.

- **Calibration:** This screen allows the DPM-RT-2 authorised technician to calibrate the unit, using the side-by-side or a filter-based calibration process. See the DPM-RT-2 Calibration manual for more information.
- **Pin Codes:** This screen allows for the editing of all the pin codes used on the unit. The DPM-RT-2 authorised technician can reset/recover your pin code if it is forgotten. See *Section 6.7 Pin Codes*.



6.1 Date and Time

The DPM-RT-2 contains a Real Time Clock (RTC) for time keeping, which allows the unit to retain the time even when powered off. But the time must be periodically updated to ensure it does not drift too much. If the unit is connected to a Wi-Fi network with an internet connection, then the unit can automatically synchronize its time with time servers on the internet using the Network Time Protocol (NTP). Alternatively, the unit's date and time can be manually updated via this screen.



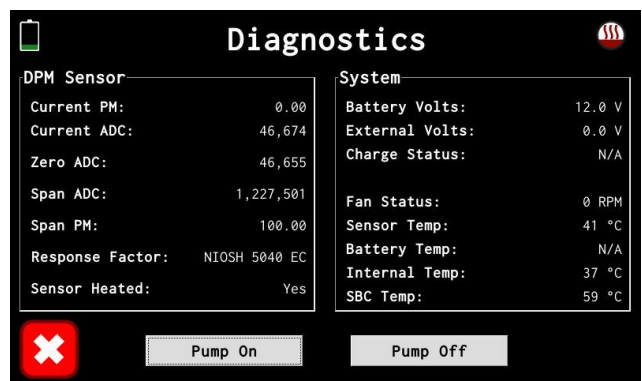
The DPM-RT-2 also supports most time zones around the world, including automatically adjusting the time for daylight savings. To select a new time zone, the user will tap on the **Time Zone Entry** Button and enter in the time zone's standard abbreviation. For example, the standard abbreviation for Australian Eastern Standard Time is **AEST** and for **Australian Eastern Daylight Time** the abbreviation would be **AEDT**. The DPM-RT-2 will then list all time zones matching the abbreviation for the user to select the appropriate one. If a time zone that supports daylight savings time is selected, the time will automatically be shifted forward/backward when required.

If the **Update Time from Internet** button is tapped, then the unit will fetch the time from the internet and update the current time on this screen. Any changes will not get saved until the **Green Tick** is tapped, if the **Red Cross** is tapped instead all changes are discarded.

6.2 Diagnostics

The Diagnostics Screen gives the user a snapshot of the current state of the unit.

In the **DPM Sensor** section, the **Current PM** and **Current ADC** values are shown to help identify any sensor issues. The current sensor status is also shown along with the calibration points including the **Zero ADC**, **Span ADC** and **Span PM** values. If the sensor is at 40°C, then the **Sensor Heated** will show **Yes** otherwise **No** will be shown.



In the **System** section the **Battery Voltage** and **External Voltage** are shown as well as the **Charging Status** of the internal NiMH battery. The **Fan Status** will show if the internal fan is running and the temperatures of various parts of the DPM-RT-2 will be displayed. The battery temperature will only be displayed while the unit is charging.

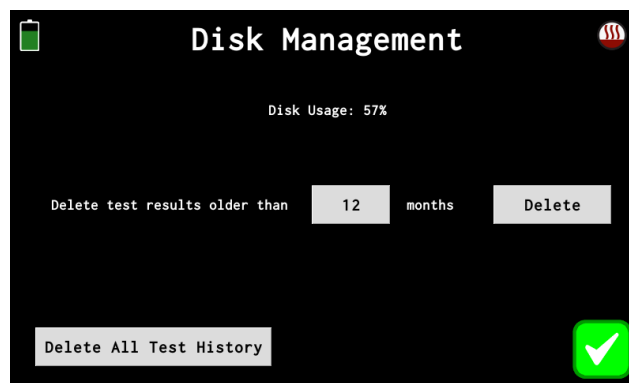
The charging states of the internal battery include:

- **N/A:** Unit is not charging due to external power being too low or not connected. External voltage must be at least 9VDC to charge if the unit is powered off, and at least 12VDC to charge when the unit is running and no more than 36VDC.
- **Charging:** Battery is currently fast charging.
- **Top Up:** Battery is currently trickle charging.
- **Charged:** Battery is fully charged.
- **Paused:** Battery charging is paused due to the external voltage being too low, less than 12V while the unit is powered on.
- **Batt Temp:** Battery charging is paused due to the battery being too hot.
- **Fault:** A hard fault has occurred during charging; this can occur if the battery is extremely flat and it takes longer than 4 hours to charge, removing external power and reconnecting will restart the battery charging. If this occurs for any other reason, it indicates the battery has a fault.

The internal air pump can also be turned on and off via the **Pump On** and **Pump Off** buttons respectively. This allows the user to view the diagnostic information while the unit is running.

6.3 Disk Management

All logged data as well as the system's application are stored on the internal disk, which uses a journaling file system to reduce the risk of corruption caused by the unit losing power before it is properly shutdown. Recorded tests are not automatically deleted, periodically the user must delete old data so that the disk does not fill up.



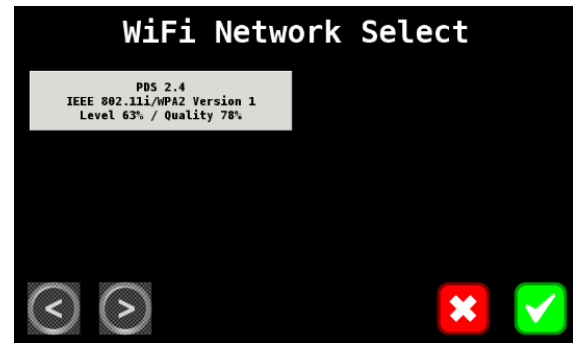
There are two ways to delete data from the unit:

- **Delete Test History Older Than:** Clicking this button will download all test results that are older than the defined number of months.
- **Delete All Test History:** Clicking this button will delete all test results from the unit.

Once test results have been deleted, they cannot be restored.

Always download test results before deleting them.

6.4 WiFi



The DPM-RT-2 utilises WiFi for keeping its internal clock in sync with time servers on the internet via the Network Time Protocol (NTP). The unit will also host a web server which is available from any computer on the same network and allows for viewing and downloading previous test results in CSV format.

The DPM-RT-2 can either connect to an existing WiFi network when the **Network Type** is set to **Client**, otherwise it can generate its own WiFi network which other devices can connect to, when this is set to **Access Point**. Only 2.4GHz WiFi networks are supported, 5GHz networks are not supported.

The **Connect** and **Disconnect** button when tapped will force the WiFi connection to be started or stopped respectively.

6.4.1 Client Mode

To connect the unit to a network, the user must first select a WiFi network by tapping on the **WiFi SSID** button, which will scan for available networks and display them to the user so they can select one. Next the WiFi password must be entered in by tapping on the **WiFi Password** button.

Once a WiFi network has been configured, the DPM-RT-2 will attempt to connect to the network whenever it is in range.

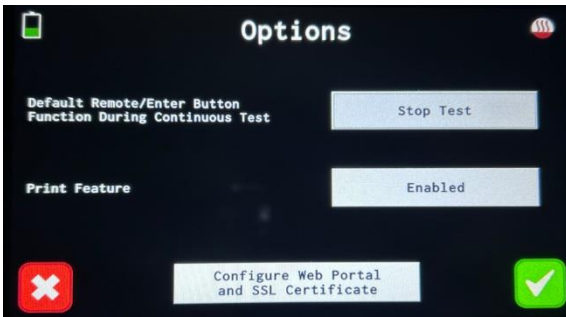
The WiFi network must have a DHCP server on the network to lease an IP Address to the DPM-RT-2. For configuring your router to provide a persistent IP Address to your unit, See Section 5.2.2 Router Settings for a Persistent IP Address.

6.4.2 Access Point Mode

When in Access Point mode the DPM-RT-2 will generate its own WiFi network like a WiFi router does, although there will be no internet access available. This WiFi network can only be used for remotely connecting to the DPM-RT-2 using a smartphone, tablet, or laptop/computer.

If required, the WiFi network's range can be increased by using standard WiFi Range Extender or Repeater devices. The WiFi **Channel** and **Mode** can also be set on this screen.

6.5 Options

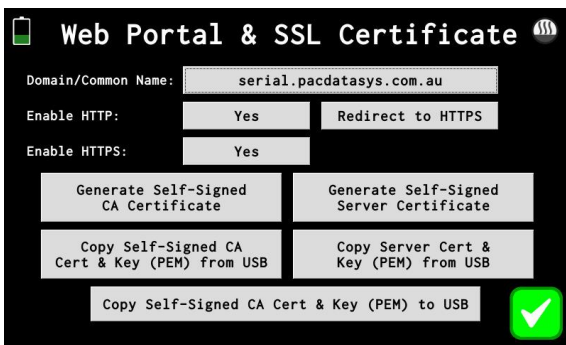


When running a Continuous Test, the ENTER Button can perform either of two functions, the default option is configured on this screen and can be one of the following:

- **Stop Test:** When the ENTER button is pressed, the test will stop.
- **Pause/Restart Test:** When the ENTER button is pressed it will either pause or restart the test.

Tapping on the **Configure Web Portal and SSL Certificate** button will bring up the portal configuration screen, see *Section 6.6 SSL Certificate for Internal Portal*.

6.6 SSL Certificate for Internal Portal.

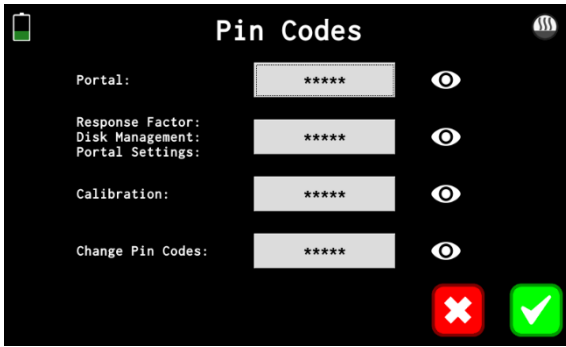


There are a several options related to the internal web portal around using SSL certificates to encrypt all the traffic to/from the internal web portal. Since the DPM-RT-2 will connect to your local WiFi network, your company's security policies may require encryption to be used

The DPM-RT-2 can either create a self-signed SSL certificate or your IT department can create/obtain one and it can be loaded into the unit.

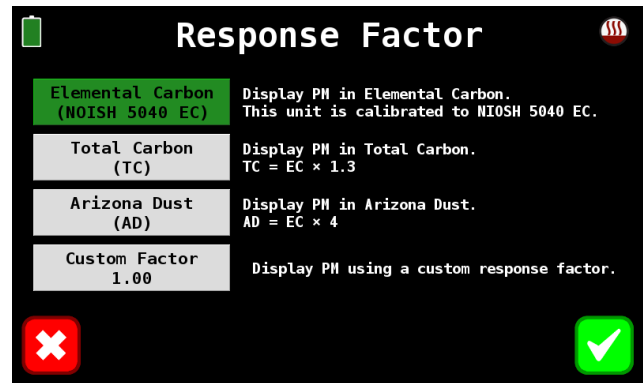
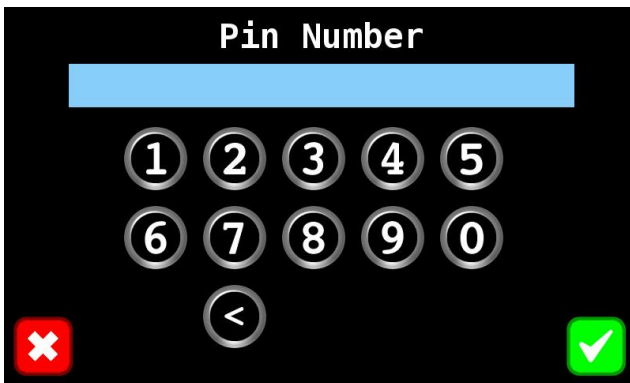
- **Domain/Common Name:** The Domain name for the web portal, this is also the Common Name for the self-signed SSL certificate. This does not perform any DNS resolution.
- **Enable HTTP:** Enable the web portal over HTTP on port 80.
- **Redirect to HTTPS / Host site on HTTP:** Sets the function for the HTTP (unencrypted) web portal, it can either redirect the HTTPS (encrypted) web portal or host the portal unencrypted.
- **Enable HTTPS:** Enable the web portal over HTTPS on port 443.
- **Generate Self-Signed CA Certificate:** Tapping on this will generate a self-signed certificate authority (CA), which you can download to USB and upload into other DPM-RT-2 units, so they all use the same self-signed CA.
- **Generate Self-Signed Server Certificate:** Tapping on this will generate a self-signed certificate for the web portal using the self-signed CA certificate.
- **Copy Self-Signed CA Cert & Key (PEM) from USB:** Copy a self-signed CA from a USB drive, and onto the DPM-RT-2. It must be in the root directory of the USB and have the filename 'dpmrt2-ca.pem'.
- **Copy Server Cert & Key (PEM) from USB:** Copy a certificate for the web portal from a USB drive, and onto the DPM-RT-2. It must be in the root directory of the USB and have the filename 'dpmrt2-server.pem'.
- **Copy Self-Signed CA Cert & Key (PEM) to USB:** Copy the self-signed CA certificate onto a USB drive. It can then be uploaded onto other DPM-RT-2 units, so they all use the same self-signed CA.

6.7 Pin Codes



All the pin codes on the DPM-RT-2 are configurable via the on-screen menu, although a pin code must first be entered before these codes can be viewed/edited. Depending on the PIN Code entered to access this screen, some codes may be hidden and cannot be viewed or edited.

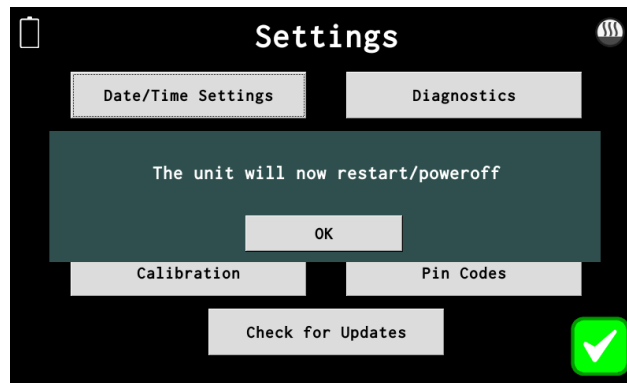
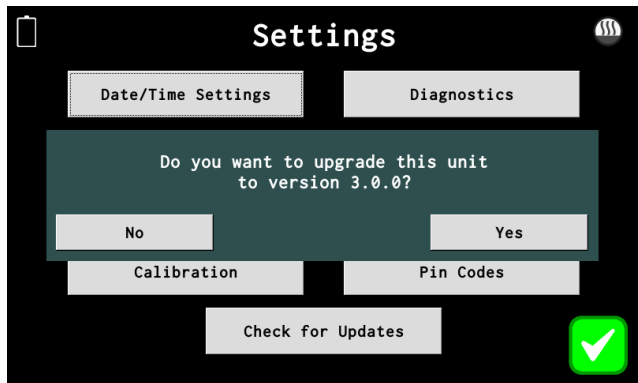
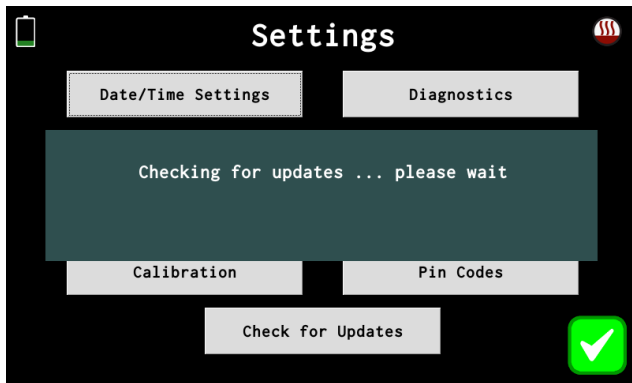
6.8 Response Factor



The DPM-RT-2 is calibrated to the NOISH 5040 Elemental Carbon, but via the **Response Factor** screen the user can change the way the unit presents its PM results. The following response factors are supported:

- **Elemental Carbon:** This causes the DPM-RT-2 to display PM values as NIOSH 5040 Elemental Carbon as it was calibrated.
- **Total Carbon:** This causes the DPM-RT-2 to display PM values as total carbon.
- **Arizona Dust:** This causes the DPM-RT-2 to display PM values as Arizona Dust.
- **Custom Factor:** This allows the user to set a custom response factor to convert the NIOSH 5040 EC to some other custom value.

6.9 Software Updates over the Internet



When the **Check for Updates** button is tapped, the DPM-RT-2 will check if there are any software updates available using its WiFi connection. The WiFi network must be connected to the internet in order for the unit to successfully check for updates. If there is an update available the unit will ask you if you want to install it, and if **Yes** is tapped, it is then installed and the unit will power off.

7 Calibration Check

Chapter

7

7.1 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:

- Put the instrument in “Continuous Measuring” mode (*See Section 4.8 Continuous Measurement*), with the sample probe resting in relatively clean air (i.e., not downstream of any vehicle exhaust). Perform the zero reading with the operating plug fitted (*See operating plug image below*)
- 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 Plug



Operating Plug

- 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 ($\pm 10\%$) as the number labelled on the Calibration-Check Plug. It will take approximately 5 minutes or more (until reading is stable) for the calibration plug to warm up and arrive at its value.
- If the displayed reading is still not $\pm 10\%$ 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 equipment. In this instance, the DPM-RT-2 instrument will need to be returned to your local service centre for further analysis.

***Importantly, the calibration-check plug should be returned with the DPM-RT-2 with each recalibration as the numerical reading on the calibration-check plug changes after each calibration.**

7.2 Calibration Services

In accordance with manufacturer's standards, calibration is recommended every 6 months. Please return to your local service centre, as per contact details in *Appendix B:*

Document / Contact Information.

8 Technical Specifications

Chapter

8

Measurement Method	Laser light-scattering photometry
Particle Concentration Range	0 to 200 mg/m ³ (Elemental Carbon*)
Resolution	0.01 mg/m ³
Sample Flow	2.0 L/min (nominal)
Zero Check	Auto-Zero prior to every test
PC Connection	2.4GHz Wi-Fi
USB Port	Data Download to USB Drives
Wi-Fi	IEEE 802.11n, IEEE 802.11g, IEEE 802.11b (2.400-2.4835GHz)
Display	7" LCD (800 × 480 pixels)
Touch Screen	Pressure-sensitive Touch Screen (Resistive Film Type)
Operating Voltage	9-36V DC (via external power source) or internal NiMH battery
External Power	9-36V DC 60W (Unit powered off and battery charging) 12-36V DC 60W (Unit running and battery charging)
Battery Life	~2 hr continuous operation per charge
Storage Temperature	-20°C - 80°C
Operating Temperature	0°C - 40°C
Analyser Mass	4.9kg
Dimensions	(245 x 180 x 230) mm
Supplied Accessories	Tail pipe probe High-temperature sample hose 24V/2.5A DC Plug Pack (100-240 V, 50/60 Hz) Calibration-Check Plug 5 x Spare filter elements (external filters) Remote 'Enter' button with 7m cable Heavy duty portable carry case (w/- wheels, carry handle) Operator manual USB flash drive
Supplied Accessories	Tail pipe probe High-temperature sample hose 24V/2.5A DC Plug Pack (100-240 V, 50/60 Hz) Calibration-Check Plug 5 x Spare filter elements (external filters) Remote 'Enter' button with 7m cable Heavy duty portable carry case (w/- wheels, carry handle) Operator manual USB flash drive

*Refer Appendix B: Laser Light Scatter Instruments and Accuracy in Measuring Elemental Carbon

Appendix A:

MDG 29 Test Procedures (Extract)



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

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^3).

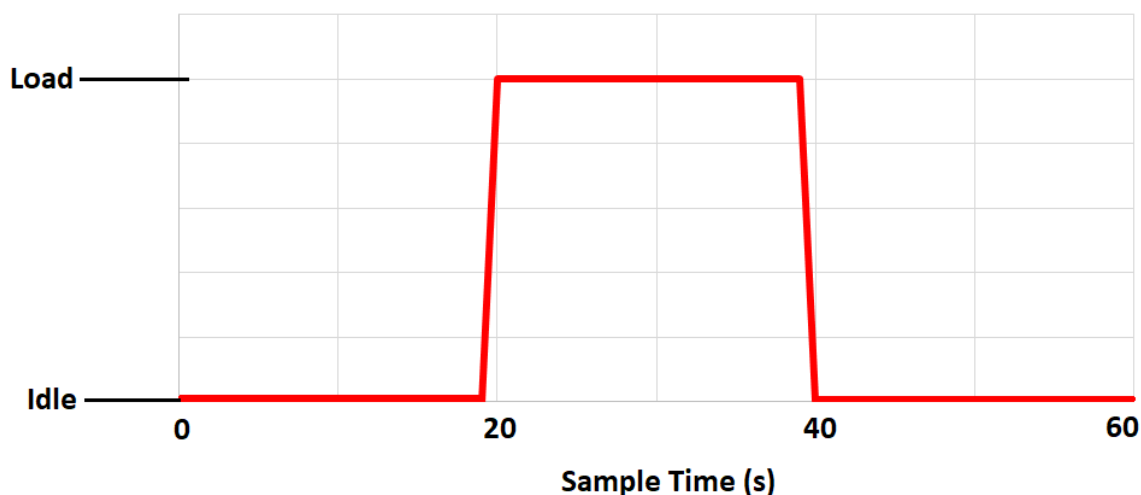


Figure 1 – Diesel particulate load cycle – Standard method

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 (mg/m^3).

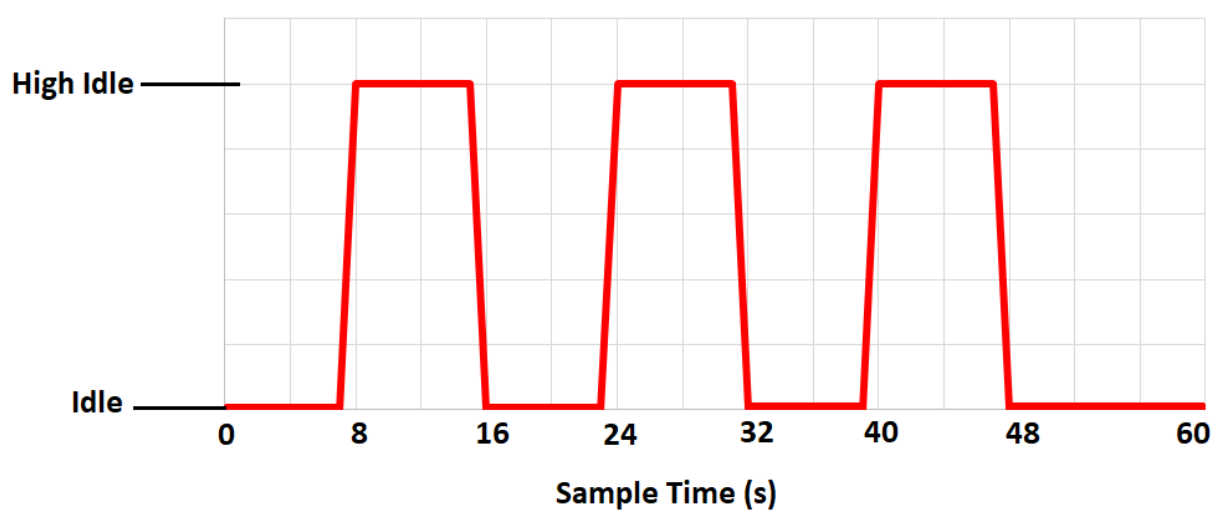


Figure 2 - Diesel particulate load cycle – Alternative method

Appendix B:

Laser Light Scatter Instruments and Accuracy in Measuring Elemental Carbon

NIOSH 5040 determines the Elemental Carbon (EC) and Organic Carbon (OC) components of the sample which combine to form the Total Carbon (TC). NIOSH 5040 has a stated accuracy of +/- 16.7% at 23ug/m³. (*NIOSH Manual of Analytical Methods (NMAM), Fourth Edition*)

The proportion of Elemental Carbon of Total Carbon in NIOSH 5040 analysis for different engines will vary

DPM-RT-2 is a precision laser light scatter (LLS) instrument with highly repeatable results. It cannot measure elemental carbon directly. This is a limitation of any laser light scatter or opacity-based measurement device.

The DPM-RT-2 can provide repeatable, correlated results with vehicle emission samples where the EC/TC ratio is consistent. The DPM-RT-2 base ratio of EC/TC is 0.77, that is $TC = .23(OC) + .77(EC)$. This is the average ratio determined by NIOSH 5040 for our proprietary diesel test rig.

Our accuracy for determining EC, where there is a stable EC ratio to TC (as is the case with our diesel calibration rig), is +/- 25%.

Using laser light scatter instruments is a practical way to perform real time testing of raw exhausts in underground mining. Various research projects have established correlation between LLS instrument measurements and EC measurements from NIOSH 5040. However the consistent theme of variation of EC/TC ratios is often discussed. Laser light scattering instruments are tools for providing an indicative reading and end users should, then, focus on the change in readings from the previous baseline readings established in managing emissions based maintenance of diesel engines.

Industry guidance in Australia recommends mines establish a baseline of results for engines at full power and at idle ([Guideline for the management of diesel engine pollutants in underground environments \(nsw.gov.au\)](http://nsw.gov.au)). It is the deviation from the baseline that is critically important when using LLS instruments in measuring engine particulate emissions. This will highlight improvements or deterioration of diesel engine performance or emissions controls performance.

Appendix C:

Document / Contact Information



DOCUMENT INFORMATION

Document Name:	DPM-RT-2 Operating Manual
Document:	Version 3.3
Software:	Version 2.2.19
Approval Date:	28/10/2024

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