
# OFWM USER MANUAL

## Contents

# About this manual

The purpose of this instruction manual is to promote safe, proper and optimal use and maintenance of the Online Ferrous Wear Meter OFWM system. The manual also helps to identify, avoid and prevent hazardous situations and related consequences.

Read and understand the manual carefully. Follow the given instructions. Follow the instructions in local laws and regulations and any orders given by local authorities.

Refer to further manuals and software to support installation and commissioning:

EMA-K32649 OFWM User Manual

EMA-K32676 OFWM Software Manual

EMA-K32677 OFWM Installation Manual

SW-K32679 Parker OFWM Software

To access resources scan the QR code or go to:

https://ph.parker.com/gb/en/product-list/on-line-ferrous-wear-meter-ofwm

# 1. Safety

## 1.1 General Safety

This equipment is only to be operated by persons trained in the use and handling of electrical and pressurised hydraulic and pneumatic systems. Local laws and regulations for installation, operation and servicing of pressurised hydraulic systems must be adhered to. Prior to operating the unit, hoses should be inspected for damage. If any damage is found, consult with Parker accordingly.

## 1.2 Safety symbols used in this manual

**WARNING** indicates a potentially hazardous situation that can cause property damage.

**CAUTION** indicates a hazard with a low level of risk that can cause minor or moderate injury.

**ELECTRICAL HAZARD** indicates a situation where a person can receive injuries from open electric sources

## 1.3 Warnings and precautions

**WARNING**

If the equipment is used in a manner, or for a specific purpose other than that described in this manual, then any safety protection may be impaired.

**WARNING**

**Pressurised systems.**

The OFWM system is designed to be connected to pressurised systems including pneumatic lines and hydraulic systems. A responsible body, the end user or system integrator, is responsible for ensuring the safety of associated systems, hoses or pipework containing fluids. This includes isolation for maintenance to the sensor(s).

**WARNING**

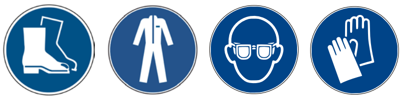
The OFWM system must be installed and operated by qualified persons only.

**WARNING**

The OFWM system must be powered on at all times. Even if the engine is off, power and air supply must be connected for both software and sensors to operate. If power or air supply is interrupted, the system must be reconnected as soon as possible. Failure to reconnect could result in sensor blockages.

### 1.3.1 Personal protective equipment

Always wear personal protective equipment (PPE). Follow the instructions in local laws and regulations and any orders given by local authorities.



Ensure Personal Protective Equipment (PPE) is always used when installing, operating and maintaining the OFWM system.

## 1.4 Improper use

The OFWM system is not suitable for use in explosive or hazardous atmospheres.

Do not attempt to open or dismantle the casing of the sensor.

## 1.5 Exclusion of liability

Parker has worked hard to ensure the accuracy of the information contained in this document. Despite these efforts, the possibility of errors cannot be eliminated. Therefore, we cannot accept liability for any errors that may exist, nor for any damage or loss that may result from these errors.

Please note that technical specifications may be updated or changed without prior notice.

# 2. Overview

The Online Ferrous Wear Meter (OFWM) is a key tool for maximising uptime and reducing operating costs on large two-stroke engines.

Cylinder condition must be monitored, but visual inspection is only possible with the engine shut down. Therefore, monitoring cylinder lubrication oil (CLO) on the underside of the piston while the engine is running provides critical insight into cylinder condition. This process is known as scavenge drain analysis (SDA).

OFWM offers an accurate method to detect, quantify, and trend ferromagnetic material (magnetic iron) suspended in CLO that has been in contact with the piston and liner. With continuous feedback, abrasive and adhesive wear can be monitored in line with OEM guidelines, helping reduce total cost of ownership by:

- Optimising the CLO feed rate
- Wear control
- Optimising overhaul intervals.

To maximise the benefit of the OFWM, it is recommended to install sensors onto each cylinder, to accurately monitor engine and system characteristics. With minimal disruption, installation can be done during port calls and requires minimal drain-line modification together with daisy-chained cabling and a compressed air line.

Optional software can be installed on a standalone PC to trend and log data and generate alerts. Alternatively, the sensor outputs can be integrated directly into the engine's supervisory monitoring system.

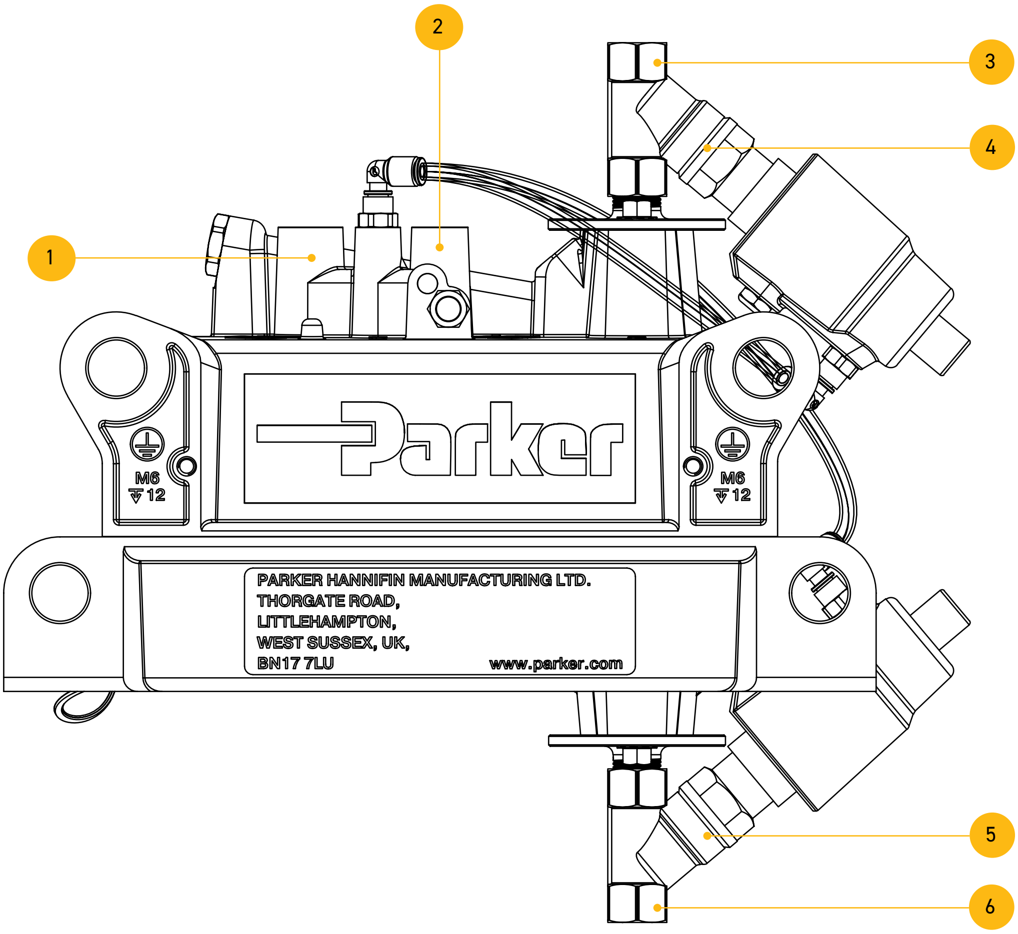
# 3. General description

## 3.1 Main components

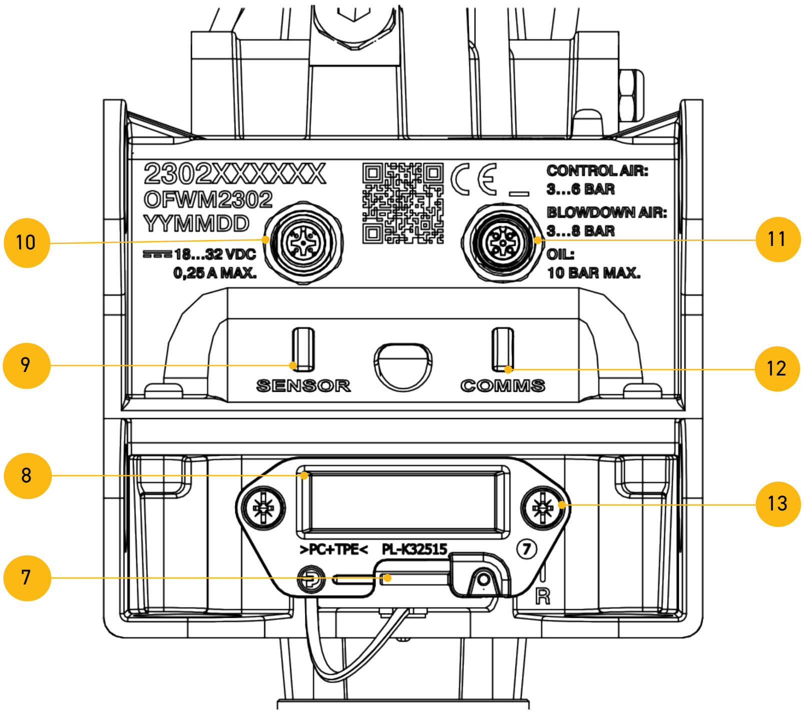
The sensor box contains:

- Sensor
- Anti-vibration mounts

The sensor has the following components:




| KEY | |
|---|---|
| 1. Blowdown air | 4. Upper angle seat valve |
| 2. Control air | 5. Lower angle seat valve |
| 3. Oil in | 6. Oil out |

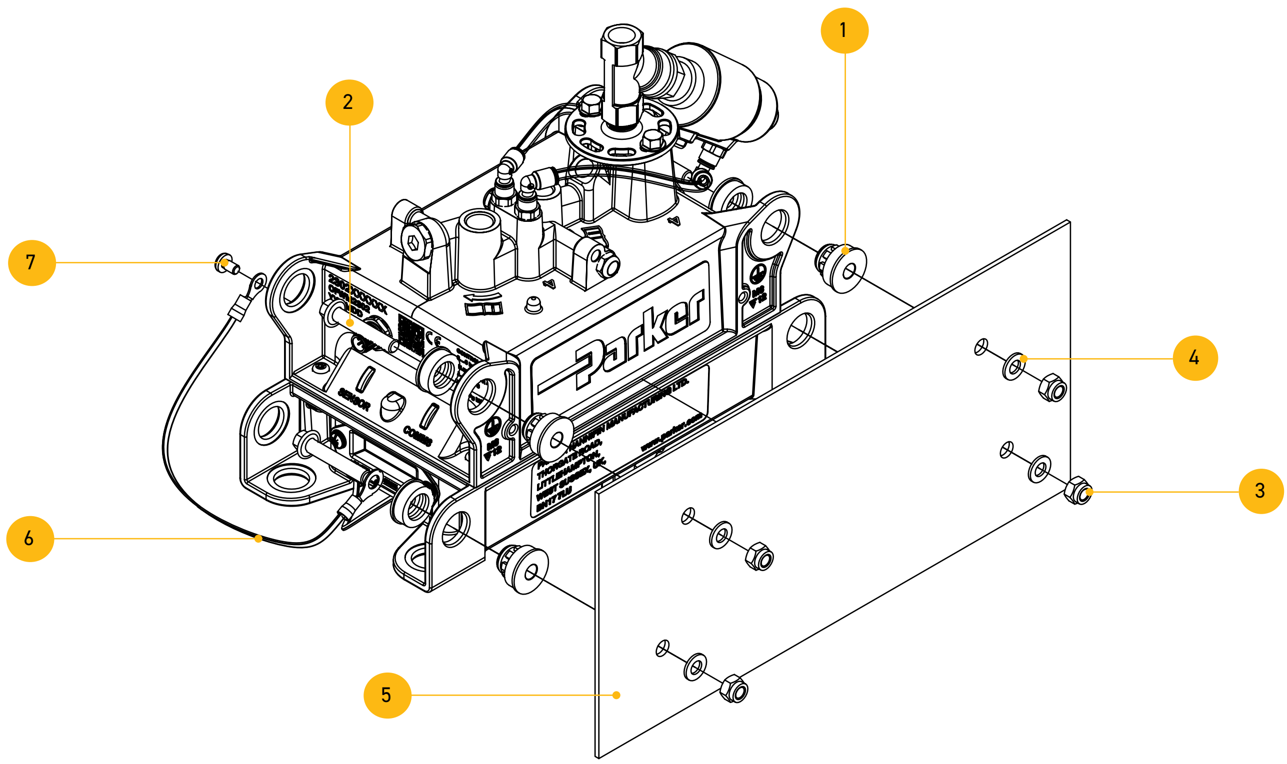



KEY

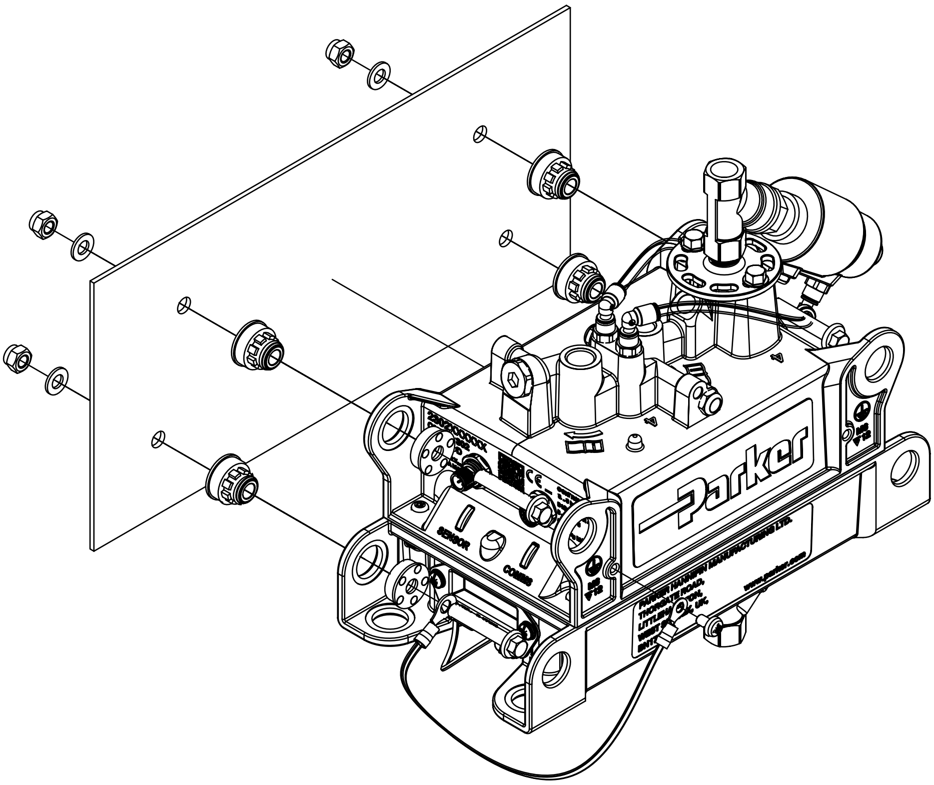
7. Probe for the reset button and DIP switch actuation
8. DIP switch cover
9. Sensor status indicator
10. Power and communications input
11. Power and communications output
12. Communications status indicator
13. Reset button — remove DIP switch cover to access

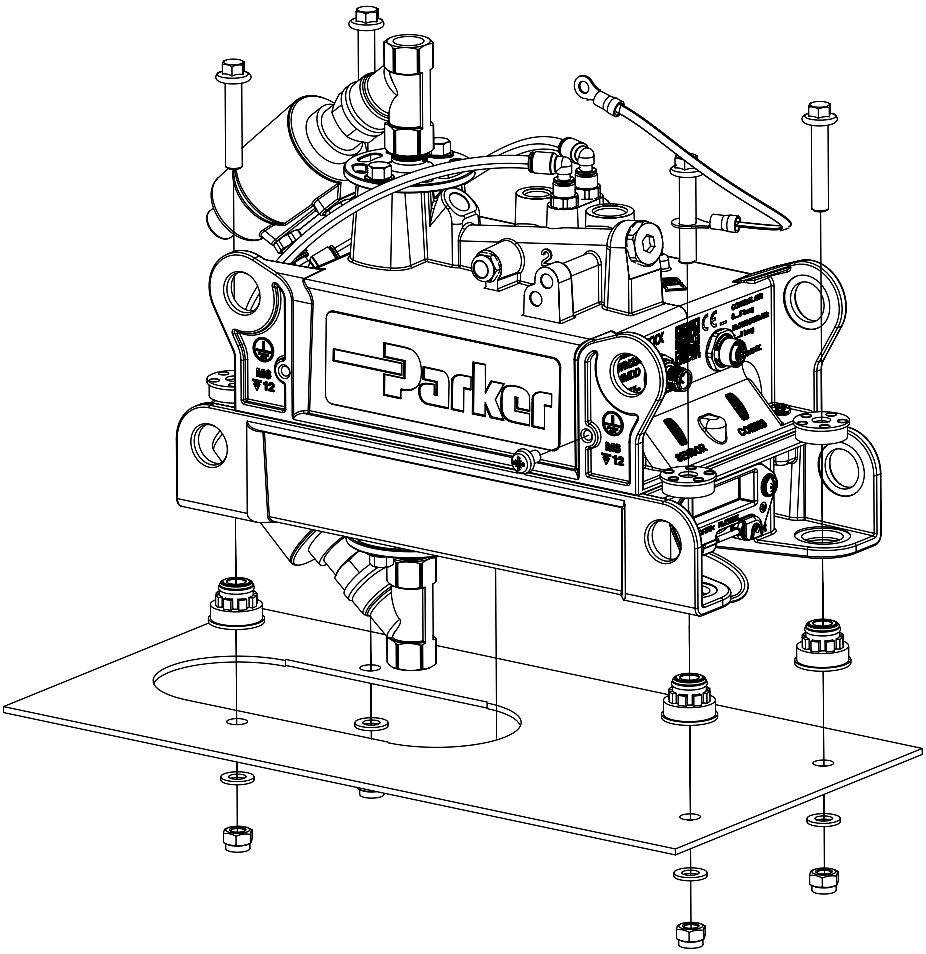
## 3.2 Sensor mounting

The OFWM sensor can be mounted in three orientations—bottom, left, or right—and must be secured at four points using the supplied vibration mounts.

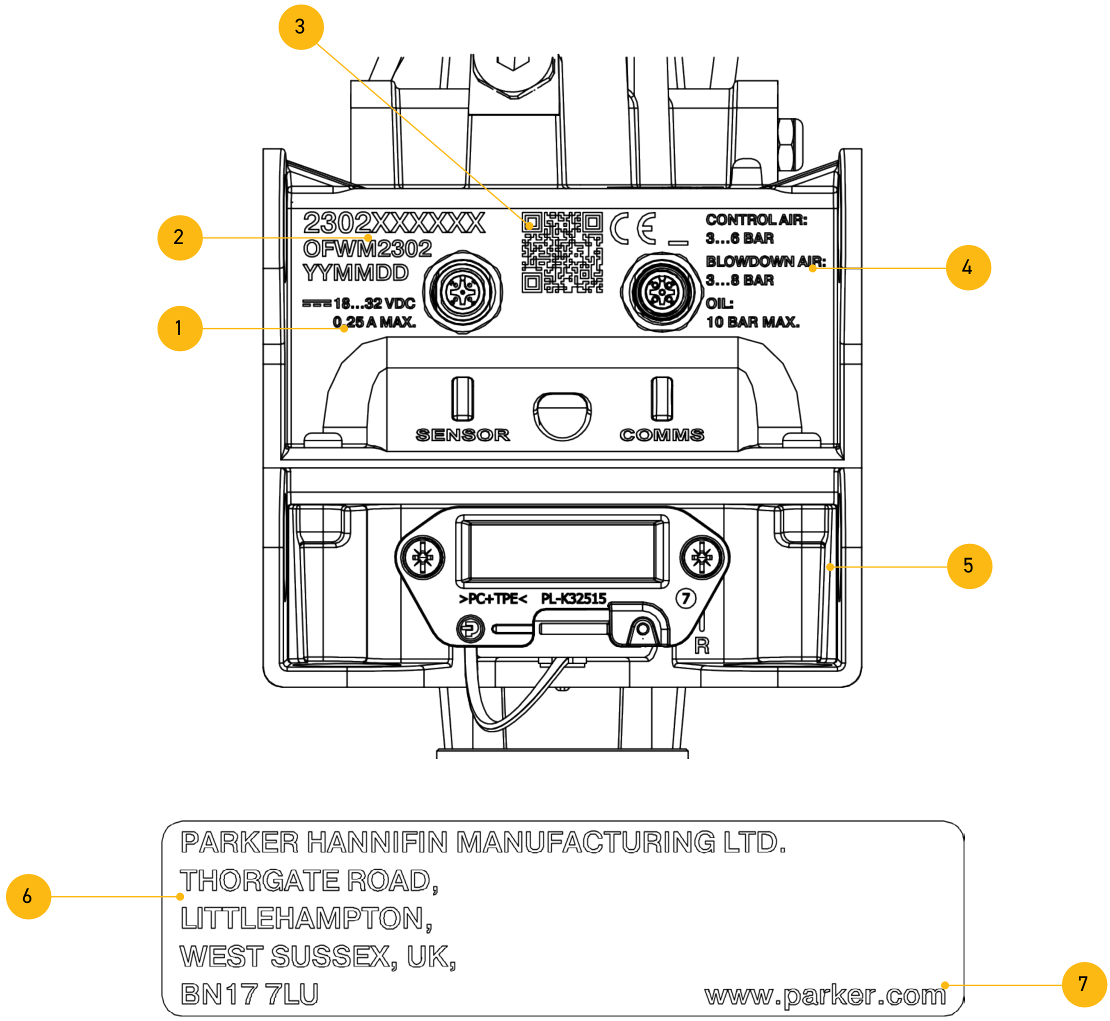



| KEY | |
|---|---|
| 1. Vibration Mounts | 5. Deckplate / Mounting Plate |
| 2. Flange Bolt (M8) | 6. Earth strap |
| 3. Self Locking Nut (M8) | 7. Earth Strap Screw (M6 x 12 mm) |
| 4. Washer | |


Parker
SENSOR
COMMS

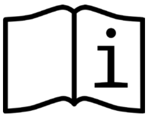

Parker
SENSOR
COMMS

## 3.3 Product markings

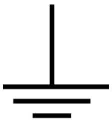



| KEY | |
|---|---|
| 1. Power requirements | 5. Location of type plate |
| 2. Product serial number, model and manufacturing date | 6. Name and address of manufacturer |
| 3. QR-code to product web page | 7. Manufacturer web page |
| 4. Air and oil pressure requirements | |

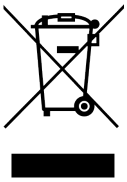
## 3.4 Symbols on the product



Refer to the instruction manual



Earth ground



Follow local laws and regulations when discarding the product.
See section 8 Decommissioning.

CE

CE certified product

2

Port #2 — Lower angle seat valve

4

Port #4 — Upper angle seat valve

## 3.5 Contents of the delivery

The sensor box contains:

- Sensor
- Anti-vibration mounts

## 3.6 Handling and storage

- Storage temperature: 0 — 55 °C
- relative humidity 65 %

Keep the product in its original packaging to prevent dust ingress. Store the packed sensor box only in locations where it will not be exposed to excessive vibrations.

# 4. Technical specification

## 4.1 Measurement performance

| | |
|---|---|
| Unit of measurement | Fe ppm (mg/kg) |
| Sensor resolution | 1 ppm |
| Minimum measurement | 20 ppm |
| Maximum measurement | 20,000 ppm |
| Calibration reference values | Fe powder/epoxy (mg/kg) |
| Sample volume | 12 ml |

## 4.2 Physical

| | |
|---|---|
| Maximum number of sensors | 14 |
| Electrical and communications | CAN Input: M12 circular socket – Male – A-coding<br>CAN Output: M12 circular socket – Female – A-coding |
| Power and communications cable | Bus system - CANopen<br>Cores - 4 core (2 twisted pairs) with shield and drain wire<br>Current - 4A nominal<br>Characteristic impedance at 1 MHz - 120 ohms |
| Interface — oil in/out | G3/8 |
| Interface — pneumatic | Air in, flow control: G1/4<br>Blowdown: G3/8 |
| Mounting fasteners | M8 |
| Earthing points | M6 x 12 mm |

## 4.3 Operating environment

| | |
|---|---|
| Environmental temperature | 10 °C — 55 °C<br>Keep the product in its original packaging to prevent dust ingress. Store the packed sensor box only in locations where it will not be exposed to excessive vibrations. |
| Handling & Storage | Storage: 0 — 55 °C<br>Keep the product in its original packaging to prevent dust ingress. Store the packed sensor box only in locations where it will not be exposed to excessive vibrations. |
| Oil temperature | 10 °C to 65 °C |
| Oil viscosity | 250 cst at 40 °C |
| Sensor ingress protection | IP65 |
| Minimum pressure delta; blowdown — oil pressure | Δ 3 barg* |
| Maximum safe operating pressure | 10 barg** |
| Blowdown pressure | 3 to 8 barg* |
| Control air pressure | 3 to 6 bar |

*Minimum pressure delta must be maintained during sensor operation. The blowdown pressure must exceed scavenge pressure by at least 3 barg to ensure reliable and complete sample purging.

** This is the sensor's safe static pressure limitation.

## 4.4 Materials

| | |
|---|---|
| Enclosure | Aluminium alloy |
| Material wetted flow path | Polyphenylene sulphide (PPS)<br>NBR seals<br>PTFE<br>Stainless steel<br>Zinc plated mild steel |

## 4.5 Electrical

| | |
|---|---|
| Sensor supply voltage | 18—32 V DC |
| Sensor current | 0.25 A |
| Communication physical layer | CAN bus V2.0b |
| Supported baud rate | 50 kbit/s, 125 kbit/s, 250 kbit/s, 500 kbit/s, 800 kbit/s, 1000 kbit/s |
| Communication protocol | CANopen |

# 5. Principle of Operation

The OFWM is an automated sensor that continuously measures ferrous (iron) particles in lubricating oil. Results are reported in parts per million (ppm) by weight (mg of iron/kg of oil). Up to 14 sensors can be daisy-chained on a single system.

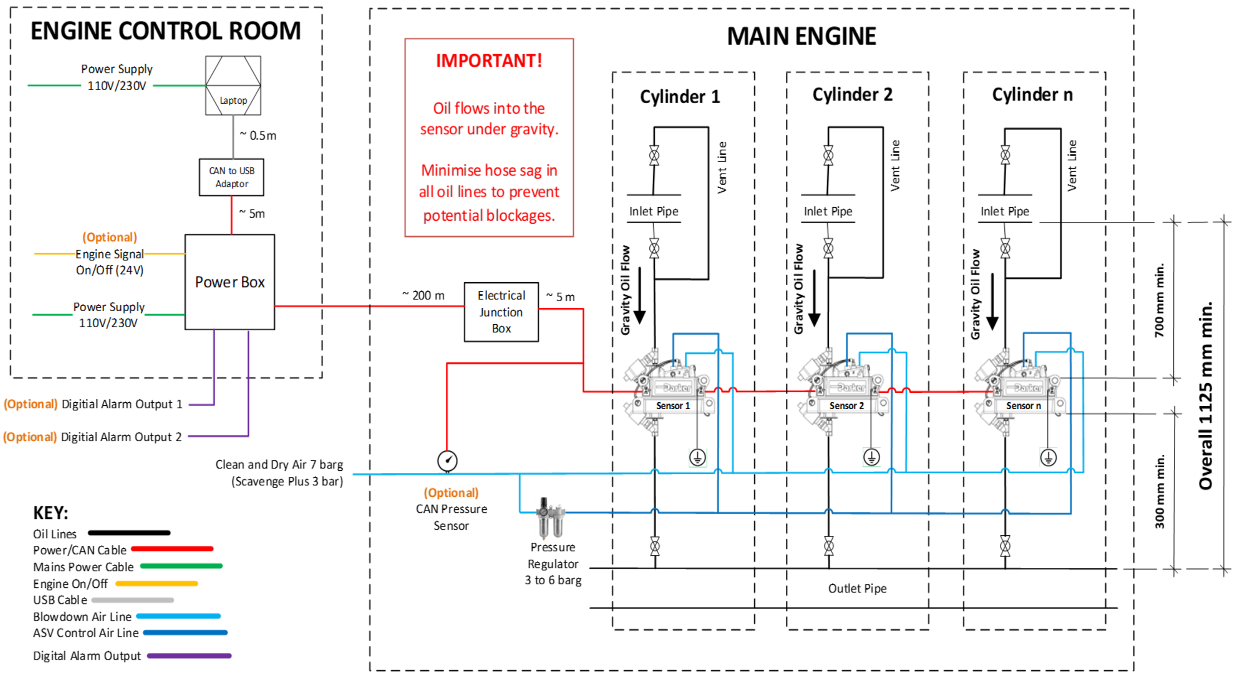
Each sensor receives oil by gravity into a sample tube. A level sensor inside the OFWM confirms when the required volume is reached, and the sensor then records a measurement. Compressed air is subsequently used to purge the tube (blowdown), after which a second measurement is taken. The difference between the "full" and "empty" readings is used to calculate the ppm concentration.

Only one sensor draws from the air supply at a time for the blowdown to ensure sufficient air volume for tube clearing. Measurement data and configuration parameters are communicated via CANopen for data logging and system setup. Data logging and configuration can be done using Parker's OFWM software or by third-party software that supports the CANopen protocol.

## 5.1 System schematic

There are alternative ways to configure standalone systems or integration into the ship's supervisory management systems.

The following is an example of a typical standalone system schematic.



# 6. Installation

For system installation guidelines, refer to the OFWM Installation Manual (EMA-K32677).

For standalone system using the Parker OFWM software, refer to OFWM Software Manual (EMA-K32676).

# 7. Maintenance

**WARNING**

The sensors are connected to pressurised systems – including pneumatic (compressed air) lines and hydraulic systems.

Before maintenance, all sensor services (power, air and oil) must be turned off or the valves to the sensor closed to isolate the sensor from the system

## 7.1 Visual inspection

It is recommended to do a visual inspection once per week for leaks, damage, loose fittings etc.

1. General visual inspection of sensor.
2. LED status indicators — make sure that both indicators are green.
3. Hydraulic hoses and fittings.
4. Isolation valves.
5. Pneumatic hoses and fittings.
6. Angle seat valves — make sure that the visual indicator works and ensure there is no oil contamination inside the sight glass.
7. Power/communication cables.
8. Vibration mounts and fastenings
9. Mains air supply — make sure that air pressure is correct.
10. Mounted boxes, for example, junction box and power box.
11. Check all electrical cable runs.

## 7.2 Routine maintenance

It is recommended to undertake the following routine maintenance sequence. The frequency will be dependent on the specific characteristics of the installation i.e. CLO type, fuel, engine, environmental conditions etc.

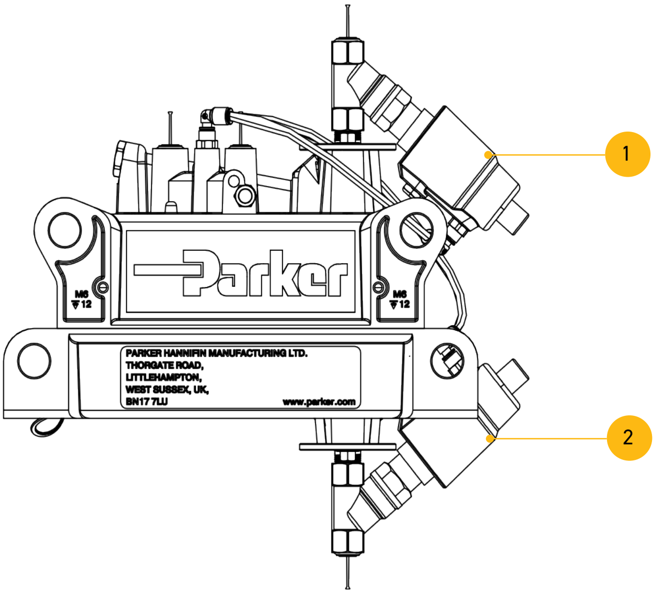
1. Remove, inspect and clean inlet and outlet hydraulic hoses.
2. With the engine turned off, Inspect and clean all isolation valves and bosses. Ensure any blockages are cleared.
3. Remove any fittings from the angle seat valves. Inspect and clear any sign of blockage.
4. Remove the top and bottom angle seat valves (refer to Section 7.3).
5. Inspect and clean angle seat valves (refer to Section 7.4). If necessary, replace with new valves. Refer to Section 7.8 for spare parts.
6. With the angle seat valves removed, inspect and clean sensor sample tube (refer to Section 7.5).

After completing the maintenance sequence, re-assemble referring to relevant sources.

## 7.3 Replace angle seat valves

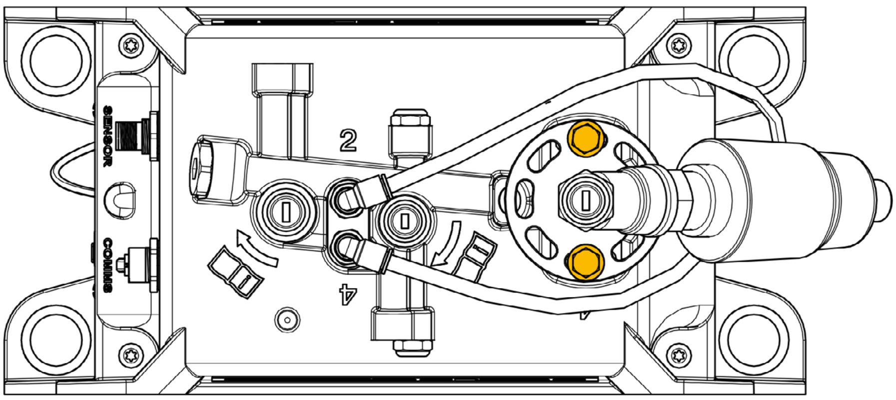
The sensor may contain residual air pressure and fluids. Wear eye protection and oil-resistant gloves. Follow any local safety practises that may be required in addition to the instructions below.

The OFWM sensor has two angle seat valves: the upper angle seat valve (1) and the lower angle seat valve (2).

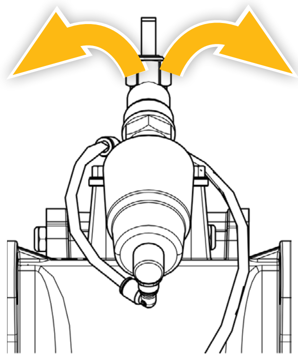



### 7.3.1 Removing angle seat valves

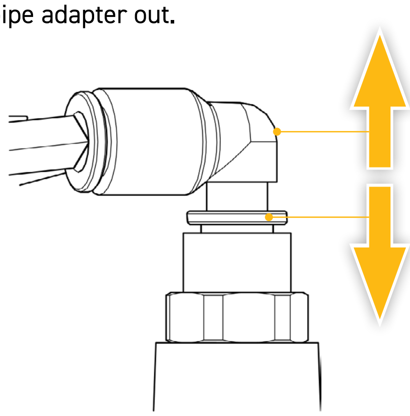
1. Close the sensor oil feed valve and vent valve. Do not close the oil drain valve.
2. Purge the sensor to clean the measurement chamber and the angle seat valves, by performing a blow down. If Parker data logging software is installed, see the **Engineering** section in the **OFWM Software User Manual** or use CANopen protocol to operate. Repeat the purge three times.
3. Isolate the air supply from the sensor.
4. Close the oil return valve.
5. Loosen the two M6 bolts on the angle seat valve. Do not remove the bolts.



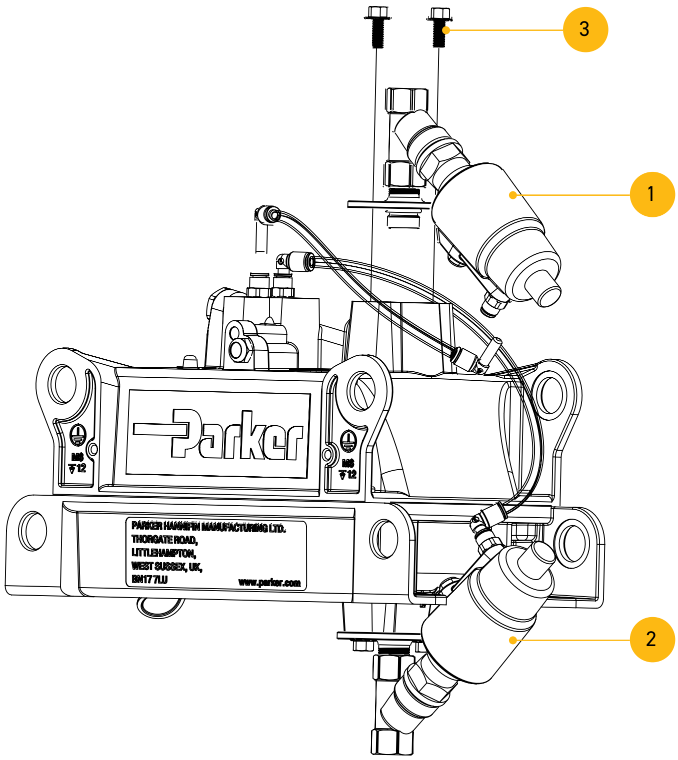

6. Gently move the upper angle seat valve from side to side and lift carefully to disengage the O-ring, allowing any residual system pressure to dissipate.



7. If required, loosen or remove hose connections at the Y piece. Be aware of residual system pressure that may dissipate.
8. Remove the air pipe that is connected to the angle seat valve from the sensor housing by pushing down the collet on the fitting and pulling the pipe adapter out.



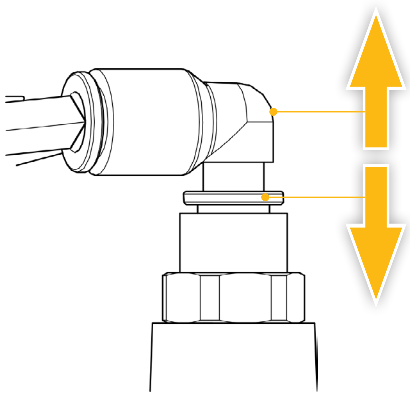
9. Remove the two M6 bolts (3) on the upper angle seat valve (1) and remove the valve.




10. Clean the bore and mating surfaces with a cloth or a cotton bud and a small amount of isopropyl alcohol (IPA).
11. Repeat steps 5 to 10 for removing the lower angle seat valve (2).

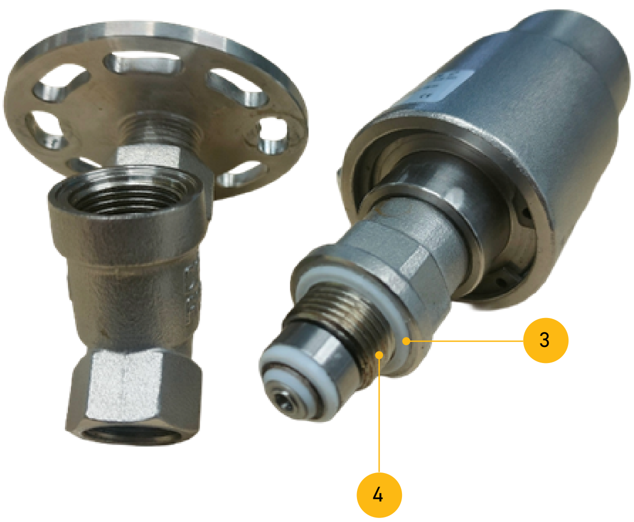
## 7.4 Angle seat valve cleaning

1. With the angle seat valve (ASV) assembly removed, remove the air pipe that is connected to the angle seat valve from the sensor housing by pushing down the collet on the fitting and pulling the pipe adapter out.



2. Grip the valve body (1, not the circular adapter) in a vice or similar and using a 24mm spanner loosen the valve head (2). Ensure the polytetrafluoroethylene (PTFE) seal (3) retracts and remains with the head so that it doesn't get misplaced.


3. With the head removed, inspect the valve plug. This should be fully retracted with metal to metal contact (4), no stem should be visible. Clean the valve plug/seal with a nylon brush/rag/IPA to remove contamination. Move to step 6 if the valve plug is fully retracted, otherwise proceed with steps 4 and 5.



4. If the head is not fully retracted due to build up of contamination, clean the contamination away from the back of the plug/steam area using appropriate tools and IPA. Do not use anything that could damage the plug/stem.

5. If after cleaning the valve plug has still not retracted to within 1mm of metal to metal contact, manually try to actuate the plug by pulling on the plug/then pushing, do this a few times to try and free it (note, the internal spring will always try to pull the valve back to its natural position,  metal/metal contact). If the plug still does not retract contact your Parker representative for a replacement ASV assembly.

6. Clean the valve body of all contamination using IPA. Inspect the O-ring on the adapter ensuring there is no damage/contamination left in the groove.

7. Reassemble the valve ensuring the PTFE seal is in place and tighten. Insert the air tube back into the push fit connector ensuring fully home. Gently pull the fitting to ensure engaged.

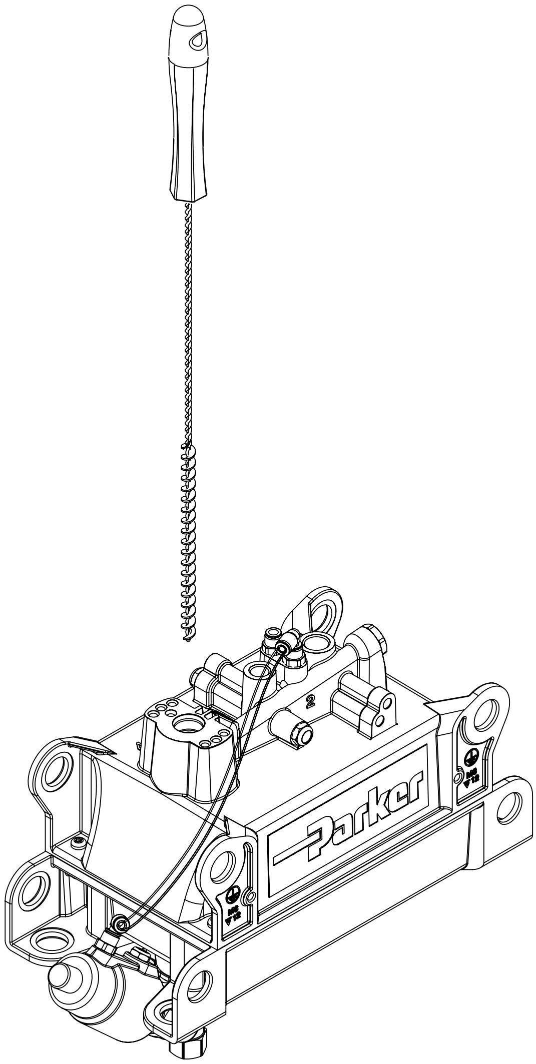
8. The ASV assembly can now be installed back onto the main unit as per section 7.4.1.

## 7.4.1 Installing angle seat valves

1. Set the angle seat valve on the sensor. Align the head centrally.
2. Fasten the angle seat valve with the two M6x16 bolts. Make sure the bolts are opposite to each other. Tighten the bolts to 10 Nm.
3. Make sure that all hoses and pipes are fastened securely. Do a gentle pull test.
4. Open the air and oil supply lines.
5. Let the sensor run. Examine for leaks and make sure that the sensor operates correctly.

# 7.5 Sample tube cleaning

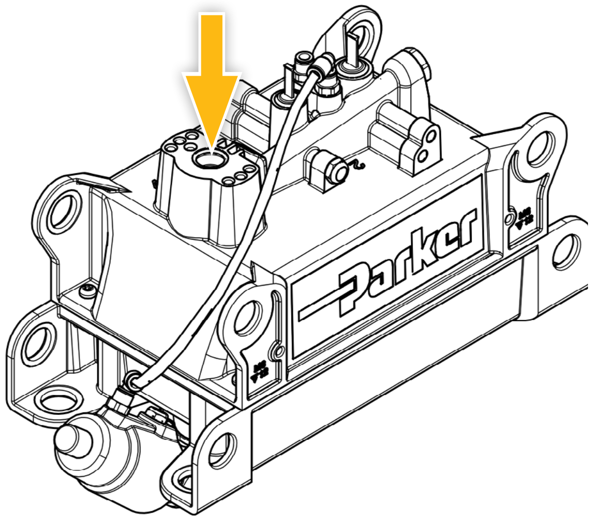
Clean the sample tube with a thin rag wrapped around a nylon brush. The cleaning tool must be more than 150 mm in length and have a maximum diameter of 8 mm to ensure the detection area is cleaned. Use a small amount of isopropyl alcohol (IPA). Ensure the whole tube diameter is cleaned. Do not use hard tools to clean the tube as this may cause damage to the sensor.



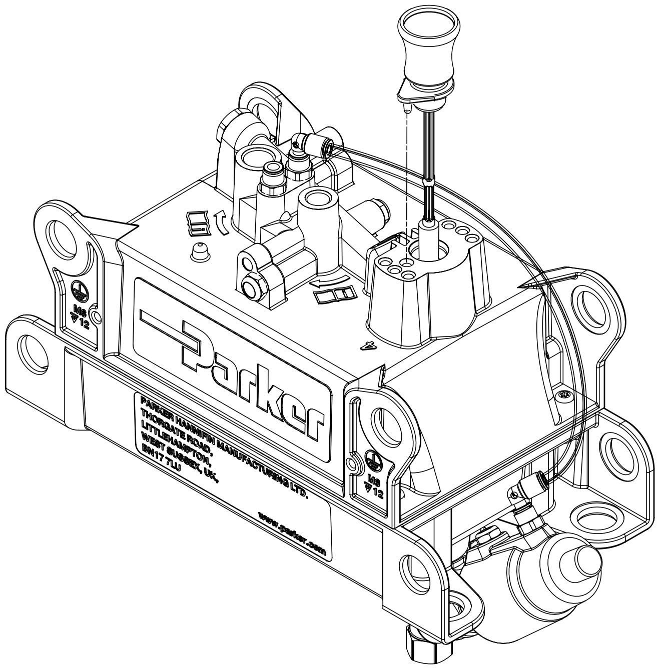
## 7.6 Sensor verification

1. Remove the upper angle seat valve. See section 7.3.1 Removing angle seat valves.

2. Clean the sample tube. See section 7.5 Sample tube cleaning.




3. With the air to the sensor still isolated and with the sensor in Run mode, insert the check standard (refer to parts list Section 7.8) into the sample tube.




4. Ensure that the check standard location pin aligns with the location hole on sensor ASV mounting face and that the check standard is fully inserted.

5. Hold the check standard in the sample tube until the sensor status indicator turns blue.

6. Remove the check standard.

7. Make sure that the system reports the correct values.  Wait at least 3 seconds before re-inserting the check standard

8. Repeat for other check standards.

9. Install the upper angle seat valve back on the sensor. See section 7.4.1 Installing angle seat valves.

### 7.7 Clean the sensor

Clean the sensor with a cloth and a small amount of isopropyl alcohol (IPA).

**CAUTION**

Do not use running water.

Do not use aggressive chemicals.

### 7.8 OFWM spare parts

| Accessories | Description |
|---|---|
| ACCK42001 | Upper 3/8" Angle Seat Valve Assembly |
| ACCK42002 | Lower 3/8" Angle Seat Valve Assembly |
| ACCK42003 | Anti-Vibration Mounts (Pack of 4) |
| ACCK42004 | Verification Check Standards |

# 8. Decommissioning

### 8.1. Recycling and disposal of materials

Only qualified persons can remove the sensor from service. The decommissioning process must be performed according to local laws and regulations.

Clean the sensor and its parts of oil. Dispose of all the parts of the sensor and any residual oil in accordance with local environmental regulations. Whenever possible, recycle the parts.

# 9. Troubleshooting

**Note**: The data logging software referred in this troubleshooting section may refer to the Parker OFWM software or third-party equivalent

<table>
<tr><th>Problem</th><th colspan="2">Possible reason</th><th>Suggested solution</th></tr>
<tr><td>Sensor status LEDs off</td><td colspan="2">Sensor has no power.</td><td>Check cables are connected.<br>Check power supply and fuses.<br>Check sensor supply voltage is in the range 18 – 32 Vdc.</td></tr>
<tr><td rowspan="8">Sensor not detected by data logging software</td><td colspan="2">Sensor has no power.</td><td>See above.</td></tr>
<tr><td colspan="2">CAN-USB adapter problem (if using Parker OFWM software)</td><td>Disconnect adapter from the PC and reconnect.<br>Make sure drivers are installed on the PC, see the Software manual.</td></tr>
<tr><td>The sensor communications error status LED shows red blinking. See the Status indicator section.</td><td>Sensor node ID and baud rate not configured.</td><td>Change DIP switches on the sensor to configure a unique node ID and to configure the correct baud rate for the CAN bus. See the Installation manual.</td></tr>
<tr><td rowspan="4">The sensor communications error status LED shows a single red flash. See the Status indicator section.</td><td>Communications cable disconnected from the PC.</td><td>Reconnect the cable.</td></tr>
<tr><td>Mismatched baud rate.</td><td>Make sure the baud rate matches that of the software.</td></tr>
<tr><td>Short circuited communications cable.</td><td>Check cables for short circuit.</td></tr>
<tr><td>Missing CAN terminator resistors from communications cable.</td><td>Make sure 120-ohm terminator resistors are connected to each end of the CAN communications cable.</td></tr>
<tr><td>The sensor communications error run LED shows blinking green. See the Status indicator section.</td><td>Not connected to the PC.</td><td>Make sure the CAN-USB adapter is connected to the PC.</td></tr>
<tr><td rowspan="6">Sensor does not report new measurement to data logging software</td><td colspan="2">Sensor node ID and baud rate not configured.</td><td>Change DIP switches on the sensor to configure a unique node ID and to configure the correct baud rate for the CAN bus. See the Installation manual.</td></tr>
<tr><td colspan="2">Sensor not in Run mode.</td><td>Put the sensor in Run mode.</td></tr>
<tr><td rowspan="4">Sensor is not filling</td><td>No system oil flow.</td><td>Manually check of oil flow.</td></tr>
<tr><td>Blocked upper angle seat valve.</td><td>See the Maintenance section.</td></tr>
<tr><td>Blockage in the system.</td><td>See the Maintenance section.</td></tr>
<tr><td>Isolation valves closed.</td><td>Open the isolation valves.</td></tr>
</table>

| | | | |
|---|---|---|---|
| | | No system air. | Make sure system air pressure and air flow is correct.<br>Examine pneumatic hoses and fittings. |
| | | Oil misting. | If you are unable to sample oil, refer to the Installation manual for potential solutions, for example, pipework baffles. |
| | | Faulty angle seat valve. | Make sure the red indicator is positioned correctly. When the red indicator is visible, the valve is open. Replace the angle seat valve. See the Replace angle seat valve section. |
| | | Vessel listing. | Check listing angle and orientation (port/ starboard). |
| Data logging software reporting block alarm. (Sensor status LED changed to red. See the Status indicator section) | Blocked sensor sample tube. | | Attempt to restart the measurement from the software (if using Parker OFWM software see the Software manual) or by pressing and re-leasing the sensor reset button (see the section Using the reset button).<br>If this fails, attempt to manually blast air down to clear the blockage via the software. If using Parker OFWM software see the Software man-ual.<br>If it is still blocked see the Maintenance section. |
| | Blocked outlet pipe. | | |
| | Blocked lower angle seat valve. | | |
| | Faulty lower angle seat valve. | | Make sure the red indicator is positioned correctly. When the red indicator is visible, the valve is open. Replace the angle seat valve. See the section Replace angle seat valve. |
| | No blowdown function. | | Check system air pressure is correct and exam-ine pneumatic hoses and fittings.<br>Check sensor supply voltage is in the range 18 – 32 Vdc.<br>Blocked lower angle seat valve. See the Maintenance section.<br>Blockage in system. See the Maintenance section. |
| Fatal error detected by the data logging software (Both LEDs 'railroading'. See the Status indicator section) | A software or hardware fault. | | The sensor will attempt to restart by itself.<br>If not, attempt to restart the sensor from the software (if using Parker OFWM software see the Software manual) or by pressing and releasing the sensor reset button (see the section Using the reset button).<br>If the sensor fails to restart, note down the fatal code from the Parker OFWM software, if possible, and export all the data ensuring the event log is included and report to your Parker distributer. |
| Firmware not installed (Both LEDs solid red. See the Status indicator section) | Firmware not installed. | | Firmware needs to be installed. Contact your Parker distributer. |
| Sensor triggers ship alarm | System power supply. | | Make sure the system power supply is isolated. |
| | Communication cable 0 V signal ground connected to earth. | | Isolate the 0 V ground from earth. |

# 10. Appendices

## 10.1 Interpreting the LEDs

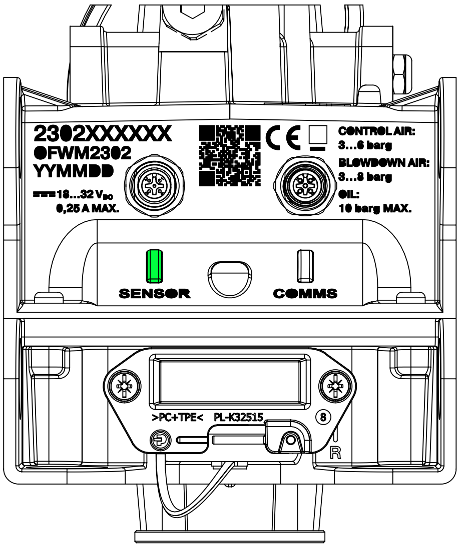
The sensor has two tri-coloured LED indicators, the sensor status indicator on the left-hand side and the communications status indicator on the right-hand side.

With the sensor configured and operating normally, the sensor status LED will be green with a blip off every 2 seconds to indicate Run mode and the communications status LED will be solid green to indicate CAN operational.

The sensor status LED will change to blue for a few seconds during an air blowdown.

Red on either LED indicates the sensor requires attention or a fault has occurred.

### 10.1.1 Sensor status LED




**Stop Mode**
Blips on once every four seconds

**Run Mode**
Blips off once every two seconds
Turns blue during air blowdown
Turns red to indicate a blocked tube or balance fail

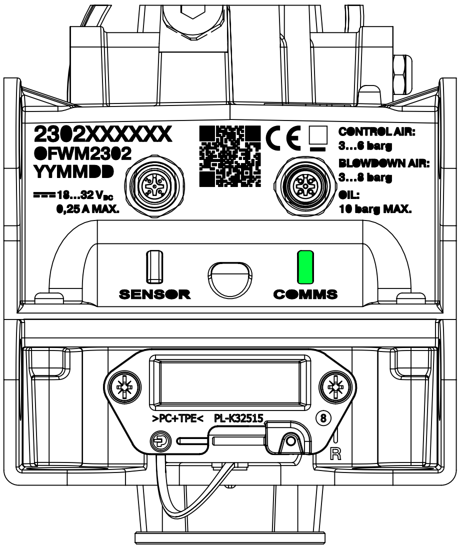
**Configuration Mode**
Double flash every 2 seconds
Turns blue during air blowdown
Turns red to indicate a blocked tube or balance fail

**Bootloader Mode**
Triple flash every 2 seconds
Changes to flicker when updating the firmware

**Factory Mode**
Quadruple flash every 2 seconds
Turns red to indicate a blocked tube or balance fail

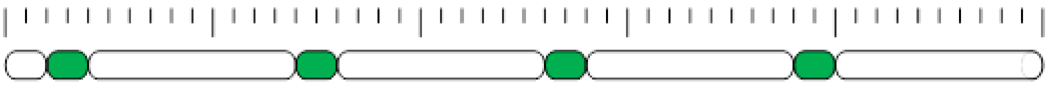
## 10.1.2 Communications status LED

The Run (green) and the Error (red) status are interleaved on the single communications status LED.




### Run status

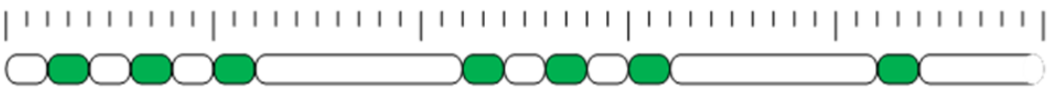
**Stopped State**
Single flash followed by a 1 s pause



**Pre-Operational State**
Blinking (200ms)

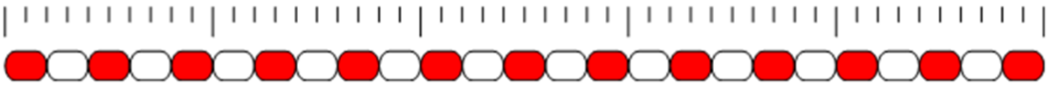
**Operational State**
Solid on

**Firmware Updating**
Triple flashes followed by a one second pause



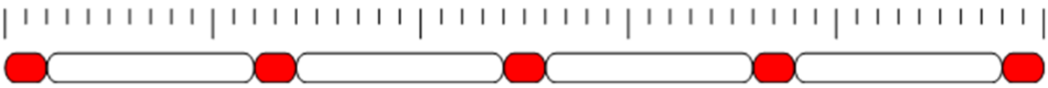
## Error Status

**Invalid Configuration**
Blinking (200ms)



**Bus Off**
Solid on

**Warning**
Single flash (200ms) flash followed by a one second pause



**Sensor status and communications status LEDs together**

**Power up sequence**
CAN and Status LEDs alternate colour

**Fatal error detected**
Railroad flash (500ms) alternating between the CAN and Status LEDs

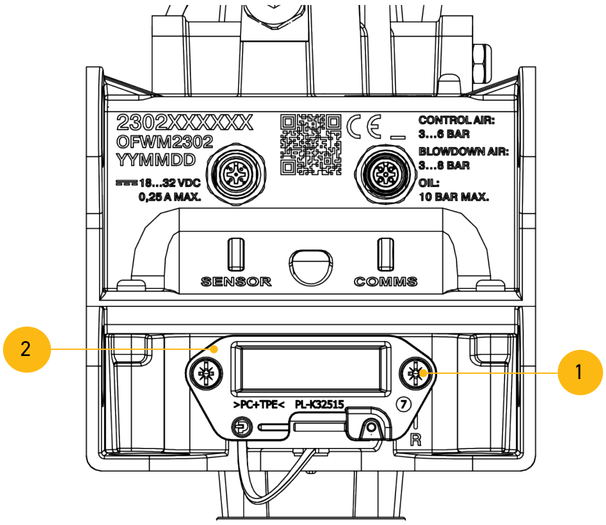
**Fatal error detected at startup**
Railroad flash (250ms) alternating red and blue between the CAN and Status LEDs

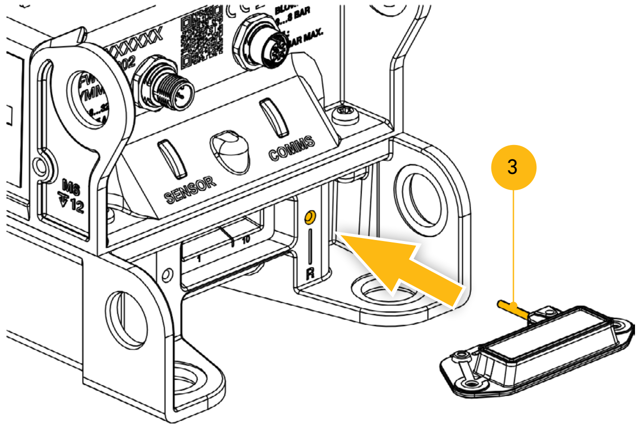
**Firmware no installed**
CAN and Status LEDs solid on

## 10.2 Using the reset button

To access the button:

1. Remove the two screws (1) on the plastic cover at the end of the sensor.
2. Remove the plastic cover (2) from the front of the sensor.
3. Rotate and use the yellow probe (3) on the plastic cover to push the button as required.
4. Set the plastic cover back on the sensor.
5. Fasten the plastic cover with the two screws.




### 10.2.1 Reset the sensor back to factory defaults

1. Push and hold the reset button for 5 seconds.

Result: Both LEDs will flash green five times to indicate the sensor has returned to factory settings, including the CANopen communication configuration.

### 10.2.2 Retry after blockage indication

If a blockage indication is shown when in Run mode, the reset button can be used to attempt to restart measurements. However, normally this restart is done from the software via the user interface.

1. Push, for under 0.5 second, and release the reset button.

Result: The sensor attempts to restart measurements.

### 10.2.3 Retry after fatal error indication

If a fatal error indication is shown, the reset button can be used to attempt to restart the sensor. However, normally the restart is done from the software via the user interface.

1. Push, for under 0.5 second, and release the reset button.

Result: The sensor attempts to restart the sensor.

## 10.3 Interpreting results

### 10.3.1 Introduction

The Online Ferrous Wear Meter system (OFWM) provides an accurate means of detecting, measuring and trending the quantity of ferromagnetic material (magnetic iron) suspended in the scavenge drain oil that has been in contact with the piston and the liner. With continuous feedback, abrasive and adhesive wear can be monitored in accordance with OEM guidelines. This can reduce the cost of ownership by:

- Optimising the cylinder oil feed rate
- Wear control
- Optimising overhaul intervals.

### 10.3.2 Original equipment manufacturer (OEM)

Original equipment manufacturers (OEMs) go to great lengths to in the research and development of their engines. They observe vessel operational data in day-to-day operation and run trials and experiments with configurations and materials. This research and development informs operational documentation.

OEM documentation covers such matters as lubricants, load rates and operating regimes. Frequently, service letters and advice bulletins are distributed. They offer up-to-date advice — especially taking into account market trends in operation and fuelling choice.

As a system, the OFWM provides continuous ppm data which can be used to determine where on the OEM schedule each cylinder is operating.

### 10.3.3 Factors affecting wear

Wear is very much related to engine parameters, such as speed, load, cylinder lubricant type and feed rate. Temperature and humidity change frequently and affect the combustion process and can interfere with how well lubricated the liner surface is. Fuels (see below) and lubricant quality — especially any contamination — will have an impact, as will the quality of air filtration. The state of the engine itself — how new or worn parts are and how they interact with each other — is another factor.

### 10.3.4 Fuels

Fuelling of 2-stroke engines is in constant change. Fuel choice is much wider than it has been, and it is expected that high sulphur fuel oil (HSFO), very low sulphur fuel oil (VLSFO), and ultra-low sulphur fuel oil (ULSFO) will continue to be the major fuels used. Liquified Natural Gas (LNG) is also growing. Many operators choose dual-fuel options based on cost and meeting legislative measures.

Bio-based fuels (biofuels) are one of the most popular alternative marine energy sources and may be blended with conventional fossil fuels as the shipping industry reduces its greenhouse gas emissions.

Fuel has an impact on cylinder condition, especially the sulphur content. HSFO with up to 3.5% sulphur can lead to corrosion of the liner from acidic by-products. This requires higher base number (BN) cylinder lubricants which also effect cleanliness and deposits in the scavenge space.

Switching between sulphur content, fuel composition and fuel type changes temperatures and pressures, which can alter the wear rate and mechanism.

## 10.3.5 Tribology and lubrication

Metal parts within the engine are separated by an oil film. This means that metal to metal contact does not occur. However, when the engine starts, there is a period where the oil film builds up. During this time metal to metal contact can occur.

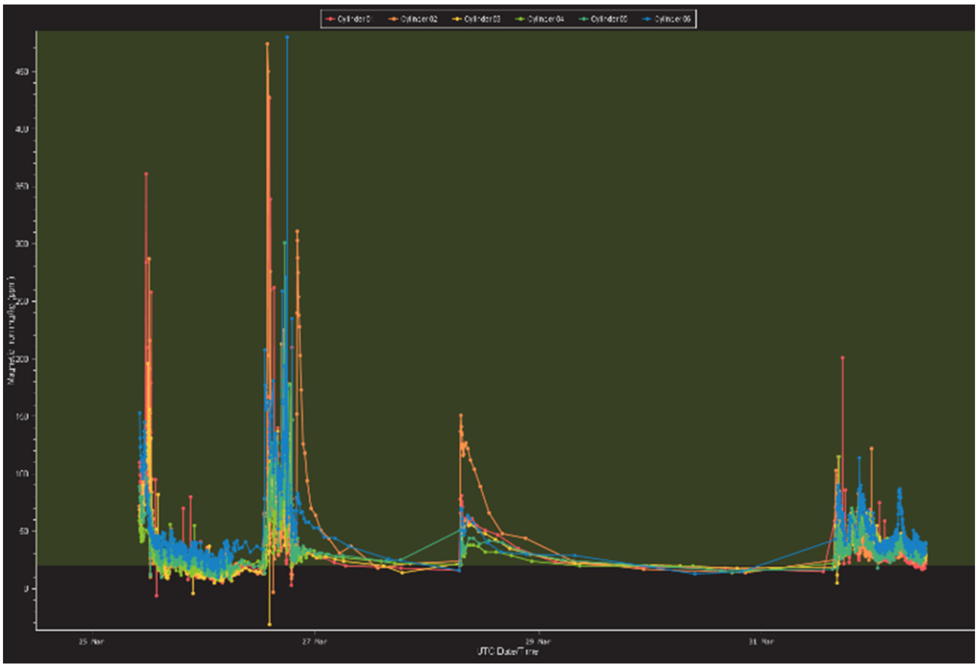
## 10.3.6 Equilibrium

Once at operating temperature and under constant load, an equilibrium is reached. With adequate lubrication the surfaces will continue to be separated by the oil film. Wear rates can be controlled to OEM guidelines. This situation is desired state; very low wear rates will be observed. The OFWM may indicate a value of < 20 ppm.

## 10.3.7 Running

### 10.3.7.1 Startup and manoeuvring

When the engine is started, the system's equilibrium is disrupted, so an increase in wear is expected. In the figure below, ppm measurements above 100 ppm indicate engine start-up.



## 10.3.7.2 Changes in load or fuel


Throughout a voyage, external factors influence load. These factors can include sea currents, wind or changing between fuel types. Switching from 0.1% to 0.5% S (VLSFO) to ≤ 0.1% S (ULSFO) will often disturb the equilibrium and result in a noticeable spike in ppm. A new equilibrium will be reached and stable readings should be observed until the next disturbance.

## 10.3.8 New engines and components

When a new liner or piston rings are fitted, a predictable wear debris profile typically emerges as components bed in and reach equilibrium. Any high spots which disrupt the oil film are removed with contact between the moving parts, which is observed in higher ppm readings.

Engine manufacturers often advise increasing the cylinder lubricant feed rate for a recommended time following component replacement or after scuffing. If the feed rate is increased for too long a period, oil is wasted. If the feed rate is increased for too short a period, damage can occur. This bedding-in period is also dependent on various parameters such as engine load and fuel sulphur. Thus, having feedback to show when the wear rates have returned to normal levels is advantageous.

Bedding in can take vastly different lengths of time: varying from 80 to more than 1000 hours for iron levels to return to normal. During the bedding-in period, liners and rings are considerably more susceptible to sudden and severe wear events. This is possibly due to the reduced clearance between the sliding surfaces.

OEM advice should be followed on running in, including expected wear ppm rates.

## 10.3.10 Scuffing

Cylinder scuffing in 2-stroke engines is a severe wear problem. Scuffing is a localized adhesive wear phenomenon where the lubricating oil film breaks down, causing direct contact between the piston rings and the cylinder liner. This results in material transfer, scoring and roughening of the cylinder surface. It can rapidly escalate and elevated readings of > 1000 ppm can be observed. This often contaminates neighbouring cylinders.

The causes of cylinder scuffing are numerous and are unpredictable. Follow OEM advice in the event of ppm readings that are abnormal. Possible causes of cylinder scuffing:

| | |
|---|---|
| Insufficient lubrication | Oil fill breakdown or poor oil distribution |
| Overheating | Excessive temperature reduces oil film strength |
| Contaminated scavenge air | Dirt or unburned fuel particles cause abrasive wear |
| Poor fuel quality | High sulphur or contaminants affect lubrication |
| Incorrect cylinder liner honing | Surface finish not optimal for oil retention |
| Mechanical faults | Piston ring sticking or misalignment |
| Rapid load changes, cold starts and manoeuvring | Temporary oil starvation during transient conditions |

## 10.3.10 Feed rate optimisation

Optimising cylinder lubricant usage is a way to reduce one of the largest overheads of an engine. However, there is a point where these savings can be diminished by increased maintenance costs. Too high a feed rate wastes cylinder oil and can cause wear through a process called “bore polishing”. Too low a feed rate will accelerate wear. Use the feedback from the OFWM system in conjunction with the latest OEM advice to find the optimum settings.

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