Biral
Visibly Better

USER MANUAL
INSTALLATION - OPERATION - MAINTENANCE

RWS-20

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CONTENTS

GENERAL INFORMATION

General Information

The sensor covered in this manual:

Sensor Model	Capability
RWS-20	Visibility - Obstruction to Vision
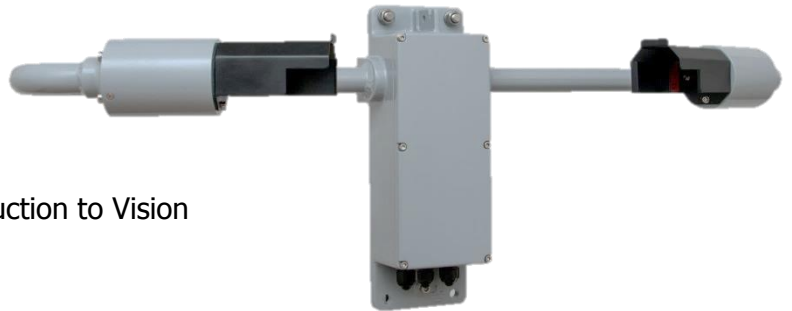
Features

Flexibility to connect to a wide range of data collection/processing units with a choice of serial, analogue and relay switching outputs.

Easy installation due to its light weight and small footprint.

Simple field calibration, automatic sequence can be initiated after fitting the optional calibration plaque.

Switching of external equipment based on both visibility and window contamination outputs.

Digital Outputs
    MOR and EXCO
    RS232
    RS422/RS485
Analogue Outputs
    Either MOR or EXCO
    0 to 10V
    4 to 20mA (optional)
Relays (optional)
    1 Fault relay switch
    1 Relay for visibility
    1 Relay for visibility or window contamination
Hood Heaters (optional)

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Thank you for choosing Biral as your supplier of Road Weather Sensors

A great deal of time has been invested at Biral to offer the best combination of sensor performance and value. More than four decades of experience and knowledge have been incorporated into the RWS series. We are confident that your purchase will provide you with many years of accurate operation.

Customer Satisfaction

At Biral we set our standards high and only your complete satisfaction is acceptable to us. If you believe your experience has not met these standards we would be grateful if you would contact us so we can rectify any issues you may have (equally, if you have positive experiences you would like to share).

After Sales Support

Biral offers support by telephone and email for the lifetime of these sensors, even if there has been a change of ownership, so please get in touch if you require help. Similarly, if you have any questions about your new equipment we are only a mouse-click or telephone call away. Our contact details are given below.

For your convenience our contact details are also on the label fixed to your sensor.

Contacting Biral

If you would like technical assistance, advice or you have any queries regarding the operation of the sensor, please do not hesitate to contact us.

For enquiries and technical support:	
Contact us by telephone on:	+ 44 (0)1275 847787
Contact us by fax on:	+ 44 (0)1275 847303
Contact us by e-mail at:	enquiries@biral.com

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Two year warranty

The RWS Road Weather Sensors comes with a two-year limited warranty against defective materials and workmanship. If you have any questions about the warranty, please contact Biral.

To help us to assist you, please be sure to include the following information:

- Model of equipment
- Serial number of equipment
- Nature of defect
- Your full name, address and contact details
- Relevant application details and data output
- Responses to R? command: See section 3.1.2.

If you need to return the sensor

The RWS sensors should give you many years of trouble-free service but in the unlikely event that the equipment proves to be faulty and we have asked you to return the sensor to us, please address the equipment to:

> BIRAL
> Unit 8 Harbour Road Trading Estate
> Portishead
> Bristol BS20 7BL
> UNITED KINGDOM

The customer is responsible for the shipping costs.

CE Certification - Safety

All Biral's RWS sensors comply with the requirements for CE marking. Once installed, it is the user's responsibility to ensure that all connections made to the sensor comply with all Local and National safety requirements.

This product **MUST BE EARTHED.** Failure to install a suitable earth may result in inaccurate readings and damage to the product and attached equipment. Failure to install an earth will make the unit potentially unsafe when using the relays to switch hazardous voltages.	⚠️

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1   SENSOR SET-UP

The format of this section is such that it logically follows these recommended procedural steps:

Step 1 - Unpack equipment and ensure that all required parts are supplied and identified.

Step 2 - Make electrical connection as required for testing and configuration.

Step 3 - Power up and test equipment on bench.

Step 4 - Configure equipment as required for site installation.

Step 5 - Installation including siting considerations and electrical grounding.

Note: Many of the tests specified within this manual require the use of a PC or equivalent. To achieve the two-way serial communication required, Biral recommends the use of a PC running the Biral Sensor Interface Software. If this software is not available, use a terminal program - for example Windows® HyperTerminal™.
The Biral Sensor Interface Software is available free of charge via the Biral website,
http://www.biral.com/technical-support/downloads/software-downloads/
or by contacting Biral at: enquiries@biral.com.

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1.1 STEP 1 - Unpacking the sensor

The sensor is securely packed in an appropriate shipping container.
In the box with your RWS sensor you will find:

Part	Qty	Identification		Biral part number
'U' mounting bolts	2			105252
M8 nuts	4			104749
M8 Washers	4 each	Plain	Split	Plain 104736 Split 105449
Mounting saddle	2			105356
Clip ferrite	2			105457
Cable gland sealing plugs (Fitted to sensor)	2 x M12 2 x M16	M12	M16	M12 106185 M16 106186
Quick start guide	1			107207
Calibration certificate	1			N/A
You may also have Calibration kit* (optional)	1			106294

*The calibration kit is in a protective carrying case, containing: a calibration plaque, a mounting arm (referred to as the calibration reference plaque when assembled) and 3 grey foam plugs (see section 5, Calibration Procedures).

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1.2 STEP 2 - Electrical Connections

All electrical connections should be completed before applying power

This sensor **MUST BE EARTHED.** Failure to install a suitable earth may result in inaccurate readings and / or damage to the sensor.
Failure to install an earth when using mains voltages on the relays will make the unit potentially unsafe.

1.2.1 Cable Glands

There are two connecting areas within the Sensor, one for the DC power and communications, and one for the relay connections.
The relay connections are separate to retain the necessary electrical isolation required for the 230VAC switching capability.
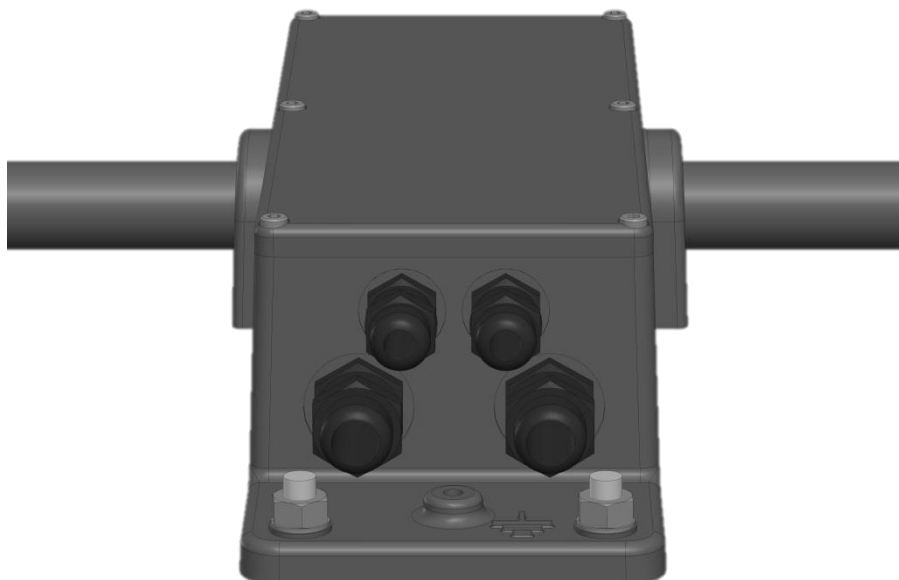
To assist in this, four cable glands are provided.

-   the 2 small cable glands are for cables between 3.5 to 7.0mm diameter
-   the 2 larger glands are for cables between 4.5 to 10mm diameter

Any of these glands can be used. The DC power supply may be separated from the signal connection cable or a single cable can be used for all required connections.
If the fault or alarm relays are being used to switch mains voltages it is essential to use cables approved for mains use for these connections which will, in general, require to be separated from the communications cable and sensor power.

Unused Glands

Any glands not in use should be sealed with the supplied sealing plugs to retain the integrity of the weatherproof housing.

1.2.2 Connecting the power supply and signal cable

The power and signal cables are connected to the sensor using the connector strip (J11 & J12) along the bottom edge of the main circuit board adjacent to the cable glands.

This connecting strip is of a lever clamp design. The wire is released by pressing on the orange lever with a small screwdriver with a flat blade of no more than 2.5mm.

For ease of assembly it is recommended that 24AWG (0.2 mm^2) stranded or solid wires are used, or equivalent. These are ideal for the low power requirements of the system.

However, the connectors can accommodate wires from 20AWG down to 26AWG (0.5 to 0.13 mm^2), of solid or stranded construction. J11 and J12 wires require a strip length of 11 mm.

Connecting the power supply:

The RWS sensor requires an input voltage supply between 9 and 36V DC. This is typically 24V DC supply at 3.5W. This will rise to typically 5.2W if the no-dew window heaters are in use.

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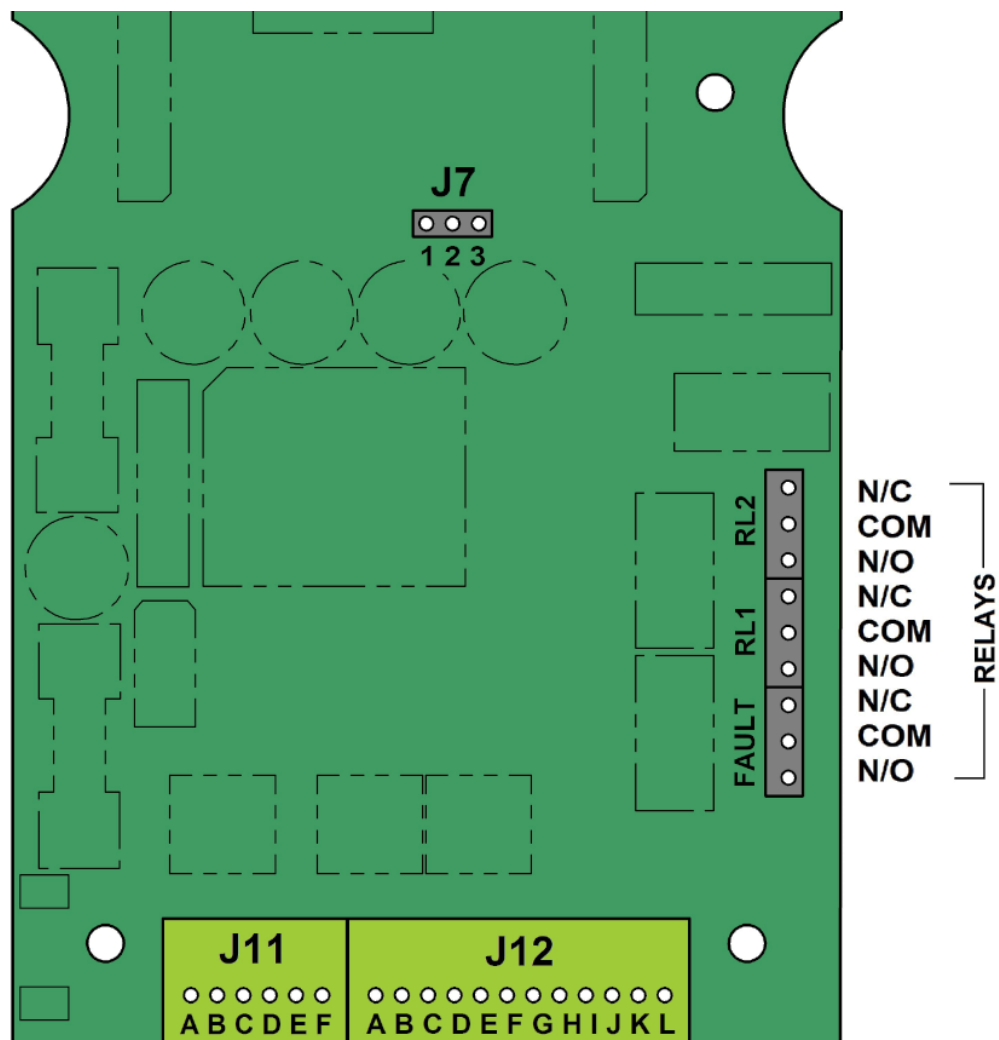
The bottom connector strip is split into two sections, a 6-way block labelled J11 and a 12-way block labelled J12. The individual connections are labelled A to F and A to L respectively from left to right.

> J11/D is the internal signal ground reference point. Care must be taken, to ensure that the negative supply lead is at near ground potential (enclosure potential). If it develops more than ±10V DC with respect to ground, damage will be caused to the sensor.

With the power removed from the supply cable, connect the +ve lead to J11/C and the negative lead to J11/D. The negative lead is the internal signal ground reference point. Care must be taken, particularly when long power leads are used, to ensure that this negative supply lead is at near ground potential.

Connecting the hood heaters (optional)

The hood heaters may be used if chosen as an option. They are wired independently and isolated from the sensor power. These should be powered from a 24V supply of either AC or DC. The RWS-20 will draw 24W from this source when the heaters are on. A higher voltage should not be used as the power will increase above acceptable levels. If a lower voltage is used, the de-icing will be less efficient. The connections are J11/A for the heater supply (switched), and J11/B heater return. See Table 1-1 Pin connections for power supply for full details.

Pin connections for power supply

Pin Number	Designation
J11/A	Hood Heater Supply 24VAC or DC
J11/B	Hood Heater Return24VAC or DC
J11/C	Power +9 to +36V DC Supply
J11/D	Power 0V Supply
J11/E & F	Not Used

Table 1-1 Pin connections for power supply

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Pin Connections for RS232 or RS422/RS485 Signal Interfaces

The sensor can be operated with either RS232 or RS422 or RS485 communications. It is not possible to operate both the RS232 and the RS422/RS485 together. See Table 1-2 and Table 1-3 for full connection details. See section 1.4.6 for RS485 configuration.

Note: *The RS232 configuration is suited to low to moderate electrical noise environments with moderate cable lengths and baud rates. For higher electrical noise environments with higher baud rates and longer cable lengths RS422 is recommended.*

Pin Number	Designation
J12/A	RS232 common/0V
J12/B	RS232 Tx (signals FROM sensor)
J12/C	RS232 Rx (signals TO Sensor)

Table 1-2 Pin connections for operating in RS232 interface mode

Pin Number	Designation
J12/A	RS422/485 common/0V
J12/D	RS422/RS485 Rx+ (TO sensor)
J12/E	RS422/RS485 Rx- (TO Sensor)
J12/F	RS422/RS485 Tx- (FROM sensor)
J12/G	RS422/RS485 Tx+ (FROM Sensor)

Table 1-3 Pin connections for operating in RS422/RS485 interface mode

Selection of RS232 or RS422/485 communications

To select which output to use, place jumper J7 onto pins 1 and 2 for RS422/485 outputs and onto pins 2 and 3 to select RS232 outputs (default). J7 is located near the middle of the board, next to the capacitors.
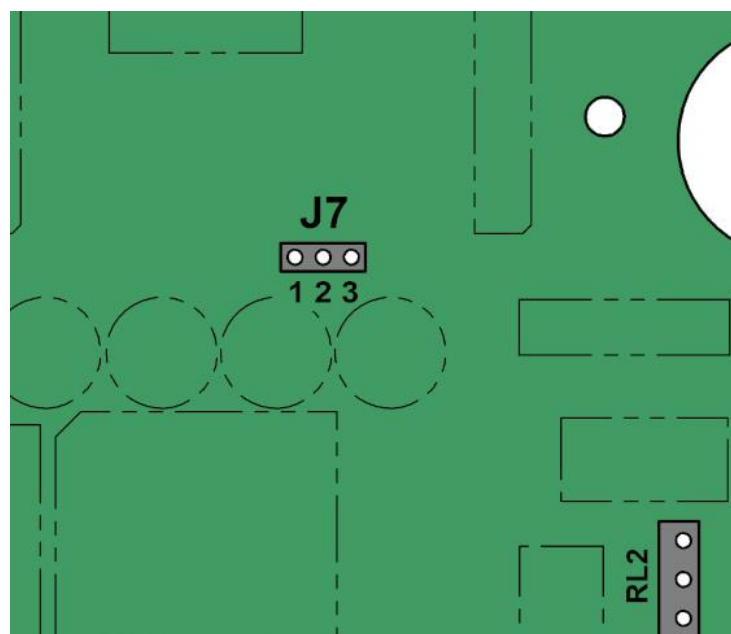
1.2.3 Connecting the relays (optional)

> Care must be taken to ensure that the voltage rating of the cable is correct for the switching application. If the relays are to be used with mains voltages, please comply with all labelling, national and international safety regulations. A protective earth bonding test of the sensor housing should be carried out.

The RWS-20 provides the ability to switch equipment using two visibility (fog) relays set at two different visibility ranges. Alternatively, the second relay can be used to indicate significant window contamination. This contamination warning is contained in the standard digital data message; this relay will give early warning that the windows require cleaning. See section 1.4.8 & 1.4.9 on configuring the relays.
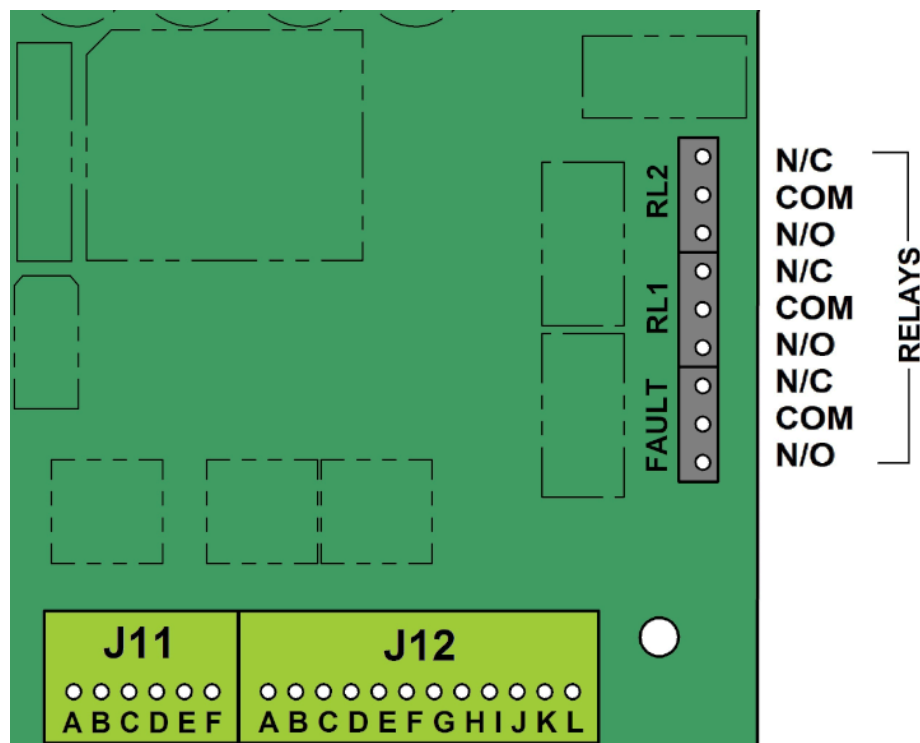
The relay connections are along the right-hand side of the main circuit board at the cable gland end. The connections are a two-part connector with pins in the circuit board and a removable plug for the connections. It is advised that the removable plug is removed from the pins (pulled upwards) to enable the connections to be made to the cable before re-connecting to the circuit board. The connections in the removable plug are of a screw clamp type.

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N/C means a Normally Closed contact

COM means common to both contacts

N/O means a Normally Open contact
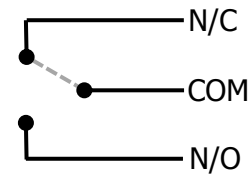
Contacts are defined here when relays are not energised

Note: The Fault relay operates in Failsafe mode - i.e. is energised when there is no fault.

For ease of assembly it is recommended that 22AWG (0.33mm^2) stranded or solid wire conductors, or equivalent is used. These are ideal for the low power requirements of the system. However, each connector can accommodate wires from 26AWG to 16AWG (0.13 to 1.3 mm^2), of solid or stranded construction. They require a strip length of 5 mm.

Configuration of the relays is covered in sections 1.4.8 & 1.4.9.

1.2.4　Pin connections for analogue outputs

An analogue 0 to 10V output representing either Meteorological Optical Range (MOR in km) or Extinction Co-efficient (EXCO in km^{-1}), is standard on the RWS-20 sensor. See section 1.4.11 on changing between output standards. The analogue outputs on the RWS are available as both a 0 to 10V and a 4 to 20 mA signal (the 4 to 20mA output is an option). The connections are as follows.

Pin Number	Designation
J12/H	0 to 10V Analogue Output +ve
J12/I	0 to 10V Analogue Output -ve
J12/J	4 to 20 mA Analogue Output +ve
J12/K	4 to 20 mA Analogue Output -ve
J12/L	Not Used

Table 1-4 Connections for RWS-20 analogue output

Connecting to the voltage output

The analogue 0-10V voltage output should be monitored using a high impedance circuit, impedance values below about 10KΩ may introduce errors in the reading.

Connecting to the current output (option)

The optional analogue 4-20mA current output is sourced from the sensor. It is derived from a 10V digital to analogue output and is not isolated. It should be terminated with a resistance not greater than 500Ω to enable the maximum current of 20mA to be available.

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Analogue output as EXCO

When the analogue output is set for EXCO (default), the 0V or 4mA reading represents 'zero' EXCO. The 10V or 20mA reading represents the maximum value of EXCO which is 300. The readings between these two extremes are proportional to the EXCO value.

To calculate the EXCO in km^{-1} value from the analogue output, use the following formula.

$$EXCO = (R_{EXCO}/10) * V_{EXCO}$$
$$EXCO = (R_{EXCO}/16) * (I_{EXCO} - 4)$$

Where:

R_{EXCO} = The EXCO range of the sensor, this has the fixed value of 300

V_{EXCO} = The analogue output voltage value in volts

I_{EXCO} = The analogue output current in mA

Note: The EXCO scale is not linear with visibility distance; its resolution is more suited to measuring lower visibility distances.

Analogue output as MOR

When the analogue output is set for MOR, the 0V or 4mA reading represents zero MOR. The 10V or 20mA reading represents the maximum value of MOR selected for that specific sensor. The default maximum is 7.5km. The readings between these two extremes are proportional to the MOR value.

To calculate the MOR value in km from the analogue output, use the following formula

$$MOR = (R_{MOR}/10) * V_{MOR}$$
$$MOR = (R_{MOR}/16) * (I_{MOR} - 4)$$

Where:

R_{MOR} = The Range of the sensor in km

V_{MOR} = The analogue output voltage value in volts

I_{MOR} = The analogue output current value in mA

Note: The MOR scale is linear with visibility distance; its resolution is more suited to measuring across the whole visibility range.

For the effects of changing between EXCO and MOR output and how to change the output, see section 1.4.11.

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1.2.5 **EMC Compliance**

> This sensor **MUST HAVE FERRITES INSTALLED.** Failure to install the supplied ferrite cores may result in inaccurate readings or lost communications ⚠️

To comply with the EMC requirements, in particular the susceptibility to conducted interference, some of the leads connected to the sensor must be fitted with the supplied ferrites. If this is not carried out, the sensor could be affected by external electromagnetic noise. The ferrites supplied with the unit should be clipped over the **power** and the **signal** leads, between the gland and the connector blocks. These are not required on the relay connections or on the hood heater supplies.
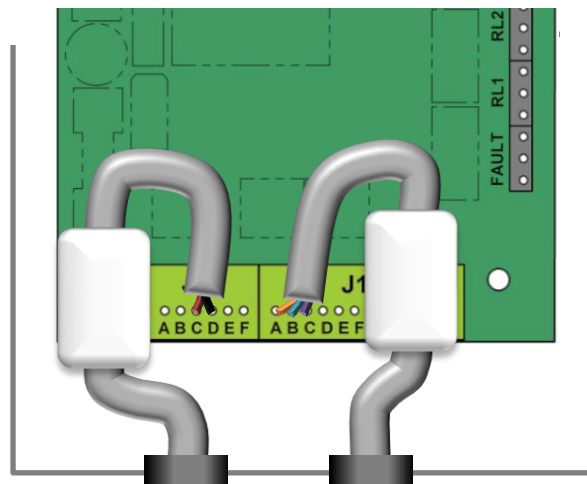
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1.3 STEP 3 - Equipment Test

Biral recommends that the equipment is powered and checked on the bench before site installation. This is to ensure that you are comfortable with the functionality of the sensor and to pre-empt any queries that arise before attempting site installation.

Note: this procedure assumes a default configuration for the sensor - please check the Calibration Certificate supplied with your sensor for specific configuration details.

> **Note: In this test, and in all subsequent sections of this manual, the following convention MUST be observed:**
> **ALL COMMANDS SHOULD BE TERMINATED WITH <CARRIAGE RETURN> AND <LINE FEED> (ASCII CHARACTERS 13 AND 10). In this manual, this is abbreviated to <CRLF>.**

1.3.1 Equipment Test Procedure

To enable the configuration setting to be checked and adjusted if necessary, it is recommended that these initial tests are carried out using the digital communication system. If it is only intended to use the analogue signals and the relays, these can be checked by following the instructions in sections 1.3.3 Analogue signal checks, and 1.3.4 Relay checks (optional).

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1.3.2 Digital Communication Checks

1. Connect the power pins on the input connector to a local power source (do not turn power source on). Ensure the sensor earth lug is connected to earth.

2. Connect the applicable digital signal pins to a PC running the Biral Sensor Interface Software. If this is not available, use a terminal program - for example Windows® HyperTerminal™. (For RS422/485 sensors a suitable converter must be used).

Biral Sensor Interface Software can be downloaded from:
htttp://www.biral.com/technical-support/downloads/software-downloads/

Note: Biral recommends testing to be done with RS232 or RS422 as applicable. When you are confident with functionality, it can then be set up for RS485 if required.

3. Configure the terminal program as follows:

Default Interface Parameters

Baud Rate..9600
Data Bits 8
Stop Bits..1
Parity ....None
Flow Control ....None

Note: the Biral Sensor Interface Software only requires the baud rate to be set.

(If using HyperTerminal, the options 'Send line ends with line feeds' and 'Echo typed characters locally' in ASCII set up should be checked.)

4. Turn the local power source "ON".

If communications are working the sensor will respond with "Biral Sensor Startup"

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5. Check Data Transmission to Sensor:

Send the command **R?** from the PC terminal to the sensor:

The sensor will respond with its Remote Self-Test & Monitoring Message.
For example:
100,2.509,24.1,12.3,5.01,12.5,00.00,00.00,100,105,100,00,00,00,+021.0,4063

The Various fields in the response are as follows:

Field	Range / Value	Description
Field 1:	**Space**	The message starts with a space.
Field 2:	**ABC**	Heater state and error flags.
		A = 0 - No A field value active.
		A = 1 - Window heaters ON.
		A = 2 - Hood Heaters ON.
		A = 4 - A/D control signal error.
		B = 0 - No B field value active.
		B = 1 - EPROM checksum error.
		B = 2 - Non-volatile memory checksum error.
		B = 4 - RAM error.
		C = 0 - No C field value active.
		C = 1 - Not Used.
		C = 2 - Ired commanded OFF.
		C = 4 - Receiver test in progress (Ired OFF).
		C = 8 - Sensor power reset since last R? Command.
		or any combination of these.
Field 3:	2.450 - 2.550	Internal reference voltage.
Field 4:	09.00 - 36.00	Supply voltage.
Field 5:	11.2 - 17.5	Internal operating voltage.
Field 6:	4.5 - 5.5	Internal operating voltage.
Field 7:	11.2 – 17.5	Internal operating voltage.
Field 8:	00.00 - 06.00	Forward scatter background brightness.
Field 9:	00.00	Not Used.
Field 10:	085 - 105	Transmitter power monitor.
Field 11:	080 - 120	Forward receiver monitor.
Field 12:	100	Not Used.
Field 13:	00 - 99	Transmitter window contamination.
Field 14:	00 - 99	Forward receiver window contamination.
Field 15:	00	Not Used.
Field 16:		Temperature °C.
Field 17:	3300-4200	ADC interrupts per second.

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6. Check Data Transmission from Sensor:

If the sensor is NOT in polled mode:
Wait for the sensor to transmit a Data Message (This takes approximately 80 seconds from power up and then it will transmit every 60 seconds (default)).

If the sensor is in polled mode:
Send the command **D?** from the PC terminal to the sensor:
After power up, sending a **D?** will result in a Data Message being transmitted immediately. See section 2.1 or details of the data message.

1.3.3 Analogue signal checks

If you wish to test the outputs of the sensor, use the *TEST* command to get the unit to temporarily simulate foggy and clear conditions which will allow you to check the analogue and (optional) relay thresholds.

*Note: Use the **CO** command before the TEST command.*
The TEST command structure is:

TEST,tt,vv.vv,f,c

Where:
tt	Duration of test in minutes - Range 00-60 (00 will stop the test)
vv.vv	Visibility in km Range 0.01 to maximum configured range, 7.5 default
f	Fault Indicator – State of the Other Selftest digit in the Selftest & Monitoring field of the data message 0 = No Fault 1 = Other Selftest Fault
c	Window Contamination Indicator digit in the Selftest & Monitoring field of the data message 0 = Windows not contaminated 1 = Window contamination warning 2 = Window contamination fault

Example:
TEST,02,07.50,0,0 – Outputs a visibility of **7.5** km for **2** min (Clear conditions)
TEST,06,00.10,0,0 – Outputs a visibility of **0.1** km for **6** min (Foggy conditions)

Using a multi-meter set to measure Voltage or Current as appropriate, connect to (J12 H & I (for 0-10V), or J12 J & K (for 4-20mA)) and ensure the output changes when the different conditions are simulated.

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The RWS analogue outputs can be configured for MOR or EXCO output (see section 1.4.11). Use the following formula to convert voltage or current readings to MOR or EXCO.

	0-10V	4-20mA (Optional)
MOR output	MOR = (Range/10) * Vout	MOR = (Range/16) * (Iout - 4)
EXCO output	EXCO = (300/10) * Vout	EXCO = (300/16) * (Iout - 4)

Range   = The maximum configured range of the sensor
Vout   = The voltage across the 0-10V output terminals
Iout   = The current flowing through the 4-20mA terminals in milliamps

1.3.4   Relay checks (optional)

Please follow local health and safety procedures if hazardous voltages or currents are present. If in doubt de-energise and disconnect the wires to the relays, and confirm the relays operation through resistance measurement.

Use a multi-meter and monitor the relay outputs, whilst simulating high and low visibility with the TEST command. Please note, to prevent repeated switching around the threshold value, the relays have a timer delay and hysteresis built in. The relays can take up to 5 minutes to change. See sections 1.4.8 & 1.4.9 for configuration.

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1.4 STEP 4 - Configuration Options

The configuration can be performed using the Biral Interface Software. This is free to download from the Biral website at:

http://www.biral.com/technical-support/downloads/software-downloads/

1.4.1 Baud Rate Configuration

Default communication parameters are 9600 Baud, 8 data bit, 1 stop bit, no parity, and no flow control. The baud rate may be changed if required as follows.

Typing %B will display the different Baud rate options.

Select required baud rate by sending the command %Bn

    where n is a number in the range 1 to 7:
        1....1200 BAUD
        2....2400 BAUD
        3....4800 BAUD
        4....9600 BAUD
        5....19K2 BAUD
        6....38K4 BAUD
        7....57K6 BAUD

    For example, to select 4800 Baud send the command **%B3**

The user then receives a prompt to send the text "OK" to the sensor at the new baud rate setting. The new setting will only be accepted if the user manages to communicate with the sensor at the new baud rate within 60 seconds. Otherwise the sensor will reset and continue operation with the original baud rate settings. If an "OK" text is received at the new baud rate the sensor will update its settings and restart.

1.4.2 Polled and automatic output

In polled mode the sensor calculates and sends the data message in response to a request using the D? command. In automatic mode the data message is calculated and sent at the end of each measurement period; default 60 seconds.

To check the status of the output mode, send the command **OSAM?**
    A reply of 00 = Polled Mode, 01 = Automatic output mode

To change the output status, send the command **OSAMx**
    where x is: 0 = Polled, 1 = Automatic

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1.4.3 Hood Heaters (if fitted)

To check the status of the Hood Heaters, send the command **OSHH?**
    A reply of 00 = Disabled, 01 = Enabled
To change the hood heater status, send the command **OSHHx**
    where x is: 0 = Disabled, 1 = Enabled
Note: When enabled, the heaters will turn on automatically when the temperature falls
below 2C, they will switch off again when the temperature goes above 4C.

For maintenance purposes the hood heaters can be temporarily turned on and off using the
following commands:
    Turn hood heaters on temporarily, send the command **DHO**
    If off at the time of command, the heaters will turn off again after 2 minutes.
    Turn hood heaters off temporarily, send the command **DHX**
    If on at the time of command, the heaters will turn on again after 2 minutes.

1.4.4 Window heater control

To check the status of the window heaters, send the command **OSWH?**
    A reply of 00 = Always off, 01 = Always on, 02 = Controlled by contamination
To change the window heater status, send the command **OSWHx**
    Where x is: 0 = Always off, 1 = Always on, 2 = Controlled by contamination

Note: 'controlled by contamination' - If any window's attenuation increases, caused by
contamination or condensation, to more than the percentage specified by WT command
(see section 3.1), the heaters will turn on for 300 seconds or until the attenuation is reduced
to 80% of the turn-on threshold.

Unless it is essential to reduce power consumption, Biral recommends the window heater is
always on.

1.4.5 Checksum to verify message

A checksum byte can be included with messages sent by the sensor to verify that noise in
the communications link has not changed the message. Generally, noise is not a problem
and checksum verification is not required.

To check the status of the checksum character, send the command **OPCS?**
    A reply of 00 = Disabled, 01 = Enabled
To change the checksum character status, send the **CO** command followed by **OPCSx**
    where x is: 0 = Disabled, 1 = Enabled
By default, the sensor is configured at the factory with checksum DISABLED.

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Note: if RS485 communications are selected then this checksum is not used.

*If using the **OPCSx** command, only transmitted data has a checksum, commands do not require a checksum*

The checksum is positioned after the message and before the end characters (<crlf>). The checksum value is between 0 and 127, and is the sum modulo 128 (the remainder after the sum is divided by 128) of all the ASCII values of the characters in the message except the end characters. The checksum value is replaced by its bit wise complement if it happens to be any of the following: ASCII 8 (backspace), ASCII 10 (linefeed), ASCII 13 (carriage return), ASCII 17 through ASCII 20 (DC1 through DC4), or ASCII 33 (exclamation point '!').

For Message:
C1 ... Cm <cksum><crlf>

The calculation is as follows:

$$< cksum >= \left(\sum_{n-1}^{m} c_n \right) MOD128$$

```
IF <cksum> =  8  THEN <cksum> = 119
IF <cksum> = 10 THEN <cksum> = 117
IF <cksum> = 13 THEN <cksum> = 114
IF <cksum> = 17 THEN <cksum> = 110
IF <cksum> = 18 THEN <cksum> = 109
IF <cksum> = 19 THEN <cksum> = 108
IF <cksum> = 20 THEN <cksum> = 107
IF <cksum> = 33 THEN <cksum> =  94
```

1.4.6 RS485 Configuration for addressable sensors

The RWS sensor can use either RS232 or RS422/RS485 signal voltage levels. If you require the sensor to be configured for RS485 in a multi-drop application, in addition to the hardware connections in section 1.2.2, the sensor software needs to be configured to use this protocol.

Please ensure Jumper J7 is in the RS422/485 configuration (Pins 1&2)

To check the status of the RS485 selection command, send the **CO** command followed by **OP485?**

A reply of 0 = RS485 Disabled (RS422), 1 = RS485 Enabled

To change the RS485 selection status send the **CO** command followed by **OP485x**

where x is: 0 = RS485 Disabled (RS422), 1 = RS485 Enabled

By default, the sensor is configured at the factory with RS485 communications DISABLED unless specifically requested when ordering.

RS485 Protocol Format

The communication protocol is based on the Modbus ASCII Frame Format.

Each data request and transfer is configured as follows:

Start: ':' (3A Hex).

Station Address: 2 Character address field.

Data: As standard SW message format.

LRC Checksum: 2 Characters - Longitudinal Redundancy Check.

End: 2 Characters - Carriage return + Line Feed.

Start

The ':' (colon) symbol is used as a start flag which is 3A Hex.

Station Address

The 2-character address is defined by the operator for the unit, see section 1.4.7 for how to change the RS485 address.

It can be any numeric value between 00 and 99. It is used by the unit to define the recipient of the message and by the master to define the destination of the message. Please note that the 'Station Address' is different from the Sensor identification number in the standard data message.

Data

This is a variable length ASCII character string as defined in section 2. The control computer has a defined range of commands available for the RWS sensor and the RWS sensor has a range of defined data messages, see section 3, Commands and Responses. These messages can either be sent as a response to a request for data by the control, or sent without any request on a timed basis, according to the sensor user settable configuration. It is strongly recommended that a polled system is used in a multi-sensor application as this can avoid most data contention issues through the design of a suitable system operating schedule.

LRC Checksum

This enables error checking, allowing the control to request a re-send if errors are detected. For RS485 a Longitudinal Redundancy Check (LRC) Checksum is generated on the data.

Note: This checksum is different from the standard RWS Checksum.

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The LRC is one byte, containing an 8–bit binary value. The LRC value is calculated by the transmitting device, which appends the LRC to the message. The receiving device calculates an LRC during receipt of the message, and compares the calculated value to the actual value it received in the LRC field. If the two values are not equal, an error is implied.

The LRC is calculated by adding together successive 8–bit bytes of the message, discarding any carries, and then two's complementing the result. It is performed on the ASCII message field contents excluding the 'colon' character that begins the message, and excluding the CRLF pair at the end of the message. The LRC byte is converted to 2 ASCII characters and appended to the message.

For example, for the message: *:42D?*
the checksum is calculated as:

ASCII string 42D?
BYTE Values (in Hex) 34+32+44+3F

Checksum is E9
One's compliment (0xFF – 0xE9) = 0x16
Two's compliment 0x16 + 1 = 0x17

Checksum is 0x17 (Hex)
Checksum ASCII characters are "17"
Transmitted string will therefore be: *:42D?17*

End
All communications will end with the standard 2 characters, carriage return – line feed (CRLF) pair (ASCII values of 0D & 0A Hex).

1.4.7 **Sensor Addressing**

To use addressable RS485 communication each sensor must have a unique address in the range 0-99. By default the sensor address is set to 0.

Querying the sensor address
To query the sensor address, send the command: **ADR?**
The sensor should respond with the address: e.g. 00.
Changing the sensor address
To change the sensor address, send the command: **ADRxx**

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where xx is a number between 00 and 99

e,g, to set the sensor address to 02, send the command **ADR02**

The sensor should respond with: OK

Checksum Override

When using addressable RS485 communications, the sensor will disregard any commands that do not have the sensor address or have an incorrect checksum. When transmitting to the sensor all commands must be prefixed by :XX (where XX is the address) and have the 2-character checksum on the end. If the checksum characters are set to FF then the sensor will accept the message without checking the checksum. This is useful when using programs such as HyperTerminal for diagnostics.

For example, for a sensor with address 00 to request a data message:
send the command **:00D?FF**

Recommendations

When using the sensor on an RS485 network it is recommended that the sensor be set up in polled mode (see section 1.4.2, for the OSAMx command) rather than transmitting a data message automatically.

Note: When RS485 communications are enabled the sensor will not output the "Biral Sensor Startup" message on power up and reset.

1.4.8 Configuring the Relay Functions (optional)

To get the current relay configuration send the command **JRO?**
The sensor will respond with a number which corresponds to:

Value	Description
0	No Relays Configured.
2	Fault Relay, Relay 1 triggered on visibility and Relay 2 triggered on visibility.
4	Fault Relay, Relay 1 triggered on visibility and Relay 2 triggered on high window contamination.

Table 1-5 Relay configuration

The default value is set to 2 when the relay option has been selected.

Note: A response of 255 means that no relays are configured (the same as '0').

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To change the configuration

To change the relay configuration, send the command **JROx**

    where x is the value from Table 1-5 above.

    e.g. to configure Relay 2 for window contamination warning send the command **JRO4**

To read the visibility Threshold levels

To read the visibility threshold levels for Relay 1 or 2 send the command **RLn?**

    where *n* is the relay number (either 1 or 2).

The sensor will respond with the visibility threshold in km, e.g. 1.00 km

The default value is 1.00 km.

To change the visibility Threshold levels

To change the visibility threshold levels for relay 1 or 2 send the command **RLn,xx.xx**

    where n is the relay number (either 1 or 2) and xx.xx is the threshold level in km.

    e.g. to set the threshold for relay 1 to 0.5km send the command **RL1,0.50**

    The allowable range is 0.10 to 7.50km.

Note: The visibility relay settings are always determined as MOR values.

1.4.9   **Relay Hysteresis Time**

To ensure that the relays will only switch on and off once stable visibility conditions have been achieved, a delay has been incorporated into the relay ON and the relay OFF operation. This default delay is set to 5 minutes for both switching to ON and switching to OFF. For example, the visibility must remain below the turn on threshold for a period of 5 minutes before the relay is switched on.

To get the current relay ON delay time send the command **RVONn?**

The sensor will respond with a number which corresponds to the current visibility timer on delay used by the relay n. This delay is a value in minutes between 0 and 15.

To set the current relay ON delay send the command **RVONn,xx**

    where xx is the ON delay value in minutes between 0 and 15.

The sensor will respond with OK if the set value is within the specified range, or BAD CMD if out of range.

To get the current relay OFF delay time send the command **RVOFFn?**

The sensor will respond with a number which corresponds to the current visibility timer Off delay used by the relay n. This delay is a value in minutes between 0 and 15.

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To set the current relay OFF delay send the command **RVOFFn,xx**

where xx is the OFF delay value in minutes between 0 and 15.

The sensor will respond with OK if the set value is within the specified range, or BAD CMD if out of range.

1.4.10 Relay Threshold Hysteresis

To avoid continual switching of the relay if the visibility remains close to the set threshold, a hysteresis is implemented between the turn on value and the turn off value. The hysteresis default value is 20%. For example, the visibility relay will turn on when the visibility drops below the set threshold, e.g. 1.00km, but it will only turn off when the visibility rises to the set point plus the hysteresis value, which for this case would be 1.20km.

To read the relay hysteresis value send the command **RLHn?**

Where n is the relay number.

The sensor responds with: AAA %, XX.XX KM

Where: AAA   = Hysteresis as a percentage

XX.XX   = Switching point in km, ie. Threshold plus hysteresis.

To change the relay hysteresis send the command **RLHn,xx**

Where n is relay 1 or 2 and xx is a percentage in the range 5 to 25 (e.g. 17 = 17%).

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1.4.11 **Configuring the visibility analogue output mode**

The analogue outputs can be set by the user to represent either Meteorological Optical Range (MOR) or Extinction Co-efficient (EXCO).

To query the output mode, send the command ***AN?***
    a reply of 0 = MOR, 1 = EXCO (Default)

To set the output mode send the command ***ANx***
        where x is the required value as above for MOR or EXCO.
The sensor will respond with OK if the set value is either '0' or '1', or BAD CMD if any other figure is entered.

Changing between EXCO and MOR analogue outputs
When changing between MOR and EXCO it is important to understand the consequences of the change.
The relationship between the two outputs is:

    MOR   = 3/EXCO
    EXCO   = 3/MOR

From the above formula, you can see the relationship is not linear and the two outputs have different uses. The below tables show how this affects the output when the sensor is configured for a 7,500m range.
Example of the MOR and EXCO output change over distance

	MOR	EXCO
100m	4.213mA	5.600mA
110m	4.234mA	5.455mA
difference	21uA	145uA

	MOR	EXCO
1900m	8.053mA	4.084mA
2000m	8.266mA	4.080mA
difference	210uA	4uA

It can be seen from the tables above that the two outputs are very different and have different applications. The MOR analogue output gives a consistent linear resolution across the output range. This is suitable when interested in visibilities across the whole visibility range of the unit.
EXCO is not linear across the visibility range and has greater resolution at the lower visibility ranges, with corresponding loss of resolution at high visibility ranges.

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It is recommended that EXCO is used in applications where emphasis is required at the lower visibility levels, such as fog detection in road applications.

1.4.12 Maximum visibility range

The minimum visibility reported by the sensor is fixed at 10m, however the maximum visibility can be set to any value between 600m and 7,500m.

The maximum visibility range of the unit is set using the command VIS,xxxx

where xxxx represent the maximum range in meters, default 7,500.
e.g. To set the range of the sensor to 10 to 3,000 metres send the command **VIS,3000**

Once the range is changed the digital output will not show a value greater than the maximum range of the device.

Note: The maximum visibility range (MOR) is 7.5km. This corresponds to a minimum EXCO reading of 0.4km⁻¹.

Important consideration:
Changing the maximum visibility range affects the MOR analogue output by rescaling it and changing the resolution of the output. The EXCO analogue output is not affected by changes to the maximum visibility range.

For a maximum visibility range set to 7,500m:
    0 - 10V = 0 - 7500m
Therefore, a change in analogue output of 0.1V represents a change in MOR of 75m.

For a maximum visibility range set to 1,000m:
    0 - 10V = 0 – 1,000m
Therefore, a change in analogue output of 0.1V represents a change in MOR of 10m.

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1.4.13 **Configuring the MOR Output Resolution**

In the factory default setting the Meteorological Optical Range (MOR) values output in the data messages are expressed in kilometres to a resolution of 10m. The output can also be expressed in metres to a resolution of 1m or kilometres to a resolution of 1m.

Changing the output format of the MOR value does not affect the EXCO output field in the sensor data message.

Querying the MOR Output Resolution

To query the MOR output resolution, send the KM? command. The sensor will respond with five characters as shown below:

       00000   Default Setting, MOR expressed in km to 10m (xx.xx KM)
       00001   Metre output, MOR expressed in m to 1m (xxxxx M)
       00002   Kilometre output, MOR expressed in km to 1m (xx.xxx KM)

Setting the MOR Output Resolution

To set the MOR resolution send the KMn command, with n set as follows:

       KM0   Default Setting, MOR expressed in km to 10m (xx.xx KM)
       KM1   Metre output, MOR expressed in m to 1m (xxxxx M)
       KM2   Kilometre output, MOR expressed in km to 1m (xx.xxx KM)

Note: The sensor will undergo a soft reset when the command is processed. Changing the resolution of MOR output in the data message has no impact on the analogue output.

1.5 STEP 5 – Installation

> This sensor **MUST BE EARTHED.** Failure to install a suitable earth may result in inaccurate readings and damage to the sensor. Failure to install an earth when using mains voltages on the relays will make the unit potentially unsafe.

Please consider the following factors when installing the sensor:

1.5.1 Height above ground

Application	Typical height	Comment
Highway fog-warning systems	1.5 to 2 metres (4.9 to 6.6 feet)	Recommended height for the sensor sample volume is the average distance of a vehicle driver's eyes above the roadway.

Table 1-6 Sensor height above ground

1.5.2 Sensor location

Please consider the following factors when choosing a location for the sensor.

Direct and Reflected Light – Care should be taken to ensure that the sensor is situated with the receiver facing away from direct sunlight (rising and setting sun) and any surfaces which could cause reflections of the IR (Infrared) illumination from the transmitter (for example walls, bridges, trees and people, etc.). Reflected IR illumination entering the sensor's optics can cause errors in the reported visibility measurements.

Air-flow – Care should be taken to ensure that the sensor is situated away from objects that disrupt the 'normal' flow of air to and through the sensor sampling volume (for example walls, trees and other equipment, etc.).

It is recommended for the RWS sensor:
- To be mounted with the sensor facing away from the traffic, not less than 3 meters away from a road, to avoid spray contaminating the lenses.
- No vegetation (trees, large bushes) within 3 metres in front of the sensor, this is to avoid IR reflections, and no vegetation less than 1 metre below the sensor.
- The sensor is located at a site where it is safe to install and maintain.

Suggested siting
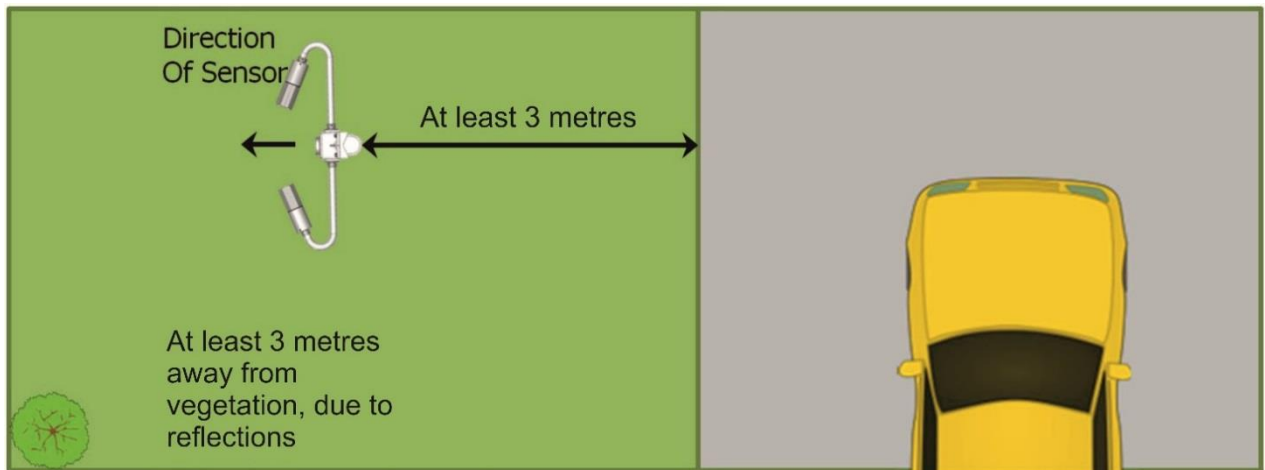
If the above siting is not possible, ensure the Sensor is facing the same direction as the closest traffic.
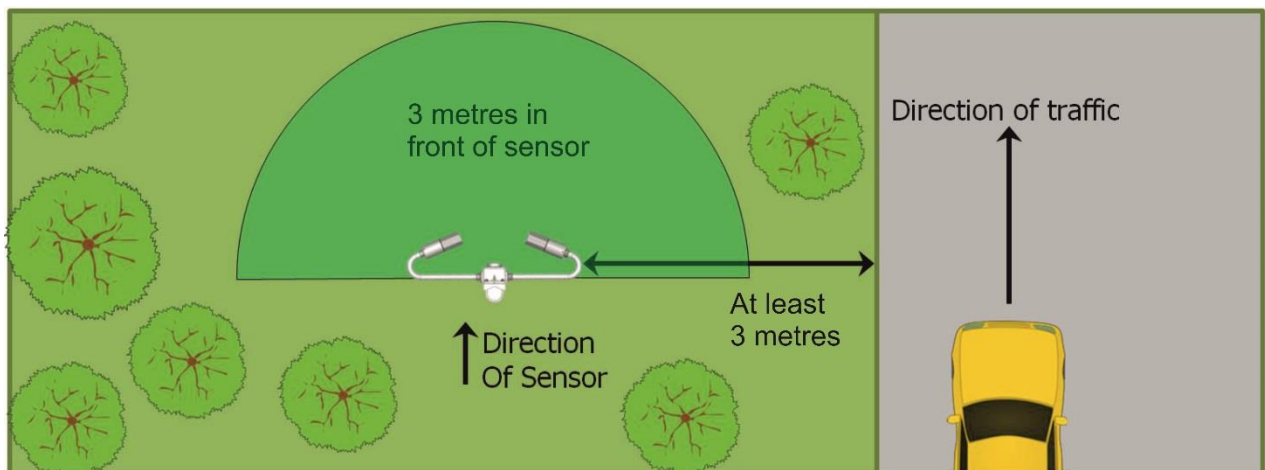
1.5.3 **Mounting detail of the Sensor:**

105449
(x4)

105252
(x2)

105356
(x2)

104736
(x4)

104749
(x4)
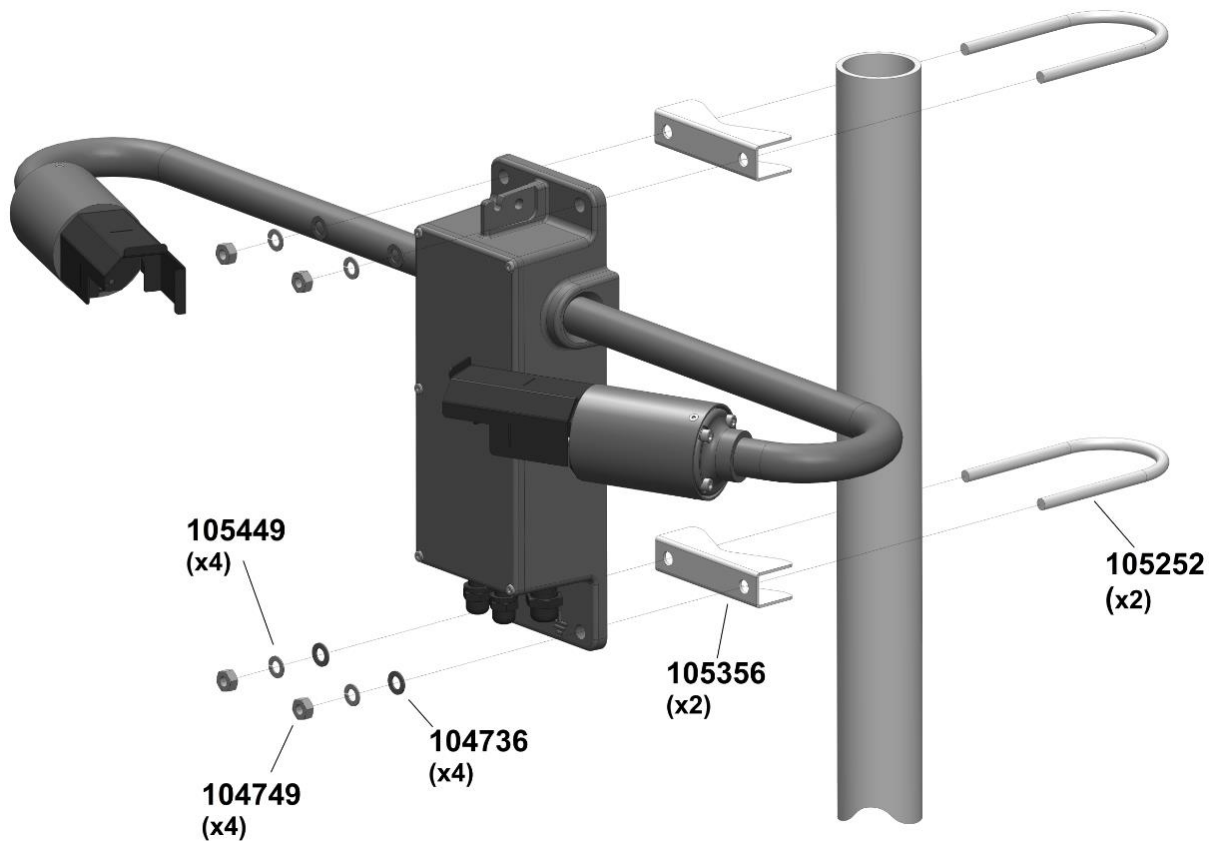
On a pole

Two stainless steel U-bolts and saddles are provided for securing the sensor to the top of a mast. The two V-block saddles oppose the U-bolt, thus providing a secure grip on the mast. The sensor can be mounted on a galvanised steel pipe or heavy walled aluminium tube with an outer diameter between 40 to 64 mm. For mast diameters outside this range the U-bolts provided will not be suitable.

The sensor head should be mounted near the very top so that the mast will not interfere more than necessary with the free flow of air through the sample volume. The flat stainless-steel washers should be placed next to the powder coated surface of the mounting plate to prevent gouging by the lock washers as the nuts are tightened.

On a flat surface

The sensor can be bolted directly to a flat surface using the four mounting holes provided. Every effort should be made to ensure that the mounting surface has minimal effect on the air flow through the sample volume.

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1.5.4 **Electrical Earth**

> This sensor **MUST BE EARTHED.** Failure to install a suitable earth may result in inaccurate readings and damage to the sensor. Failure to install an earth when using mains voltages on the relays will make the unit potentially unsafe.

An M6 earth bolt is provided, this is attached to the earth stud. The earth stud is indicated by the Earth symbol located at the front of the case, between the two front lower bracket mounting holes.

Earth Stud
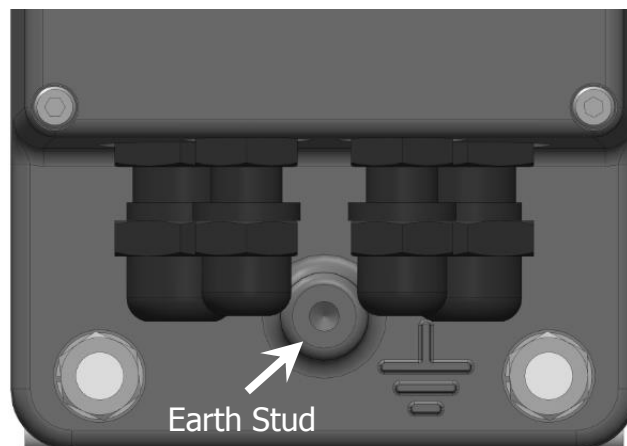
Failure to install a suitable Earth means the unit is not protected against over voltage transients induced on the power line and the signal distribution lines.

Destructive over volt transients can occur in many ways (e.g., lightning induced transients, AC power line transients and EMI/RFI electromagnetic noise). Sensitive components can be damaged by unprotected lines, or sensor failure may occur over a long period of time due to slow device degradation.

The power/control subsystem of the sensor contains transient surge-arrestors on all power and signal lines as a standard feature. EMI filters are present on the power and data lines entering the power/control subsystem. This protection requires an Earth to function to prevent damage and ensure a long life for your sensor.

It is essential to connect the sensor to earth ground for maximum protection of the sensor. The following notes are intended to provide some guidance in the design and construction of an electrical grounding system.

1. Ground Rod: A 2.5m ground rod should be used to make contact with moist soil during even the driest periods.

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2. 13mm^2 solid copper wire should be used to connect the sensor (and thus the transient voltage suppressers) to the Ground rod. Use the shortest and most direct paths to the ground. Simply connect the wire between the Earth Stud provided on the front of the lower mounting flange of the sensor and the Ground Rod.

3. System Interconnections: Eliminate all isolated earth loops. The shield of the signal output cable, for example, should be attached only at one end of the cable and left floating at the other end. Preferably, it should be attached to earth at the sensor end of the signal cable.

4. Connections: Use tight corrosion-proof bare metal connections throughout the earth system.

YOUR SENSOR SHOULD NOW BE FULLY CONFIGURED, TESTED AND INSTALLED READY FOR USE

THE REMAINDER OF THIS MANUAL COVERS:

- **STANDARD DATA MESSAGES**

- **COMMANDS AND RESPONSES**

- **OPERATIONAL AND MAINTENANCE PROCEDURES**

- **CALIBRATION CHECK AND RE-CALIBRATION PROCEDURE**

- **SENSOR DETAILS AND SPECIFICATIONS**

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2 STANDARD OPERATING DATA

When in standard mode a data message will be output from the sensor every measurement period (default 60 seconds). When in polled mode the same message is output only in response to the D? command. The operating mode is set with the OSAM command. Instructions for setting this are provided in section 1.4.2.

Note: All responses from the sensor are appended with carriage return and line feed characters (<crlf>).

2.1 Standard Operating Data Message for the RWS-20

The data message format for the RWS-20 is:

RWS-20,NNN,AA.AA KM,CCC.CC,DDD,EE,FF<cs><crlf>

MESSAGE	MEANING
RWS-20	RWS-20 message prefix.
NNN	Sensor identification number. Default 000.
AA.AA KM	Meteorological Optical Range (km). This is the averaged value.
CCC.CC	EXCO value. This is the averaged value.
DDD	Self-test and Monitoring (see section 4.2): DDD O = other self-test values OK. X = other self-test faults exist. O = windows not contaminated. X = window contamination warning – cleaning recommended. F = Window contamination fault – cleaning required. O = sensor not reset since last "R?" command. X = sensor reset since last "R?" command. T = sensor in 'test' mode.
EE	Transmitter Contamination level (%)
FF	Receiver Contamination level (%)
<CS>	If selected this will be the checksum character. The checksum is off by default.

Table 2-1 RWS-20 Operating data message format

3 COMMANDS AND RESPONSES

3.1 Sensor Commands

Note: All commands should be terminated with <Carriage Return> and <Line Feed> (<crlf>)
Where a command restarts the sensor, this will be marked with a *.
Commands marked with # must be preceded by the CO command.

Command	Description	Reply
ADR?	Get RS485 Sensor Address	xx (sensor address)
ADRxx	Set RS485 Sensor Address to xx (Range 0 to 99) see section 1.4.7.	OK
AN?	Get Analogue Output Type Message	0 = MOR 1 = EXCO
ANx *	Set Analogue Output Type x: 0 = MOR, 1 = EXCO	OK
BT?	Get current EXCO value	+XXX.XX
C?	Get Calibration Parameters	Calibration constants displayed
CE #	Calibrate EXCO	See section 5
CO	Enable Calibration	OK
CS *	Set NVRAM checksum	OK
CX *	Disable Calibration	OK
D?	Display Operational Message	See section 2
DHO	Turn Hood Heaters On See section 4.1.2	OK
DHX	Turn Hood Heaters Off See section 4.1.2	OK
ID?	Get sensor identification number	XXX
IDxxx *	Set sensor identification number to xxx (range 0 to 999)	OK
JRO?	Get Relay Configuration, see section 1.4.8	OK
JROx *	Set Relay Configuration , see section 1.4.8	OK
KM?	Get the current MOR reporting resolution	See section 1.4.13
KNn *	Set MOR reporting resolution	See section 1.4.13
OPCS?	Get Checksum Option Setting See Section 1.4.5	00 = Disabled 01 = Enabled
OPCSx * #	Set Checksum Option Setting See Section 1.4.5	OK
OP485?	Get RS485 Option Setting See Section 1.4.6	00 = Disabled 01 = Enabled
OP485x * #	Set RS485 Option Setting See Section 1.4.6	OK
OSAM?	Get Automatic Message Transmission Settings. See Section 1.4.2	00 = Disabled 01 = Enabled
OSAMx *	Set Automatic Message Operating Settings, See section 1.4.2	OK
OSHH?	Get Hood Heater Operating Settings See Section 1.4.3	00 = Disabled 01 = Automatic (controlled by temperature)

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OSHHx *	Set Hood Heater Operating Settings, 0 = Hood Heaters Disabled 1 = Hood Heaters on Automatic See section 1.4.3	OK
OSWH?	Get Window Heater Operating Settings See Section 1.4.4	00 = Off 01 = On 02 = Controlled by contamination levels
OSWHx *	Set Window Heater Operating Settings, where x is 0, 1, or 2 0 = Off 1 = On 2 = Controlled by contamination levels See section 1.4.4	OK
PV?	Display Program Version	SIxxxxxx.yyy
R?	Display Remote Maintenance Message	See section 3.1.2
RLn?	Get Relay Threshold Message	See section 1.4.8
RLn,xx.xx *	Set Relay Threshold	See section 1.4.8
RLHn?	Display Relay Threshold Hysteresis of relay 'n'	AAA %,XX.XX KM See section 1.4.10
RLHn,xx *	Set Relay Threshold Hysteresis	See section 1.4.10
RVONn?	Display Relay Alert Timer Delay Message See Section 1.4.9	AA = Timer Delay in minutes
RVONn,xx *	Set Relay Alert Timer Delay See Section 1.4.9	OK
RVOFFn?	Display Relay No Alert Timer Delay Message See Section 1.4.9	AA = Timer Delay in minutes
RVOFFn,xx *	Set Relay No Alert Timer Delay See Section 1.4.9	OK
RST *	Reset sensor	OK
SN?	Query Serial Number	Jxxxxx.xx
TEST,tt,vv.vv,f,c,* #	Start/Stop Test Mode	See section 1.3.3
T?	Send sensor times message.	See section 3.1.1
TAx*	Set Auxiliary Measurement sample period. See Section 3.1.1	OK
TMx *	Set measurement interval. See Section 3.1.1	OK
VIS?	Display maximum visibility range See Section 1.4.12	xxxx
VIS,xxxx *	Set maximum visibility range (metres)	See section 1.4.12
WF?	Display Window Contamination Fault Threshold Percentage	XX See Section 4.2.2
WFn * #	Set Window Contamination Fault Threshold Percentage (n=WT to 50) Default 30%.	OK See Section 4.2.2
WT?	Display Window Contamination Warning Threshold Percentage	XX See Section 4.2.2
WTn * #	Set Window Contamination Warning Threshold Percentage (n = 0 to WF) Default 10%, Maximum 40%.	OK See Section 4.2.2
%Bx	COM1 Baud rate Selection Routine	See section 1.4.1

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3.1.1 Command *T?* - Send Sensor Times Message

Response: **aaaa,bbbb,ccccc,dddd**

      aaaa: Measurement interval for each operational data message (10 to 300 seconds)
                (default = 60).

      bbbb: Auxiliary measurement sample period - time between measurement of peripheral signals during measurement interval. (2 to 20 seconds) (default = 5).

      ccccc: Not used.

      dddd: Not used.

The auxiliary measurement period should always be set such that the measurement interval is an integer multiple of the auxiliary period. For example, if the measurement period is set to 15 seconds, set the auxiliary period to 3 seconds. Recommended values are shown below:

TM $\geq$ 60	TA = 5
TM = 30	TA = 5
TM = 15	TA = 3
TM = 10	TA = 2

To set the auxiliary measurement period use the following command: Tax

Where x is the time in seconds. Range 2 to 20 seconds. Default 5 seconds.

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3.1.2 Command *R?* - Send Remote Self-Test and Monitoring Message

Example response:

100,2.509,24.1,12.3,5.01,12.5,00.00,00.00,100,105,100,00,00,00,+021.0,4063

The various fields in the response are as follows:

Field	Range / Value	Description
Field 1:	**Space**	The message starts with a space.
Field 2:	**ABC**	Heater state and error flags.
		A = 0 - No A field value active.
		A = 1 - Window heaters ON.
		A = 2 - Hood Heaters ON.
		A = 4 - A/D control signal error.
		B = 0 - No B field value active.
		B = 1 - EPROM checksum error.
		B = 2 - Non-volatile memory checksum error.
		B = 4 - RAM error.
		C = 0 - No C field value active.
		C = 1 - Not Used.
		C = 2 - Ired commanded OFF.
		C = 4 - Receiver test in progress (Ired OFF).
		C = 8 - Sensor power reset since last R? Command.
		or any combination of these.
Field 3:	2.450 - 2.550	Internal reference voltage.
Field 4:	09.00 - 36.00	Supply voltage.
Field 5:	11.2 - 17.5	Internal operating voltage.
Field 6:	4.5 - 5.5	Internal operating voltage.
Field 7:	11.2 – 17.5	Internal operating voltage.
Field 8:	00.00 - 06.00	Forward scatter background brightness.
Field 9:	00.00	Not Used.
Field 10:	085 - 105	Transmitter power monitor.
Field 11:	080 - 120	Forward receiver monitor.
Field 12:	100	Not Used.
Field 13:	00 - 99	Transmitter window contamination.
Field 14:	00 - 99	Forward receiver window contamination.
Field 15:	00	Not Used.
Field 16:		Temperature °C.
Field 17:	3300-4200	ADC interrupts per second.

Table 3-1 Command R? Response

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3.2 Sensor Responses

RESPONSE	MEANING
BAD CMD	The command was not understood by the sensor. Check the text of the command and re-send.
COMM ERR	An error was detected in a character in the command. Re-send the command.
OK	Command with no quantitative response was understood and executed.
TIMEOUT	Command was sent with more than 10 seconds between characters. Re-send the command.
TOO LONG	Command message was longer than 24 characters including end characters. Check the text of the command and re-send.

Table 3-2 Sensor Responses

4 MAINTENANCE PROCEDURES

The RWS series of sensors require very little maintenance. The following sections detail the checks that are advisable to ensure continued good operation of the sensor. The frequency of these checks depends upon the location and environmental conditions under which the sensor operates.

4.1 General Checks

A general check of the physical condition of the sensor should be carried out at regular intervals. Attention should be paid to the condition of the cable(s) from the base of the unit. It is suggested that this is carried out at least every three months, in conjunction with window cleaning (see 4.1.3 below).

Paragraph 4.2, Self-Test Codes, describes the meaning of the self-test codes provided in all the standard data messages. It specifies what actions, if any, are required to restore the sensor to full operational capability.

4.1.1 De-mister Heaters (fitted as standard to all sensors)

The window de-misters are low powered heaters designed primarily to prevent condensation. They maintain the temperature of the windows at a few degrees above ambient temperature.

The default setting is ON. See section 1.4.4 for details.

The warmth may be detected with the finger on the window but is easier to detect using a thermometer with surface temperature probe. The windows should be between 2°C and 8°C above ambient temperature after at least 10 minutes operation. Ensure that windows are cleaned after coming into contact with the skin.

4.1.2 Hood Heaters (Optional)

Hood heaters are optionally pre-fitted to the inside of each of the hoods. See Figure 4-1 Hood Heater.

The hood heaters are high-power heaters (24W in total) designed to prevent the build-up of frozen precipitation in the hoods. These heaters operate according to the ambient temperature, only being switched on when the temperature is below 2°C, and off when above 4°C. When switched on, it is easy to detect the heating by placing a finger on the end of each hood.

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The hood heater is the raised red mat on the inside of the hood near the window
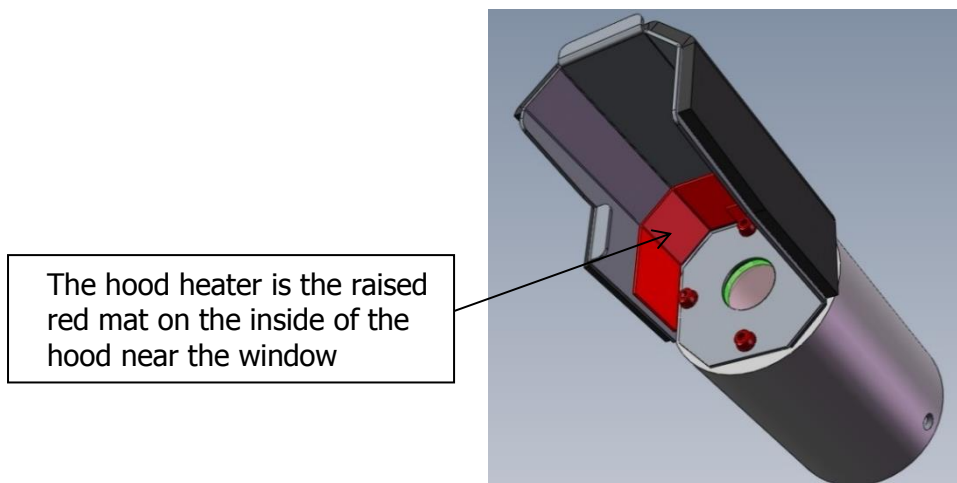
Figure 4-1 Hood Heater

When the temperature is above the switching temperature the heaters will be switched off but may be controlled using a PC running the Biral Sensor Interface Software. If this is not available, use a terminal program - for example Windows® HyperTerminal™. The heaters may be switched on temporarily using the command DHO and off again using the command DHX. When using DHX and DHO commands, normal heating will resume at the end of the next measurement period.

4.1.3 Window Cleaning

RWS sensors are optical sensors and are therefore susceptible to accumulation of contaminants on the windows in the hoods. The windows should be cleaned by gently wiping the windows using water and a soft clean cloth.

All RWS-20 sensors are fitted with a Transmitter Window monitoring system and a Receiver Window monitoring system, which compensates for contamination and will flag a warning when the contamination on either reaches a pre-set amount (default 10%). When this occurs, the appropriate part of Self-test and Monitoring message in the sensor Data Output Message changes from O (no contamination) to X (warning) – see sections 2.1 and 4.2.2 below. If this registers an 'X', the windows should be cleaned at the earliest convenient opportunity. If the contamination continues to increase above the window contamination fault limit, default 30%, on either window, the accuracy of the sensor may begin to deteriorate. The self-test monitoring message will change to 'F', and the windows should be cleaned as a matter of urgency.

Note: (optional) Relay 2 can be set to switch when the window contamination exceeds the warning level, see Section 1.4.8. This is of particular importance if the analogue outputs are used, rather than the digital output which contains the window contamination warning.

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4.2 Self-Test Codes

Self-Test and Monitoring information is provided in the standard Operating Data Message. This information consists of three alpha-numeric characters - see Table 2-1 for the meanings.

4.2.1 Most Significant Character (Sensor Reset Flag)

This will be set to "X" on start-up. It will only be set to "O" following receipt of an **R?** command. If it subsequently is set to "X", this is an indication that a fault, such as a power interruption, has caused the processor to reset. This is generally of no importance, but may assist in the diagnosis of installation problems.

The character will be set to "T" when the sensor is in Test mode. See section 1.3.3.

4.2.2 Central Character (Window Contamination)

RWS-20 sensors have monitoring of contamination on the transmitter window and on the receiver window.   The processor compensates the visibility reading to allow for this contamination and checks both the contamination figures against the warning and fault thresholds. This Self-test code can be one of three characters, O, X or F dependent on the contamination reading received. These have the following meaning:

"O": Both window contamination values are less than the warning threshold. No action required.

"X": Window contamination warning. One (or both) of the window contamination values is above the warning threshold and both values are below the fault threshold. The visibility reading provided is corrected utilising the contamination figures, but it is recommended that the windows are cleaned at the earliest possible opportunity.

"F": Window contamination fault. The value of either window contamination is above the fault threshold. Although the visibility reading is still corrected using these contamination figures, the accuracy may deteriorate as the contamination increases. The windows require cleaning.

The default warning threshold is 10%. The default fault threshold is 30%. The thresholds can be read and adjusted using the WT and WF commands as described in section 3.1.

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4.2.3 **Least Significant Character (Other Self-Test errors)**

A variety of operating parameters are regularly checked against normal operational figures as an early warning of possible sensor faults. This character indicates whether all parameters other than window contamination are normal. This Self-test code can be one of two characters, O, or X. These have the following meaning:

"O": No Fault. No action required.

"X": Internal error. Send command "R?" to list all internally monitored parameters. Check against paragraph 3.1.2 to determine the cause of this error. Send command "RST" to restart the sensor. If the fault persists, arrange for the sensor to be serviced at the earliest possible opportunity.

Note: The command "R?" provides a response with full diagnostic information. This response is detailed in section 3.1.2.

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4.3 User Confidence Checks

> **The following user confidence checks require bi-directional communications with a PC running the Biral Sensor Interface Software. If this is not available, use a terminal program – for example Windows HyperTerminal**

To provide continuing confidence in the correct operation of the system, it is suggested that these should be carried out every 12 months (minimum).

4.3.1 Calibration Check

If you wish to carry out a user confidence calibration check please follow the calibration check procedure in section 5, to ensure that the sensor calibration values are still within specified limits.

> **THIS PROCEDURE CAN ONLY BE COMPLETED IF A SUITABLE RWS CALIBRATION KIT AND PC ARE AVAILABLE**

4.3.2 Window Monitor Checks

RWS-20 sensors monitor the transmitter and receiver windows for contamination. The values measured are used to adjust the MOR value, and are also used to determine when the windows should be cleaned.

The performance of the monitoring circuit can be checked by the following procedures:
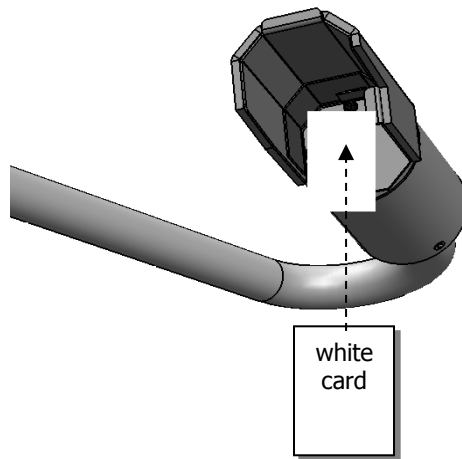
Transmitter Window Monitor

Step 1. Clean the transmitter window.

Step 2. Send the command *R?*

Step 3. Verify that the 'Transmitter Window Contamination' field value is 00 to 02.

Step 4. Insert a white card (or paper) in the transmitter hood that blocks and almost touches the window (see Figure 4-2 Transmitter hood with white card).

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Figure 4-2 Transmitter hood with white card

Step 5. Send the command *R?*

Step 6. Verify that the 'Transmitter Window Contamination' field value is much greater than 10 (e.g. 99).

Step 7. Remove the white card.

Receiver Window Monitor

Carry out the following procedure for the receiver window.

Step 1. Clean the receiver window.

Step 2. Wait for an operational data message from the sensor.

Step 3. Send the command *R?*

Step 4. Verify that the 'Receiver Window Contamination' field value is 00 to 02.

Step 5. Insert a white card in the receiver hood that blocks the window, and almost touches it (similar to Figure 4-2 Transmitter hood with white card).

Step 6. Wait for an operational data message from the sensor.

Step 7. Send the command *R?*

Step 8. Verify that the Receiver Window Contamination field value is much greater than 10 (e.g. 99).

Step 9. Remove the white card.

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4.3.3 **Receiver Background Brightness Measurement Checks**

The receiver background brightness value measures the optical signal detected by the receiver caused by the ambient background. The following procedure will check this function of the receiver.

Step 1. Insert a grey foam plug ('Zero Plug', supplied in the calibration kit) into the receiver hood, blocking all light from the window.

Step 2. Send the command *R?*

Step 3. Verify that the value in the 'Forward Scatter Background Brightness' field is less than 00.06. (field 8, see section 3.1.2).

Step 4. Remove the zero plug from the receiver hood.

Step 5. While shining a flashlight directly into the receiver window send the command: R?

Note: *This test requires the use of a filament bulb flashlight. There is insufficient IR radiation from a visible LED source to carry out this test successfully with a LED torch.*

Step 6. Verify that the value in the 'Forward Scatter Background Brightness' field is much greater than 00.06.

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5 CALIBRATION PROCEDURES

This section explains how to CHECK the calibration of the sensor, and ONLY IF NECESSARY how to recalibrate it.

<div style="border:1px solid black; padding:10px; text-align:center;">

ALL THE PROCEDURES IN THIS SECTION REQUIRE

A CALIBRATION KIT

</div>

> ⚠️ **ENSURE THE CORRECT MODEL AND REVISION OF CALIBRATION KIT IS AVAILABLE.**
> **Use of the wrong calibration kit will result in incorrect calibration of the sensor.**
>
> See section 5.1 for details.

The calibration of the sensor is checked using the procedure detailed below (section 5.2).

The Calibration Reference Plaque used for the calibration check has been assigned a forward EXCO calibration value. This value is shown on the label on the arm of the Calibration Reference Plaque. Each Calibration Reference Plaque also has a MOR equivalent value assigned to it. This value is shown on the surround of the Calibration Reference Plaque. All these calibration values are also provided on the Calibration Certificate sent with the Calibration Kit.

Assembly of the Calibration Reference Plaque is shown in Figure 5-1.

5.1 Calibration Plaque Identification

Only the Calibration Kit designed for use with the SWS sensor family should be used. Use of a Calibration Kit intended for use with another sensor family is not possible due to the unique mounting arrangements. Any attempt to use an incompatible Calibration Kit may result in damage to the sensor and Calibration Kit. The carry case of the SWS Calibration Kit is fitted with a label stating, "SW Calibration Plaque" or "SWS.CAL".

In January of 2014 the main IRED light source of the SWS sensor family was changed from a device operating at 880nm to one operating at 850nm; this change was necessary due to component obsolescence. A consequence of the change of wavelength is that calibration

plaques intended for use at 880nm are not compatible with sensors operating at 850nm and vice versa.

To ensure that it is not possible to use an incompatible calibration plaque the alignment features that control the fitting of the plaque to the sensor and the fitting of the plaque disk to the plaque arm are different on plaques intended for 880nm use compared to those intended for 850nm use.

IF THE PLAQUE DOES NOT FIT EASILY ON TO THE SENSOR IN THE CORRECT POSITION IT IS NOT COMPATIBLE WITH THE SENSOR.

UNDER NO CIRCUMSTANCE MUST THE PLAQUE BE FORCED INTO POSITION OR THE ALIGNMENT FEATURES BE TAMPERED WITH.

To provide a quick and simple method of checking the compatibility of a plaque with a sensor the colour of the sensor label, Calibration Kit case and plaque metalwork are used. See the table below for details.

Feature	880nm	850nm
Sensor Label	White	Silver
Calibration Kit box colour	Black	Blue
Calibration plaque frame colour	Black	Silver

5.2 Calibration Check

The following instructions show how to check the calibration of a RWS-20 sensor. This procedure can only be completed with:

1. An SWS Calibration Kit
2. Connection to a PC running the Biral Sensor Interface Software, or, if this is not available, terminal emulation software (such as Windows® HyperTerminal™) using the serial connection. *If you need help with this please do not hesitate to contact us (contact details on page v).*
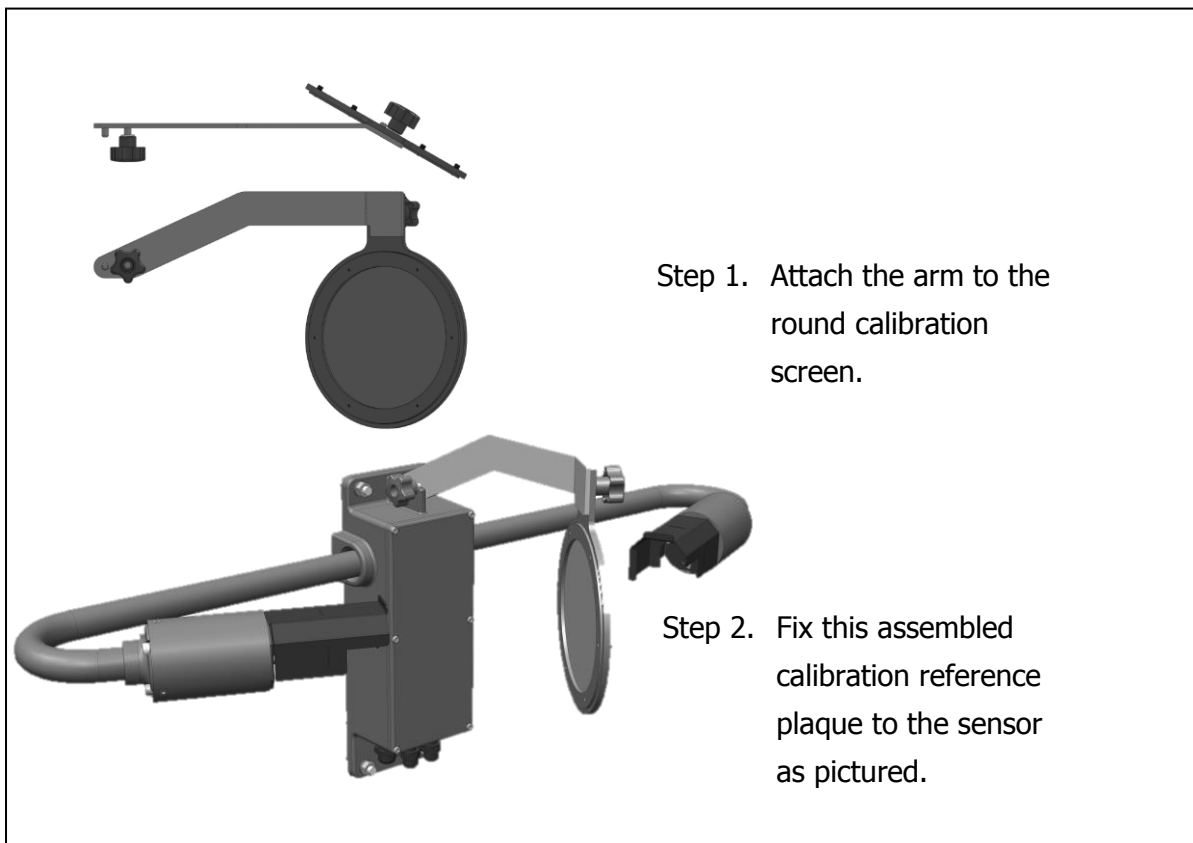
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CALIBRATION CHECK NOTES

PLEASE READ THESE NOTES BEFORE CONTINUING

The MOR (Meteorological Optical Range or visibility) values depend heavily on the prevailing weather conditions and should only be carried out with the sensor:

1. **CORRECTLY INSTALLED AS PER SECTION 1.5**

2. **REGISTERING THE MAXIMUM VISIBILITY (7.5km MOR, 0.4 EXCO).**

3. **POWERED FOR AT LEAST 1 HOUR**

2. **NOT RECEIVING OPTICAL REFLECTIONS (from surfaces, vegetation or clothing)**
3. **THERE IS NO PRECIPITATION PRESENT**

ASSEMBLING THE CALIBRATION REFERENCE PLAQUE

Step 1. Attach the arm to the round calibration screen.

Step 2. Fix this assembled calibration reference plaque to the sensor as pictured.

Figure 5-1 Assembly of calibration reference plaque

Note: All commands should be terminated with <Carriage Return> and <Line Feed> <crlf>.

STEP 1: The windows should be cleaned by gently wiping the windows using a soft clean cloth and water. Check the cleanliness using a portable light if possible. **(Step 1 may not be necessary if checking or commissioning a new sensor)**

STEP 2: Attach the calibration reference plaque to the sensor as shown in Figure 5-1 (power to the sensor need not be removed). Do not stand close to the sensor during calibration as reflections may cause errors in the reported values.

Zero Check:

STEP 3: Insert GREY FOAM PLUGS in the front of each window blocking out all light. (There are 3 foam plugs top left in the calibration case - you will only use 2 of these for the RWS-20).

STEP 4: Send the command **RST**
Verify the response "OK".

STEP 5: If the sensor is operating in the polled mode, send the **D?** command at 60 seconds intervals. (If the sensor is set to automatically output data then the sensor will output data every 60 seconds.)

STEP 6: Wait for the fifth (5th) data message from the sensor. Send the command **BT?**
Verify that the response value is between 0.00 and 0.05.

STEP 7: Remove the foam plugs.

Gain Check:

STEP 8: To restart the sensor, send the command **RST**
Verify the response is "OK".

STEP 9: If the sensor is operating in the polled mode, send the **D?** command at 60 seconds intervals. (If the sensor is set to automatically output data then the sensor will output data every 60 seconds.)

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STEP 10: Wait for the fifth (5th) data message from the sensor. Send the command **BT?**
Verify that the response value is within ±10% of the forward EXCO calibration value
assigned to the Calibration Reference Plaque.

STEP 11: Remove the calibration reference plaque from the sensor.

**If the results of the calibration check have agreed with the value on the
label attached to the calibration reference plaque within the limits stated
above, re-calibration is NOT required.**

**A re-calibration is required ONLY if the EXCO values are outside those on the
calibration reference plaque AND the calibration check has been carried out
ACCORDING TO THE CALIBRATION CHECK NOTES on page 47.**

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5.3 Sensor Re-Calibration

RE-CALIBRATING THE METEOROLIGICAL OPTICAL RANGE SHOULD <u>ONLY</u> BE
CARRIED OUT IF THE SENSOR HAS FAILED A CORRECTLY PERFORMED
CONFIDENCE CHECK

ERRORS DURING THIS RECALIBRATION PROCEDURE WILL CAUSE
THE SENSOR TO GIVE INCORRECT DATA

BEFORE CONTINUING ENSURE THAT THE SENSOR:

1. IS CORRECTLY INSTALLED AS PER SECTION 1.5

2. IS REGISTERING THE MAXIMUM VISIBILITY (7.5KM, 0.4 EXCO)

3. HAS BEEN IN CONTINUOUS OPERATION FOR AT LEAST 1 HOUR

4. THE WINDOWS ARE CLEAN

5. IS NOT RECEIVING OPTICAL REFLECTIONS (from surfaces, vegetation or
    clothing)

6. THERE IS NO PRECIPITATION PRESENT

STEP 1.   Set up the sensor with the calibration reference plaque in place - see section
5.2 (power to the sensor need not be removed).

STEP 2.   Send command **CO**
Sensor replies: OK.

STEP 3.   Send command: **CE**
Sensor replies:
        CLEAN WINDOWS,
        BLOCK FWD SCAT RCVR OPTICS,
        BLOCK TRANSMITTER OPTICS
        INSTALL REF STD,
        ENTER FWD SCAT VALUE
        FORM: XXX.XX

STEP 4.   Fit the grey foam plugs (supplied with the calibration kit) against both
windows.

STEP 5.   Enter the forward EXCO calibration value from the calibration plaque.

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STEP 6.   Sensor replies:

　　　　　　CAL IN PROGRESS

Wait for approximately 2 minutes.

Sensor replies:

　　　　　　REMOVE OPTICS BLOCKS,

　　　　　　ENTER "OK"

STEP 7.   Remove grey foam plugs from both windows and send text: "OK"

Sensor replies:

　　　　　　CAL CONTINUES

STEP 8.   Wait for approximately 2 minutes.

Sensor replies:

　　　　　　CAL COMPLETE

　　　　　　REMOVE REF STD

Note: Do not remove the calibration reference plaque at this point.

STEP 9.   Wait for the third data message to be received at the PC.

STEP 10.   Send the command ***BT?*** and note the response value.

If the response to the BT? command is within ±3% of the forward EXCO calibration value of the plaque, the sensor can be returned to its operational configuration with confidence.

If the response to the BT? Command is outside ±3% of the forward EXCO calibration value of the plaque, contact Biral for advice. See page v for contact details.

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6   PRODUCT OVERVIEW

6.1 Sensor Specifications

Visibility Measurements (MOR) and Atmospheric Extinction Co-efficient (EXCO)

Function	Details
Meteorological Optical Range (MOR)	Default: 10m to 7.5km (Max MOR configurable 0.6 to 7.5km)
Extinction Co-efficient (EXCO)	0.4 to 300km^{-1} (Min EXCO configurable 0.4 to 5.0km^{-1})
Visibility	MOR – Meteorological Optical Range, reductions caused by: fog, haze, smoke, sand, drizzle, rain, snow and general precipitation.
Measurement Accuracy	Better than ±10%
Measurement Time Constant	Default: 60 seconds (Configurable 10 to 300 seconds)

Maintenance

Function	Details
Calibration Check	12 months. See section 4.3
Clean Windows	3 months, typical. See section 4.1.3

Table 6-1 Sensor Specifications

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6.2 Sensor Characteristics

Physical

Function	Details
Scattering Angle	45° with ±6° cone angle
Sample Volume	400 cm^3
Weight	4.3 kg
Length	0.81m

Light Source

Function	Details
Type	IRED
Central Wavelength	0.85μm
Bandwidth	0.04μm
Lifetime (at maximum working temperature)	>10 years
Modulation Frequency	2,000Hz

Detector

Function	Details
Type (Photovoltaic)	Silicon
Filter Bandwidth	0.08μm at 0.85μm

Temperature Sensor

Function	Details
Type	Circuit mounted IC
Range	-60°C to 100°C

Power Requirements

Function	Details
Voltage	9V to 36V DC (24V typical)
Power consumption	3.5 W
Hood Heaters Voltage	24V DC or AC (if fitted)
Hood Heaters Power consumption	24W (if fitted)
Additional Power for: No-Dew Window Heaters	1.7W (User selectable)

Environmental

Function	Details
Sensor Operating Temperature Range	-40°C to +60°C
Altitude	0 to 20,000ft
Precipitation	All weather
Humidity	0 to 100%
Protection Rating	IP66/IP67
CE Certified	√
EMC Compliant	EN61326-2013
RoHS and WEE Compliance	√

Table 6-2 Sensor Characteristics

6.3 Digital Communication Interface

Communication Protocol

Function	Details
Interface Type	RS232C Full Duplex
User selectable	RS422/RS485 Two wire half duplex, 4 wire full duplex.

Communication Parameters:

Function	Details
Baud Rates	1200 Baud to 57K6 Baud
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None
Message Termination	<CR,LF>
Message Check Sum:	Selectable (sum modulo 128) for RS232/422 LRC for RS485
Reporting Interval	Programmable 10 to 300s (default 60s) or Polled
Message Content:	• Sensor Identification Number (Programmable) • Meteorological Optical Range • EXCO • Remote Self-Test & Monitoring Flags • Transmitter contamination • Receiver contamination

Table 6-3 Communication Parameters

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6.4 Analogue Outputs

Function	Details
Voltage	0 to 10V. Equivalent to 0 to MOR_{MAX}.
Current	4 to 20mA. Equivalent to 0 to MOR_{MAX}

Table 6-4 Analogue Output Specification (MOR)

Function	Details
Voltage	0 to 10V. Equivalent to 0 to $300km^{-1}$ EXCO
Current	4 to 20mA. Equivalent to 0 to $300km^{-1}$ EXCO

Table 6-5 Analogue Output Specification (EXCO)

6.5 Relay Outputs

Each relay has a Common terminal and NC (Normally Closed) and NO (Normally Open) terminals.

Function	Details
Fault	Normally energised. Releases on fault condition
Relay # 1	Settable for visibility range 0.10km to MOR_{MAX}.
Relay # 2	Settable for visibility range 0.10km to MOR_{MAX} or Triggered by window contamination exceeding Warning Threshold
Switching Voltage (Max)	220V dc, 250V ac
Switching Current (Max)	2A
Switching Power (Max)	60W, 125VA
Contact Type	Silver alloy with gold alloy overlay

Table 6-6 Relay Outputs

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6.6 RWS-20 Sensor – external dimensions
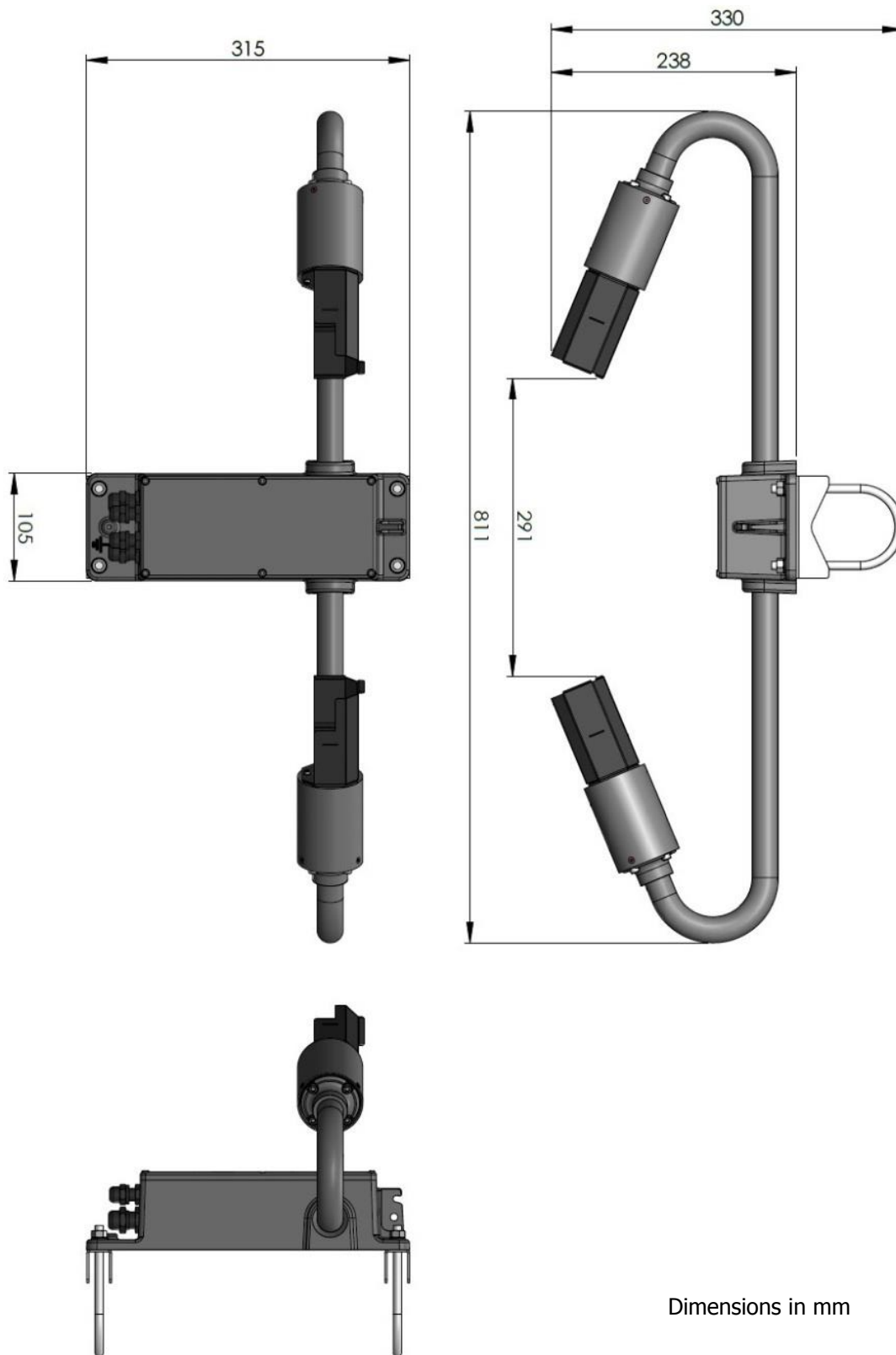
The dimensions of the RWS-20 are shown below

Dimensions in mm

Figure 6-1 External Dimensions of RWS-20 sensor

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7 NOTES:

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