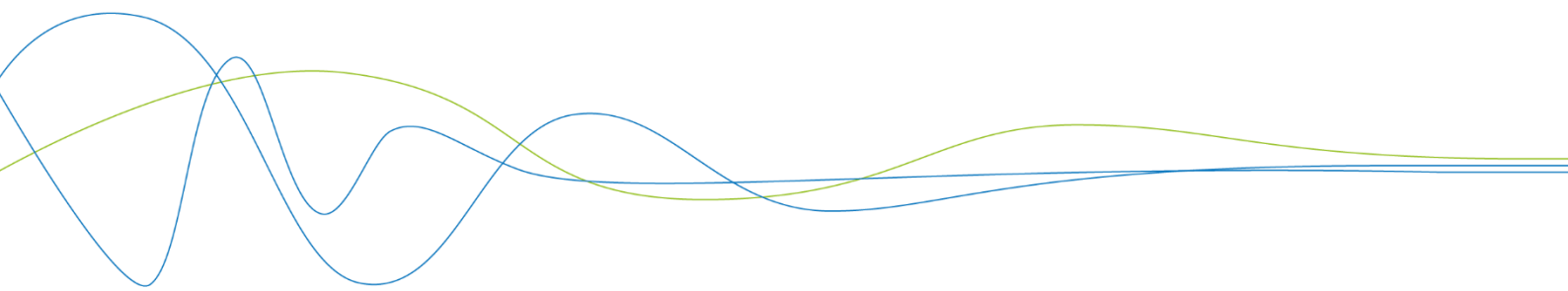
STACK 710

USER MANUAL



STACK 710

Particulate Measurement System

USER MANUAL

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1. Introduction

1.1 Purpose of this Manual

This manual contains all the information necessary for the correct installation, setup, operation, and maintenance of the instrument. The procedures included in this manual must be carried out only by suitably trained and qualified personnel.

Equipment Operation

Use of this instrument in a manner not specified by ENVEA may be hazardous.

Electrical Power Supply

Before working on the electrical connections, all electrical power lines to the equipment must be isolated. All the electrical cables and signal cables must be connected exactly as indicated in these operating instructions. If in doubt, contact ENVEA.

Face and Eye Protection

Suitable face and eye protection must be worn when working on hot vessels and ducts. Special safety measures must be taken when working on a high-pressure duct.

Protective Clothing

Protective clothing must always be worn when working in the vicinity of hot vessels or ducts.

Storage

The instrument should be stored in its packaging in a dry, sheltered area.

Unpacking

Check all packages for external signs of damage. Check the contents against the packing note.

Return of Damaged Goods

If any item has been damaged in transit, this should be reported to the carrier and the supplier immediately. Damage caused in transit is the responsibility of the carrier, not the supplier.

DO NOT RETURN a damaged instrument to the sender as the carrier will not then consider a claim. Save the packing with the damaged article for inspection by the carrier.

Return of Goods for Repair

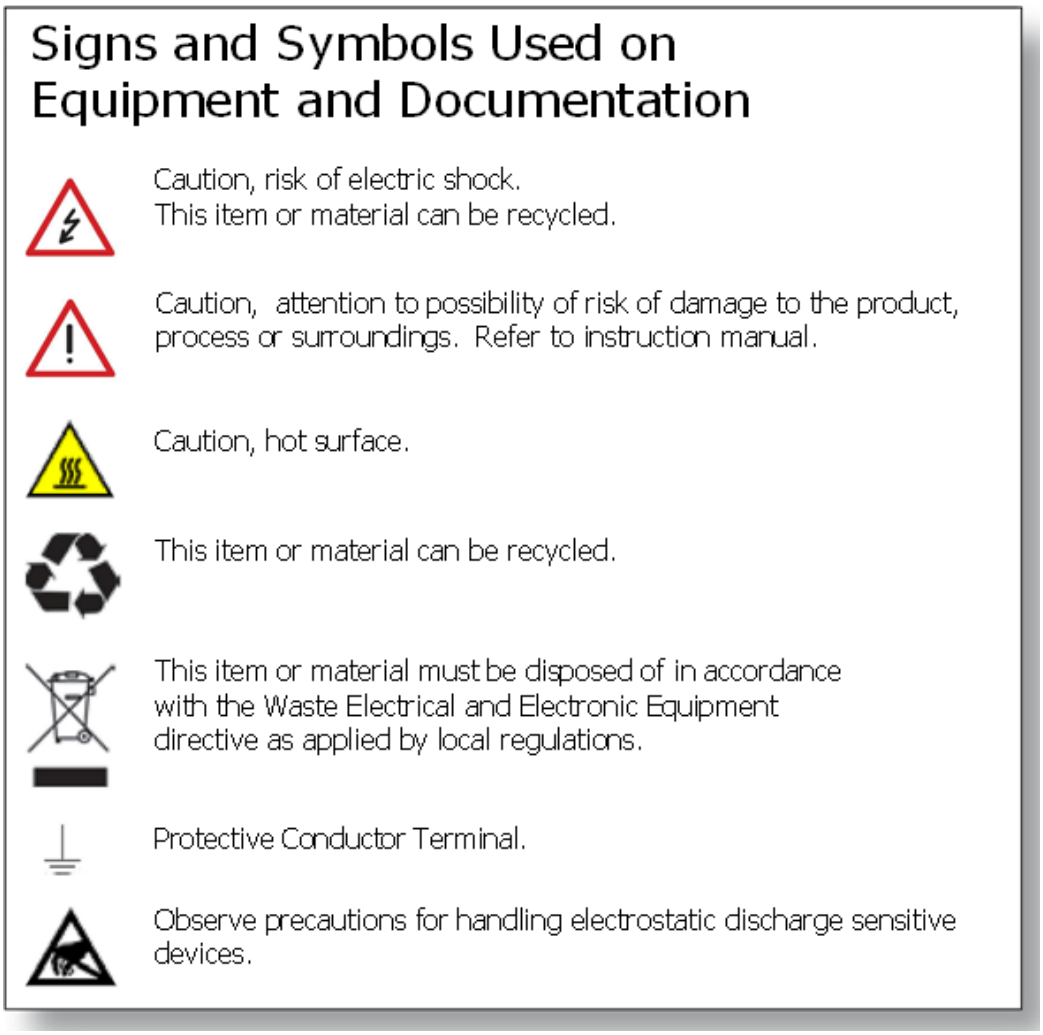
If you need to return goods for repair, please contact our Customer Service Department. They will be able to advise you on the correct returns procedure.

Any item returned to ENVEA should be adequately packaged to prevent damage during transit.

You must include a written report of the problem together with your name and contact information, address, telephone number, email address etc.

Lifting Instructions

Where items are too heavy to be lifted manually, use suitably rated lifting equipment. Refer to the Technical Specification for weights. All lifting should be done as stated in local regulations.



1.2 Limits of Use

To achieve optimum performance and safe operation, the equipment must be operated within the limits detailed in the **System Specification** section of this manual. Operation outside these limits may result in damage to the equipment or failure to achieve the performance specification.

1.2.1 Danger from Process

The sensor may be installed in ducting that contains process particulate (and other flue gas constituents) hazardous to health. This may take one or more of the following forms:

Particulate which is toxic or in some other way hazardous to health

Particulate contained within high-temperature gas.

Take Precautionary Measures

Unless the process conditions are known to be entirely safe, suitable precautions such as the use of breathing apparatus or duct purging/detoxifying must be employed before any entry is made into the duct for installation or maintenance purposes. If in doubt, consult your local Safety Officer and/or local safety procedures.

1.3 Additional Information

1.3.1 Product Serial Numbers

The serial number label can be found on the side of the sensor/control unit enclosure. The serial number on the instrument should match that on the Test Record Card, which is included with the product documentation.

1.3.2 List of Abbreviations

The following abbreviations and terms are used in this manual:

Abbreviation	Meaning
ESP	Electrostatic precipitator
PSU	Power supply unit
Rx	Receiver (sensor head)
Tx	Transmitter (sensor head)

1.3.3 Related Documentation

The following literature may be consulted in conjunction with this manual as applicable. A *Reference Library* with supporting information for your instrument is included with the product documentation.

Included in the Reference Library

- ProController User Manual (Publication Part Number (PPN): PC-000859-MA)
- Standard Controller User Manual (PPN: PC-000841-MA)
- Installation of Network Devices- User Manual (PPN: 492501)
- TN004 Installation Notes (Publication Part Number (PPN): 491021)

- TN054 Air Purge Guide for *Opacity*® Sensors (PPN: 491024)
- TN007 Network Cable Lengths (PPN: 491033)
- PC-ME DUST TOOLS Quick Start Guide (PPN: 494003)

1.3.4 Product Parts and Options

For details of product options, software, accessories, and spares, refer to the STACK 710 datasheet and order information available on request and for download from the ENVEA UK website (see the reverse of this manual).

1.4 Certification

1.4.1 Conformance and Related standards

ENVEA UK Ltd hereby declares that this instrument – within the limits specified in this manual – conforms to the essential requirements and other provisions of the pursuant of the following:

1. European Union Directives: Low Voltage and EMC.
2. UK Regulation 2016: Low Voltage and EMC.

For details, refer to the relevant Declaration of Conformity (DoC) for this instrument or system supplied with your order.

2. Product Description

The STACK 710 Continuous Opacity Monitoring System (COMS) measures opacity by shining a light beam through flue gases.

An internal microprocessor calculates dust density and other parameters.

The STACK 710 is designed for continuous operation in all weather conditions. Maintenance requirements are minimal.

Figure 1: STACK 710- general overview.

Transceiver Containing all the major electronic and electro-optic components.

Retro-reflector Containing a corner cube reflector.

Air Purge System A continuous supply of purge air is essential to prevent dust and corrosive gases from affecting the optical system. Single and dual electric blowers or compressed-air driven devices are available to suit individual site requirements. Automatic fail-safe shutters can also be fitted for temporary protection in the event of a purge air failure.

2.1.1 Power Supply

The STACK 710 operates from a 24 V DC supply.

2.1.2 Analogue Output

The STACK 710 Dust (opacity monitor) has a current loop output that may be set to one of the four functions:

- Opacity
- Constant Current
- Dust
- Optical Density

The output can be set to 'TRACK' or 'HOLD' the measurement signal during calibration routines. If 'TRACK' is set, the measurement signal will continue to be output during calibration. If 'HOLD' is set, the measurement signal will remain at the last recorded reading before calibration, until the calibration routine is complete.

2.1.3 Relay Outputs

Located on the key panel of the instrument are three LEDs that light to indicate the operation of the following relay outputs:

a. SYSTEM OK

b. CALIBRATION

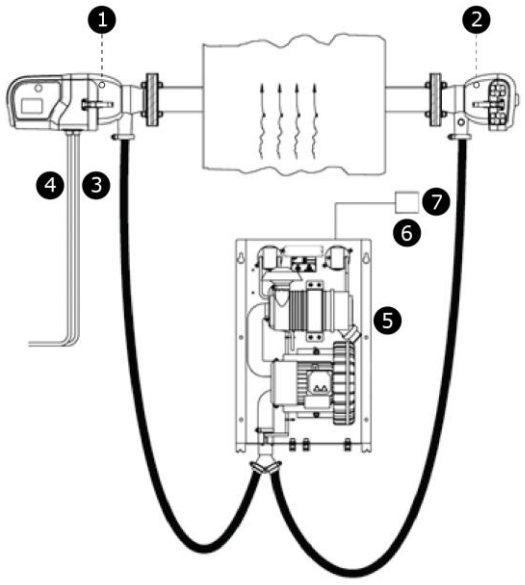
c. ALARMS

2.1.4 Computer Interface Operation

The STACK 710 Dust (opacity monitor) may be connected to a computer or data acquisition system via its RS485 Modbus interface.

2.2 Installation Diagram

The STACK 710 Dust Opacity Monitoring System, showing all components installed.



1. Transceiver
2. Retro-reflector
3. 24V dc Power Supply
4. Data Connections
5. Air Blower Unit with Filters
6. External power isolator with overcurrent protection
7. Blower Power Supply

Figure 2: STACK 710- installation diagram.

IMPORTANT: An external circuit breaker incorporating over-current protection or a power isolator and fuse must be fitted to the blower supply.

3. Installation Instructions

3.1 Installation Checklist

1. Select the installation location.
2. Install the mounting flanges.
3. Install the Air Blower Unit(s) for the purge air supply. Consult the Air Blower Unit Instruction Manual for full details.

CAUTION - Risk of damage to equipment
The purge air supply must be connected and working before the Transceiver and the Retro-reflector are installed.

4. An external circuit breaker incorporating over-current protection or a power isolator and fuse must be fitted to the blower supply.
5. Route all signal and power cables.
6. Connect the power supply to the Air Blower Unit(s).
7. Connect the electrical power supply and signals to the instruments using the 5m (16 ft) pre-terminated cables supplied.
8. Power up the air purge system.
9. Install the Transceiver and Retro-reflector; remember to connect the purge air supply from the Air Blower Unit(s) before mounting them on the flanges.
10. Power up the instrument and calibrate it.

3.2 Selecting an Installation Location

The location of the mounting flanges may be affected by the type of Air Blower Unit(s) to be used. Please refer to the Air Blower Unit manual.

1. For new plants, the location of the Transceiver should be planned during the design stages. For existing plants, the best possible location must be selected. The Transceiver should be mounted so that it measures a representative concentration of dust across the stack or duct diameter.
2. If the monitor is to be used for US regulatory compliance, the location should be determined by the EPA installation specifications detailed in 40 CFR 60, Appendix B, Specification 1, or a location approved by the appropriate agency. In Europe, the location should the determined in accordance with EN15259.
3. At the installation location, there should be as much negative pressure as possible, for example, a stack updraft.
4. The mounting area must have a safe walkway: if necessary, a sufficiently large and accessible platform should be constructed.
5. The ambient temperature at the mounting location must remain between -20 °C and +55 °C (-4 °F and 131 °F), or down to -40 °C (-40 °F) with optional equipment. If necessary, heating, ventilation, or a sun shield should be used to ensure this temperature range is not exceeded.

6. If the duct walls are too thin to support the instrument's weight, additional reinforcement will be required.
7. The mounting flanges must be positioned such that the Transceiver and Retro-reflector face each other across the centre of the stack or duct. Since most applications involve a vertical stack, the axis common to both flanges must be level and perpendicular to the direction of gas flow.

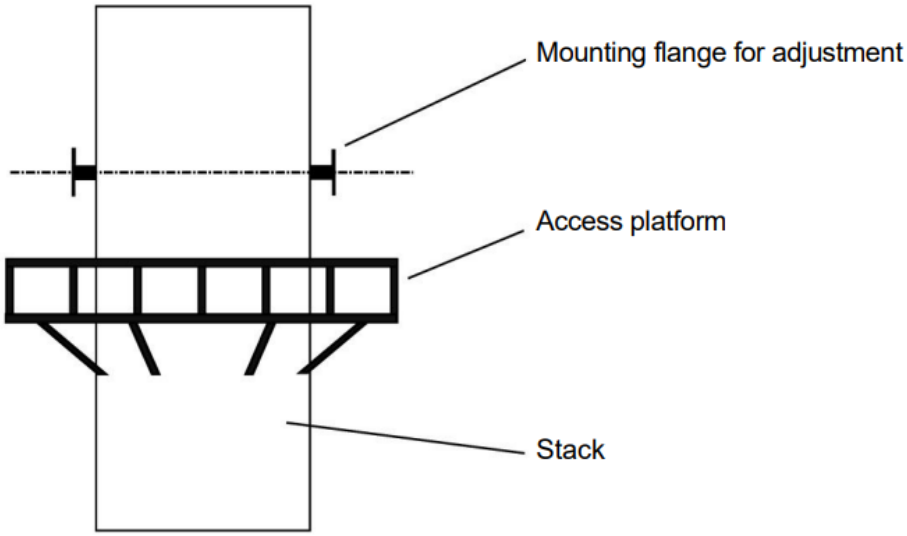


Figure 3: STACK 710- installation schematic

3.3 Maintaining the pathlength during installation

The installation pathlength is defined as the distance between the outer faces of the mounting flanges fitted to the stack or duct.

The installation pathlength must be specified at the time of order as the instrument is factory set.

This pathlength is indicated on the back of the Transceiver.

During the welding and alignment procedures, the flange-to-flange measurement path must not change by more than ±1%. Otherwise, the accuracy of the measurement readings may be affected.

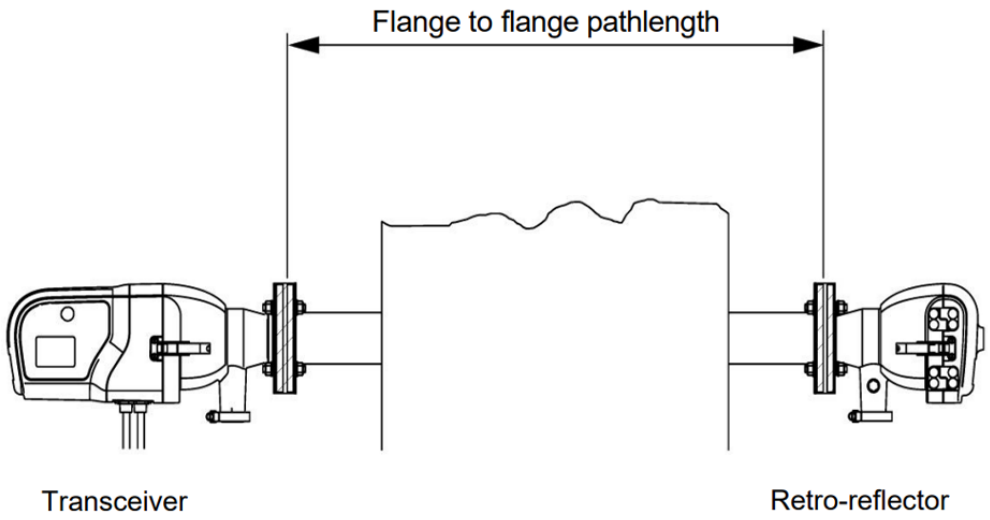


Figure 4: STACK 710- pathlength distance.

3.4 Installing the Mounting Flanges

The STACK 710 is supplied with two mounting flanges with stand-offs (sleeves) used to mount the Transmissometer onto the stack or duct.

1. Each sleeve is 128 mm (5.04”) long.Adjust the sleeves to obtain the proper measurement path.
2. Accurately mark the centre of each mounting flange on the stack and punch a locating mark through the liner onto the inner stack plating.
3. On both sides of the stack, cut a hole from the liner large enough to allow welding of the mounting flange to the stack.
4. Where the Transceiver will be installed, cut a hole through the stack at the punched location mark.
5. Where the Retro-reflector will be installed, make a 6 mm to 12 mm diameter pilot hole (0.25” to 0.50”)
6. Position the Transceiver mounting flange with the “TOP” label in the 12 o’clock position and tack weld the mounting flange in place.

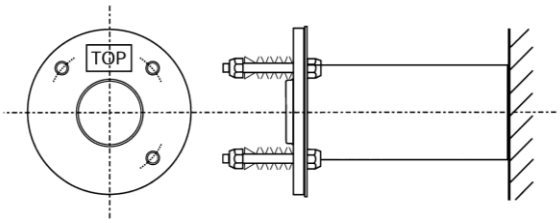


Figure 5 Mounting flange schematic.

Accurate positioning of the flange at this stage is critical to the operation of the instrument. If the flange is not parallel to the stack wall, it will be impossible to align the instrument correctly.

7. Cut a hole around the Retro-reflector pilot hole, large enough to allow eventual welding of the outsideof the flange stub to the stack wall. The mounting flange plate must be parallel to the stack wall.
8. If the measuring path is short (under 2m / 6.5ft) and easily accessible the flanges can be aligned using a straight piece of tube.

   8a. Slide the tube through both flanges., ensuring that the specified flange-to-flange measuring path is maintained to within ±1%.

   8b. Tack weld the Retro-reflector mounting flange in place.

   8c. Make any necessary adjustments to the Transceiver mounting flange

   8d. to ensure alignment between the two flanges is maintained. Weld the flange permanently in place.

   8e. Make any necessary adjustments and weld the Retro-reflector mounting flange permanently in place.

If the diameter of the stack is too large (over 2m / 6.5 ft) to use an alignment tube, ENVEA can supply an optical flange alignment tool. Contact ENVEA or your local ENVEA representative for more information.

3.5 Mounting Details

3.5.1 Air Purge Mounting Holes

The air purge unit must be fixed to the mounting flange. It has three mounting holes to accept the mounting studs from the Standpipe.

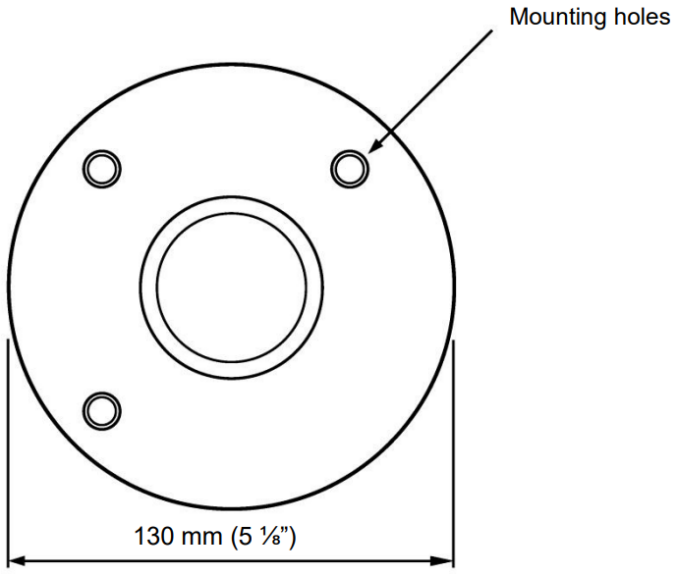


Figure 6: Front view of Air Purge showing mounting holes.

3.6 Flange Alignment Tool

Please refer to the STACK 710 Datasheet and Order Codes Guide available from ENVEA, your ENVEA representative, or the ENVEA website (www.envea.global).

3.7 Important information for installing the Transceiver and Retro-reflector

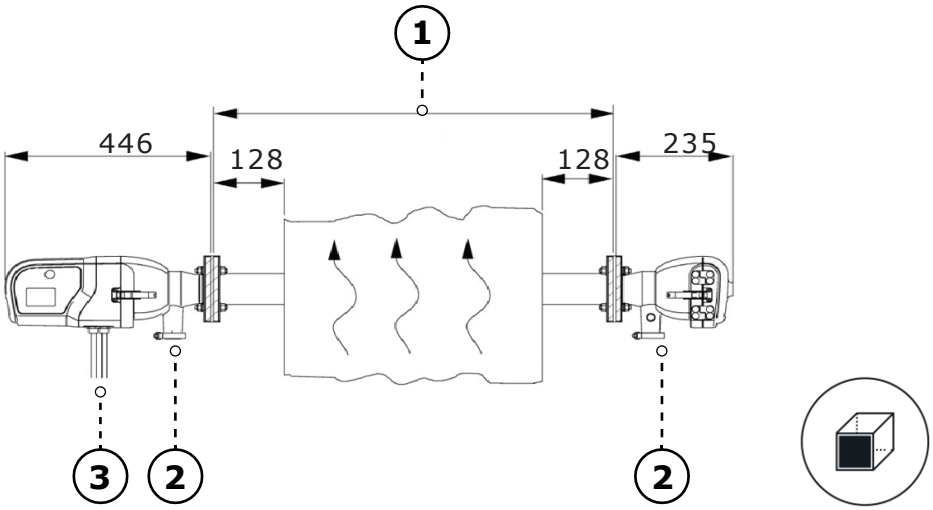


Figure 7: Installing the Transceiver and Retro-reflector (side view).

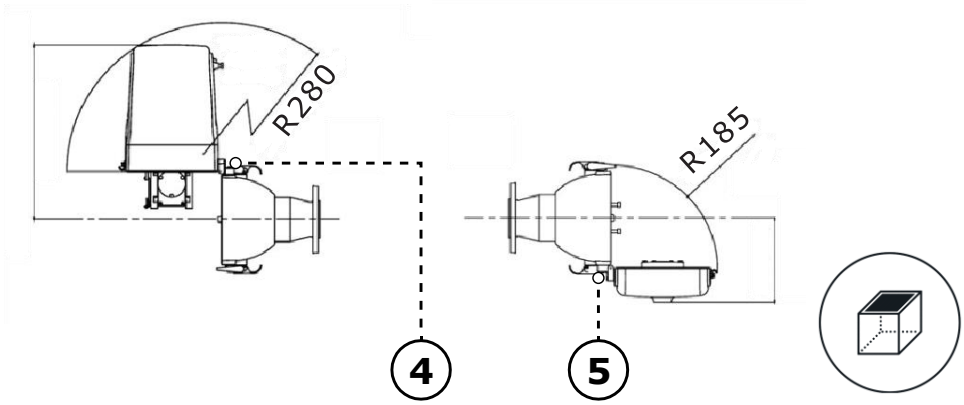


Figure 8: Installing the Transceiver and Retro-reflector (top view).

1. Check the dimensions carefully before installation.

   1a. Allow at least 1 m (3.3 ft) for mounting and removal procedures

   1b. Allow a minimum of 200 mm (7.9”) directly below the instrument for purge air (3) and electrical connections (4).

   1c. Allow sufficient space to the side of each instrument to allow the hinges (6 and 7) to be opened.

   1d. Check the Blower Unit Manual for additional installation requirements.

2. The air hose fitted between the air blower unit (see the diagram in section A2) and its two connections on the instrument (3) must not exceed 7m (23 ft).

3. The flange-to-flange path length (5) is factory set and must not be changed. It is given on the back of the Transceiver.
4. Pre-terminated 5 m power and data cables are supplied with this instrument.

3.8 Mounting the Transceiver and Retro-reflector

1. Ideally, the instrument should be installed when the process is not operating and the stack is cold.
2. The air blower unit should be operating and connected to the Transceiver and Retro-reflector before the instrument is mounted onto the flanges.
3. Check that each mounting stud has four pairs of spring washers (5) arranged as shown - these may have been removed if the flange alignment tool was used.

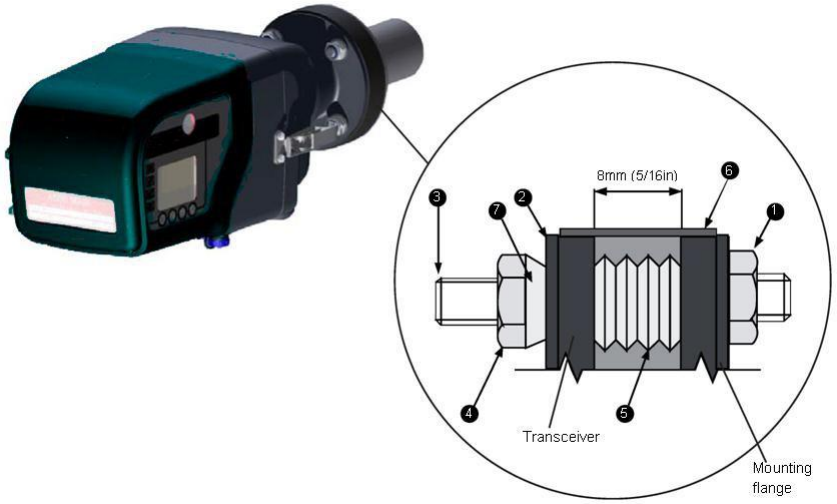


Figure 9: Mounting the Transceiver and Retro-reflector.

4. Place a rubber sealing band over the mounting flanges for the Transceiver and Retro-reflector.It cannot be fitted after the instrument is mounted on the flange.
5. Remove the three M10 nuts (4) and dome washers (2) from the mounting flange, and locate the Transceiver onto the studs (3).
6. Replace the Nyloc nuts (4) and dome washers (2) and tighten them, compressing the spring washers (5) until there is a gap of 11 mm (0.43”) between the two flanges, all round. Pull the sealing band (6) into place over the gap.
7. Install the Retro-reflector following the same procedure.

Important

If the instrument is being hoisted into position, the case clips must be covered or taped closed.

3.9 Electrical Connections

All switch cabinets, distribution boxes, fuses and other components for electrical installation must be provided by the customer, as must the mains power supply connections. Installation should be carried out by a competent person, and cables should satisfy current carrying capacity and voltage rating.

3.9.1 Air Blower Unit Connections

Refer to the Instruction Manual supplied with the Air Blower Unit.

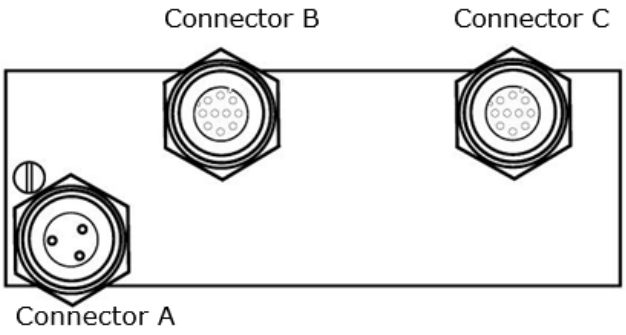
3.9.2 DC Supply

The instrument requires a 24 V dc supply. Current consumption is 0.25 A without case heaters, or 2.25 A with case heaters (for operation <-20 °C).

3.9.3 Signal Connections

Transceiver data cables (See diagrams in section **3.10**)

3.10 Transceiver Connections



Connector A

View on back of connector

Pin Nº	Colour	Function
L	Red	+24 V dc
N	Blue	0 V
E	Screen	Screen

Connector B

View on back of connector

Pin Nº	Colour	Function
1	Red	In Cal Relay NO
2	Blue	Alarm Relay COM
3	White	Alarm Relay NO
4	Yellow	CLOP Out Pos
5	Green	CLOP Out Neg
6	Screen	Screen
7	N/C	N/C
8	Black	In Cal Relay COM
9	Brown	Alarm Relay NC
10	Violet	In Cal Relay NC

Connector C

View on back of connector

Pin Nº	Colour	Function
1	Screen	Screen
2	N/C	N/C
3	Red	Sys OK Relay COM
4	Blue	Sys OK Relay NO
5	Green	RS485 D1
6	Yellow	RS485 DØ
7	N/C	N/C
8	N/C	N/C
9	White	Sys OK Relay NC
10	Black	RS485 COM

Figure 10: Transceiver connections.

3.11 Connection to ENVEA Control Unit

A spur unit is supplied to facilitate connecting the power and comms cable to the ENVEA control unit. Standard ENVEA 4-core cable should be used to connect from the Control Unit to the terminal box.

Alternatively, if the control unit is installed close to the sensor, you may wire the sensor directly to the Sensor/Network connector in the control unit.

3.11.1 Method a: Using a spur unit

At control unit: data cable connections are as follows from left to right (Sensor/Network Connector). Connect the cable screen from each cable to the nearest earth stud using an eyelet tag.

0V	Blue
Comms B (RS485 D0)	Orange
Comms A (RS485 D1)	Green
24V	Brown

At Spur: follow the wiring as shown in **Figure 11**.

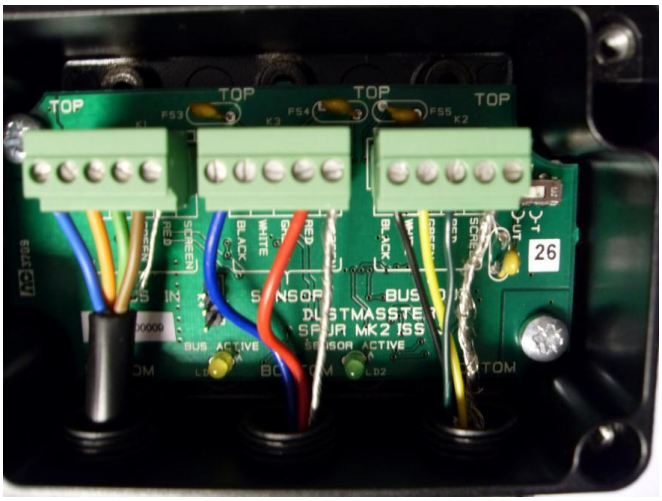


Figure 11: SPUR unit connections.

Left Connector (from left to right): to control unit:

0V	Blue
Comms B (RS485 D0)	Orange
Comms A (RS485 D1)	Green
24V	Brown
Screen	Screen

Middle Connector (from left to right): to sensor connector A (power):

0V	Blue
-	-
-	-
24V	Red
Screen	Screen

Right Connector (from left to right): to sensor connector C (comms):

0V	Black
Comms B (RS485 D0)	Yellow
Comms A (RS485 D1)	Green
-	-
Screen	Screen

3.11.2 Method b: Direct sensor to control unit connection

At control unit (Sensor/Network) from left to right:

0V	Blue (Connector A) + Black (Connector C)
Comms B (RS485 D0)	Yellow (Connector C)
Comms A (RS485 D1)	Green (Connector C)
24V	Red (Connector A)

Connect the cable screen from each cable to the nearest earth stud using an eyelet tag.

3.12 Cable Specification

Cable types recommended:

Electrical Connections Overview	Nº of Cores	Core Size (mm^2)	Core Size strands/dia	Core Size awg	Screened	Supplied by
1	3	0.5	16/0.2	22	Yes	ENVEA
2	8	0.25	7/0.2	24	Yes	ENVEA
3	8	0.25	7/0.2	24	Yes	ENVEA
4	4	0.5 to 1.5	16/0.2 to 30/0.2	22 to 16	No	Customer
5	3	1.0	32/0.2	18	No	Customer

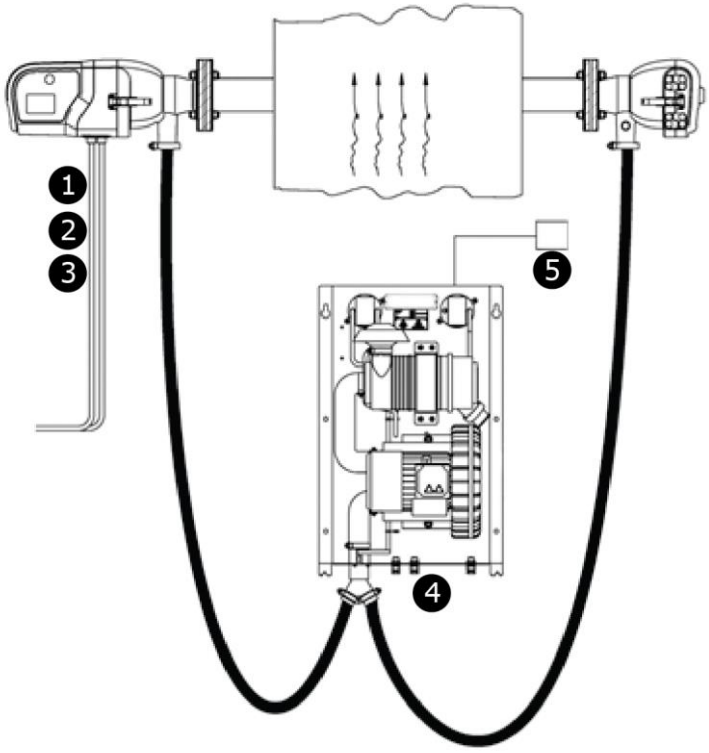


Figure 12: Electrical connection overview.

3.13 PC Software (PC-ME DUST TOOLS)

The minimum system specifications (for PCs/laptops) are shown below. For information on available software modules and other requirements, refer to **Product Parts and Options** on page **12**.

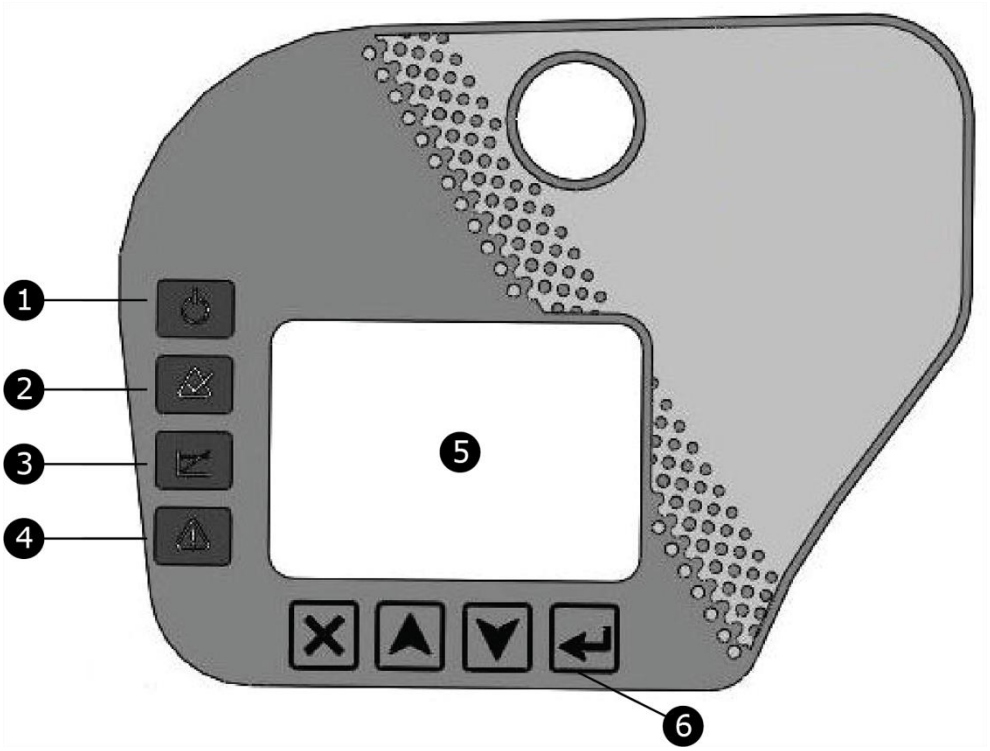
Operating system	Windows XP or higher
System memory	32 Mb RAM 20 Mb free hard disk space
Monitor	1024 x 768 pixels, high-colour graphics
Data communication	1. Serial port (for connection to one or more instruments) *ProController only* – 2. Ethernet (RJ45; via Modbus TCP) *3.* USB 2.0 cable, standard type A-to-A, M:M
Optical disc drive (DVD/CD)	PC-ME DUST TOOLS software is supplied on a software CD and is also available for download from the ENVEA UK website (**www.envea.global/s/process-en/dahs-software/pc-me-dust-tools/**).
Licensing	Multi-user license options (for up to 5 or up to 10 users)

4. Getting Started

4.1 User Interface

The STACK 710 is operated from the User Interface in the Transceiver. The User Interface has four function keys and four illuminated indicators.

The liquid crystal display normally indicates the opacity measured by the instrument. Error messages and other parameters can also be displayed, as explains in a later section. The displayed opacity is corrected for Pathlength Correction Factor (PLCF). The PLCF is factory set and cannot be changed by the customer (see section C1-3).



1 Power on

2 System status

3 Calibration in progress

4 Alarm Status

5 LCD

6 Function keys

Figure 13: User interface.

4.2 Function Keys

The following function keys are located on the touch panel below the LCD display on the side of the STACK 710 Transceiver:

✕ Exit- Return to the previous menu level or cancel data entry.

⇧ Up- Change menu item or increase data value.

⇩ Down- Change menu item or decrease data value.

⏎ Enter- Select menu item or save the data entry.

1. Displayed Value

When the LCD display shows only the instrument reading, pressing the ⇧ or ⇩ arrows will change the value displayed. If the units are %, the value is Opacity. If the units are mg/m3, the value is Dust Density. If no units are shown, the value is Optical density.

2. Menu Selection

When the LCD display shows only the instrument reading, press ✕ or ⏎ to go to the menu. Use the ⇧ and ⇩ arrows to select the required menu item and press ⏎

To cancel a menu selection, press ✕

3. Data Entry

To change a data value, use the ⇧ arrow to increase the value and the ⇩ arrow to decrease it.

When the value is correct, press ⏎ to store it permanently.

To abandon the change and revert to the previous value, press ✕.

The STACK 710 provides an accelerator facility for entering large numbers.

To increase the value, hold down the ⇧ arrow. Initially, the least significant digit is highlighted white on black. The highlighted digit is incremented, completing the decade in which it starts plus one more cycle through the values from 1 to 9 and 0. The highlight then moves to the next higher digit leaving the previous digit at 0. Releasing the key allows a short pause for further changes to the value with single presses of the ⇧ and ⇩ arrows. If the keys are released for about 2 seconds, the highlight progresses down the digits, pausing for about 2 seconds on each one to allow further adjustment. When the highlight leaves the lowest digit, the value is validated and may be automatically adjusted to bring it within permissible limits. The value can be stored by pressing ⏎ when the highlight is on the last digit and the ⏎ symbol is present. Pressing ✕ leaves the original value unchanged. It is not possible to store a value that is out of limits.

Decreasing the value using the ⇩ arrow works in a similar manner.

4.3 STACK 710 Symbols

1		Enter	**32**		Show Negative Values
2		Exit	**33**		Alarm
3		Up	**34**		Output Type
4		Down	**35**		Output Range
5		Unlock	**36**		Constant Current
6		Supervisor Unlocked	**37**		Dust Settings
7		Engineer Unlocked	**41**		Parameter Number
8		Lock	**42**		Scroll Parameters
9		Locked	**45**		List Faults
15		Calibration	**46**		Clear Faults
16		Settings	**51**		Dust Gain 1
17		Parameters	**52**		Dust Gain 2
18		Diagnostics	**53**		Dust Offset
21		Calibration Check	**55**		Zero Check
22		Clear Stack Calibration	**56**		Span Check
23		Audit	**61**		Confirm Clear Path
24		Gravimetric Test	**62**		Confirm Blocked Path
25		Confirm About Calibration	**63**		Test Filter Opacity
31		Calibration Check Intervals			
65		Fast Response	**86**		Restore Previous Calibration
66		Averaged	**87**		Restore Factory Calibration
71		Start	**88**		Confirm Restore Calibration
72		Stop	**89**		Completed Successfully
73		Please Wait	**91**		C Constant

75		No Negative Values	**92**		X Constant
76		Show Negative Values	**93**		B Constant
81		Opacity			
82		Opacity Density			
83		Dust Density			
85		Previous Calibration			

4.4 Glossary of Terms

Op	Opacity
O.D	Optical Density
Dust	Dust Density
Averaging	Time period used to calculate block
Status System	Status Faults
Loop O/P	Current loop output reading in mA
Last Zero	Last zero calibration value
Last Span	Last span calibration value
Cal. Drift	Drift of signal between calibrations (range 0.1 to 1.0)
Version	Software Version Number
Blank	A blank line
So	Signal Detector Offset
Sf	Signal Detector Flood Value
Sm	Signal Detector Measurement Value
Ro	Reference Detector Offset
Rf	Reference Detector Flood Value
Rm	Reference Detector Measurement Value
C	Calibration Constant (slope)
X	Calibration constant (offset)
B	Balance correction
G	Gain correction factor
Q	Uncorrected transmission factor
Dust Gain	Constant relating Optical Density to Dust Density. Dust
Dust Offset	Dust Density zero offset (usually zero)
Dust Gain 2	Quadratic term relating optical density to dust density (usually zero)
OP Damper	Low pass digital filter applied to the output
PLCF	Path Length Correction Factor
Last Cal.	Data stored from the latest calibration
Zero Comp.	Opacity compensation due to dust build on the lens

Gravimetric O.D.	Average Optical Density calculated during gravimetric test
Running In	Positioning the zero reflector or upscale filter to an active position
Running Out	Positioning the zero reflector or upscale filter to an inactive position

4.5 Using the Instrument for the First Time

Tools required: a 19 mm spanner and a 5 mm hexagonal (Allen) key.

Note: When entering numbers using the ⇧ and ⇩ arrows on the keypad, wait until the ⏎ symbol appears on the display before pressing the ⏎ key to confirm the value.

4.5.1 Complete Installation

Ensure that the installation has been completed and that the purge air blowers are running.

4.5.2 Check the Pathlength Correction Factor

If the STACK 710 is to be used to report Opacity, the Pathlength Correction Factor (PLCF) must be set correctly. PLCF is not relevant for Dust Density or Optical Density (Extinction) measurements.

Press

Use the ⇧ and ⇩ arrows to select Parameters and press ⏎

Use the ⇧ and ⇩ arrows to select Parameter Number and press ⏎

Use the ⇧ and ⇩ arrows to change the Parameter number to 137 and press ⏎

If the PLCF is correct press × three times to return to the main screen.

If it is incorrect, the opacity monitor must be returned to ENVEA for reprogramming.

4.6 Align the Retro-reflector

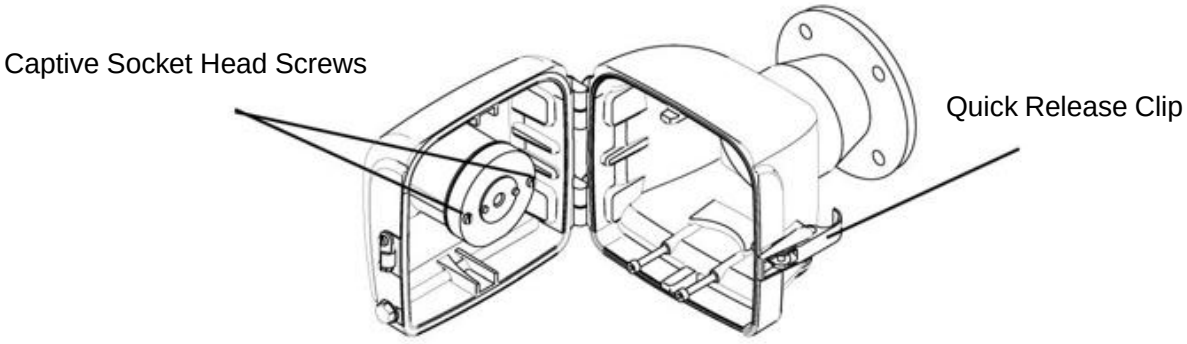


Figure 14: Opening the Retro-reflector case & releasing the reflector.

1. Open the Retro-reflector case by undoing the two quick-release clamps.
2. Release the Retro-reflector Mount by unscrewing the two captive socket head screws on either side of the Retro-reflector Mount. Remove the reflector and stow it in the purge housing.
3. Close the case and fasten the quick-release clamps.

Warning
Eye and face protection must be worn when looking into hot gases.

4. Observe the alignment target through the window (3). A bright green spot (4) should be visible.
5. If the green spot is not visible, undo the quick release clamps on the Retro-reflector and look down the purge barrel. The bright green light from the Transceiver should be clearly visible. If not, then the Transceiver is either misaligned, or the instrument is malfunctioning.
6. To move the green spot horizontally, adjust the M10 nut (1) on the air purge flange and to move it vertically, adjust the M10 nut (2), also on the air purge flange as illustrated in **Figure 15**. Adjust these nuts until the green spot is central in the inner circle.
7. In bright sunshine, the green spot on the alignment target may not be visible. In this case, return to the Transmissometer, undo the quick-release clamps and swing the instrument away from the purge. It should now be possible to adjust the Retro-reflector until the bright circle of sunlight, visible through the Transmissometer purge unit, is centred on the target.
8. Ensure that the 4 pairs of spring washers between the air purge flange and the mounting flange are under moderate compression. The instrument must be firmly held in place to maintain optical alignment.
9. Open the Retro-reflector case, re-fix the Retro-reflector in position, and tighten the captive socket head screws. Close the Retro-reflector case and fasten the two quick-release clamps.

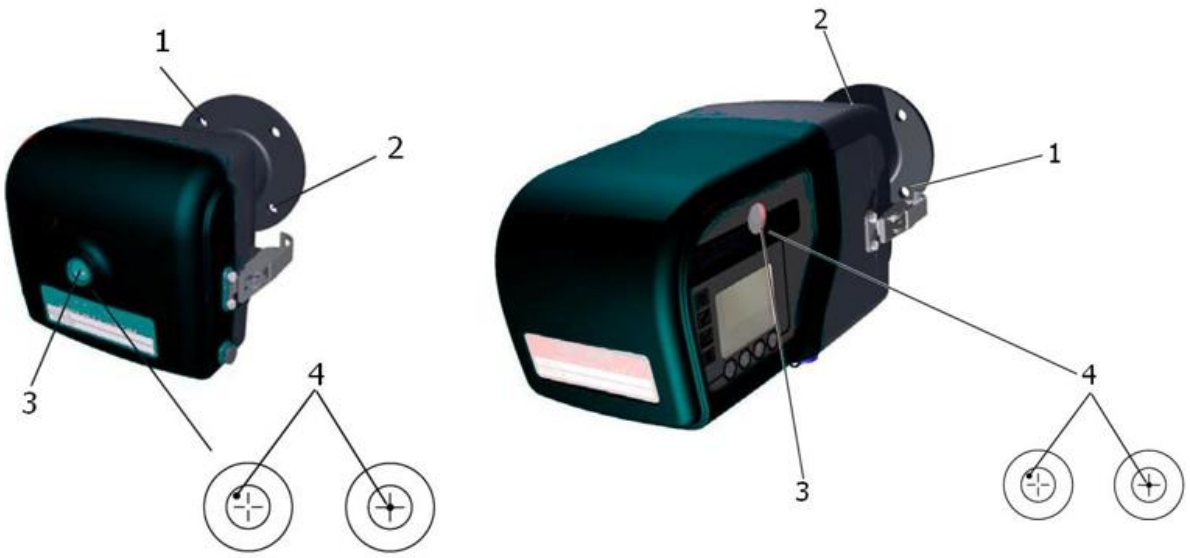


Figure 15: Aligning the Retro-reflector.

4.7 Align the Transceiver

Transceiver Alignment Target

1. Observe the alignment target through the window (3). A bright green spot (4) should be visible.
2. To move the green spot horizontally, adjust M10 nut (1) on the air purge flange and to move it vertically, adjust the M10 nuts (2), also on the air purge flange as illustrated in **Figure 15**. Adjust these nuts until the green spot is inside the inner circle.
3. In bright sunshine, the green spot on the alignment target may not be visible. In this case, return to the Retro-reflector, undo the quick-release clamps and swing open the rear cover. It should now be possible to adjust the Transmissometer until the bright circle of sunlight visible through the Retro-reflector purge unit is centred on the target. Close the Retro-reflector again. If the green spot is visible, adjust the nuts until it is central in the inner circle.
4. Ensure that the 4 pairs of spring washers between the air purge flange and the mounting flange are under moderate compression. If the compression becomes excessive, the third nut has likely been over tightened, or the mounting flange may not have been fitted accurately.

Note: If any of the settings are changed from their default values, the new values should be noted on the Calibration Report and Settings List supplied with the instrument.

4.8 Setup Calibration Check Interval

Press

Unlock is displayed, press .

Use the and arrows until the Supervisor code (Default:1 0) is displayed and press .

Use the and arrows to select Settings and press

Use the and arrows to select Calibration Check Interval and press .

Use the and arrows to change Calibration Check Interval (in hours) and press .

Press to return to Settings .

4.9 Setup Current Loop Output

The STACK 710 normally provides the power supply for the current loop output. It is intended to be connected to a passive input device. To connect the current loop output to an active device, option links inside the Transceiver must be changed.

Switch off the power. Remove the rear cover from the Transceiver (see section C6-4) and locate Link 1 and Link 2 on the Main printed circuit board.

The STACK 710 is shipped set for Active output with the Links in the following positions:

Link 1: B

Link 2: A

For Passive output, set the Links in the following positions:

Link 1: A

Link 2: B

To configure the current loop output:

From Settings , press .

Use the ⇧ and ⇩ arrows to select Output Type  and press ⏎ .

Use the ⇧ and ⇩ arrows to select Opacity  , Optical Density  or Dust Density  .

Press ✕ to return to Output Range.

Use the ⇧ and ⇩ arrows to select Output Range  and press ⏎ .

Use the ⇧ and ⇩ arrows to change the output value corresponding to 20 mA and press ⏎ .

Press ✕ to return to Output Range.

Use the ⇧ and ⇩ arrows to select Show Negative Values  and press ⏎ .

Use the ⇧ and ⇩ arrows to select Show Negative Values  or No Negative Values  and press ⏎ .

Press ✕ to return to Show Negative Values  .

If required, the current loop output can be set to deliver a constant current for test purposes.

Use the ⇧ and ⇩ arrows to select Output Current  and press ⏎ .

Use the ⇧ and ⇩ arrows to change the output current and press ⏎ .

When the test is complete, press ✕ to switch back to normal operation. Press ✕ to return to Settings  .

4.10 Setup Alarm

Note that the Alarm value is expressed in terms of the Output Type (Opacity , Optical Density or Dust Density) selected as described in section **4.9**.

From Settings , press .

Use the and arrows to select Alarm and press .

Use the and arrows to change the Alarm Level and press Press to return to Settings .

4.11 Calibration Check

From Settings use the and arrows to select Calibration .

Use the and arrows to select Calibration Check and press Start is displayed, press to Start the Calibration Check.

The hourglass is displayed while the Calibration Check is in progress.

It disappears when the Calibration Check is finished.

Press twice to return to the main display.

The STACK 710 is now ready for use.

4.12 Modbus Interface

Modbus communications, based on the RS485 duplex hardware standard, provide direct access to the STACK 710 system data. Details of the Modbus protocol are available from the Modbus website **www.modbus.org**. The STACK 710 implements Functions: 3 (Read Holding Register), 6 (Pre-set Single Register) and 10 (Pre-set Multiple Registers)

Each Modbus must have one termination resistor at each end and one bias network somewhere on the bus. The STACK 710 can provide a termination resistor and a bias network. As supplied, the termination resistor is switched on, and the bias network is switched off. To change these, switch off the power, remove the rear cover from the Transceiver (see section C6-4), and locate switch S1 on the Main printed circuit board. The four sections of S1 have the following functions:

1 and 2	- Bias network	Supplied OFF
3	- Not used	

4	- Termination resistor	Supplied ON

The STACK 710 is shipped with the following default communication settings:

Baud rate: 57600

Parity: Even

Data bits: 8

Stop bits: 1

Slave Address: 7

The Baud rate, Parity and Slave Address can be changed as follows:

Press

Use the and arrows to select Parameters and press .

Use the and arrows to select Parameter Number and press .

Use the and arrows to change the Parameter number to 1 and press .

Use the and arrows to change the Slave Address to the desired number in the range 1 to 247 and press .

Use the and arrows to change the Parameter number to 2 and press .

Use the and arrows to change the Slave Address to 9600, 19200, 38400, or 57600 and press .

Use the and arrows to change the Parameter number to 3 and press .

Use the and arrows to change the Parity to 0 (None), 1 (Even), or 2 (Odd) and press .

When the communication settings are correct, press twice to return to the main screen.

4.13 Modbus Registers

A brief list of the most useful Registers is in section **4.13.2**. A complete list is included on the CD-ROM.

Note: The definition of Register Numbers given in the Modbus standard can confuse. For historical reasons, Registers are given decimal numbers beginning at 1, but Register 1 is located at Address Offset 0. Register numbers are always one greater than their associated bus addresses. The Table below uses Register Numbers.

4.13.1 Scaling

In the Table below, the value in the Modbus register must be divided by the scaling factor to obtain the actual value.

4.13.2 Read-Only Registers

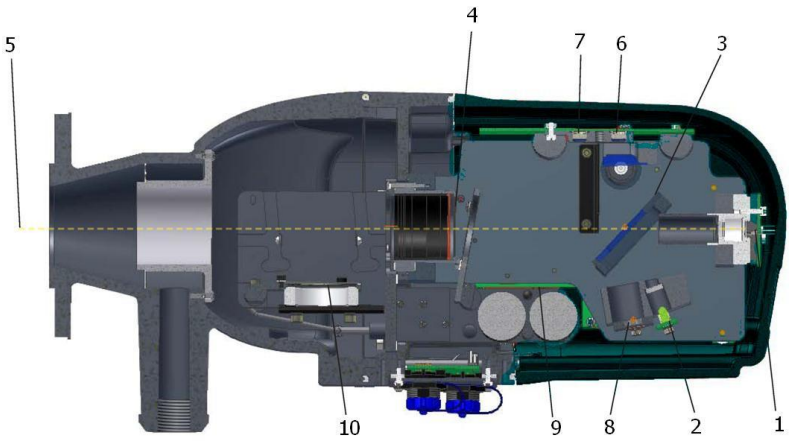
Modbus Register	Data Value	Description	Range	Scaling
127	Opacity	Calculated opacity	-25% - 100%	x100
128	Optical density	Calculated optical density	-1 - 3	x1000
129	Dust density	Calculated dust density	0 - 9999	x1
130	Dust density fractional	Fractional part of the dust density (Reg 503)	0 - 99	x100
131	Average optical density	Average optical density during gravimetri c test	-1 - 3	x1000
132	Stored Average Optical Density	Stored average optical density	-1 - 3	x1000
133	Held opacity	Calculated opacity not updated during a cal audit or a cal check	-25% - 100%	x100
134	Held optical density	Calculated optical density not updated during a cal audit or a cal check	-1 - 3	x1000
135	Held dust density	Calculated dust density not updated during a cal audit or a cal check	0 - 9999	x1
136	Held dust density fractional	Fractional part of the held dust density (Reg 506)	0 - 99	x100
73	Alarm status	Transceiver alarm	0 = Inactive 1 = Active	NA

51	Number of faults	Indicates the number of faults currently present (regardless of mask states)	0 - 32	NA
52	Error Flags	Error flags	Bit 0 = Zero motor jammed Bit 1 = Upscale motor jammed Bit 2 = Source LED fail Bit 3 = Flood Led fail Bit 4 = ADC over-range Bit 5 = ADC fault Bit 12 = Negative opacity Bit 13 = Checksum error Bit 14 = Lens contamination limit Bit 15 = Failure during calibration	NA
201	Average during audit		0 = Off 1 = On	NA
202	Initiate Calibration		Bit 0 = Cal check Bit 1 = Cal audit	NA
95	Cal check interval	In hours (Default = 24)	0 - 1000	NA
96	Time to next cal	Time to next cal in minutes	0 - 65535	NA

Note: Read operation on an unassigned Register will return zero rather than an exception.

5. Periodic Mode of Operation

5.1 Calibration Check



1	LED light source	7	Reference Detector
2	Flood LED	8	Concave Mirror
3	50/50 Beam Splitter	9	Span Filter
4	Collimating Lens	10	Zero Point Reflector
5	Collimated Beam		
6	Measurement Detector		

Figure 16: STACK 710- Transceiver.

The Transmissometer periodically performs a two-step calibration check. In the first step, a zero-point reflector (10), mounted within the air purge of the Transceiver is placed into the optical axis. In the second step, the span filter (9) is also placed in the light path. The monitor reads the difference in light between the current zero-point and the zero-point established during the last clear stack calibration, and notes this value as the amount of drift and optical dust build-up. The opacity value of the span filter (9) is shown on the calibration certificate which accompanies the instrument.

As required by ASTM D6216-07, the STACK 710 indicates the PLCF value on the current loop output for 90 s at the end of each calibration check. The value is scaled from 0.0 to 10.0. For example, PLCF = 1.2; the output value will be 4 + (1.2/10) x 16 = 5.92 mA. This function can be disabled by setting the output to hold during calibration (parameter 188=1).

Caution
Do not attempt to move the zero point reflector by hand. The precision gearbox will be irreparably damaged.

5.2 Calibration Audit

A convenient Calibration Audit facility is provided for carrying out Calibration Audit tests as required by USEPA and other Environmental Regulatory Authorities.

5.2.1 Calibration Error and System Response Time Checks

Press 

Unlock  is displayed, press 

Use the  and  arrows until the Supervisor code (Default: 10) is displayed and press  .

Use the  and  arrows to select Calibration  and press  Use the  and  arrows to select Audit  and press 

Fast Response  is displayed, press 

The Zero Reflector is driven into its working position, and opacity is displayed; it should be 0.0%. Release the clips on both sides of the Transceiver housing. Swing the instrument open on its hinges.

Note:	Do not attempt to move the Zero Reflector (2) by hand. The precision gearbox will be irreparably damaged.

Insert a calibrated neutral density filter into slot 1, taking care not to touch the glass. Read and record the displayed opacity value.

Note that this value is pathlength corrected. If the PLCF is set to 1.0, the displayed value should match the filter opacity. If the PLCF is not 1.0, use the following formula to calculate the expected instrument reading:

$$Displayed\ Opacity = 1 - (1-FilterOpacity)^{1/PLCF}$$

The operating wavelength of the STACK 710 is 525 nm. All audit filters will be calibrated at this wavelength.

Remove the filter, insert the next filter and record the reading.

5.2.2 Averaging Period Check

To perform an Averaging Period check, first, remove the test filter. Use the  and  arrows to select Averaged  and press  . Opacity values will be averaged using the same time constant as in normal operation. Insert a filter and record readings as required.

5.2.3 Exit from Audit Mode

Use the ⇧ and ⇩ arrows to select Stop  and press ⏎ .

The Zero Reflector is retracted, and the instrument resumes normal operation.

Press ✕ twice to return to the main screen.

5.3 Clear Stack Calibration

A Clear Stack Calibration must only be performed when there is no smoke or dust in the beam of the opacity monitor. It can be carried out in-situ if a clear optical path can be achieved. Alternatively, the instrument may be removed and attached to test stands or a pipe for calibration. The STACK 710 provides a convenient facility for testing on a workbench or other flat surfaces. The Transceiver may be laid on its left side and the Retro-reflector on its right side; the screw on the left side of the Transceiver case can be adjusted to achieve the correct alignment. Note that unless the calibration is performed in-situ, the distance between the Transceiver and the Retro-reflector must be adjusted until it exactly matches the distance in normal operation ±6 mm (1/4”).

Ensure that the pathlength is correct and that the surfaces of the main lens and Retro-reflector’s elements are clean and dust-free. Align the instrument as described in B 1-4 paragraph 3.

Press ⏎

Unlock  is displayed, press ⏎

Use the ⇧ and ⇩ arrows until the Supervisor code (Default: 10) is displayed and press ⏎ .

Use the ⇧ and ⇩ arrows to select Calibration  and press ⏎ .

Use the ⇧ and ⇩ arrows to select Clear Stack Calibration  and press ⏎ Start  is displayed. When ready, press ⏎ .

Confirm Clear Path  is displayed. Check that the optical path is clear and press ⏎ the hourglass  is displayed while the instrument waits for the readings to settle.

Confirm Blocked Path  is displayed. The simplest way to achieve a blocked path is to release the clips on the side of the Transceiver and swing it open on its hinges until the beam is pointing into free space. Alternatively, to calibrate the

instrument at an opacity other than 100%, insert a filter into the slot in the calibration unit, close the Transceiver on its hinges and apply the clips.

Press . The hourglass is displayed while the instrument waits for the readings to settle.

Test Filter Opacity is displayed and the value is pre-set to 100%. If the Transceiver was pointed into free space, or if the beam was completely blocked, press . If a calibrated filter was used, set the filter's opacity with the and arrows and press .

Zero Check is displayed while the instrument deploys and checks the Zero Reflector.

Span Check is displayed while the instrument deploys and checks the Upscale Filter. During this time, the calibration constants X and C values are displayed for use by Service Engineers.

The hourglass is displayed while the instrument retracts the Zero Reflector and the Upscale Filter.

When the hourglass disappears, the Clear Stack Calibration is complete.

5.4 Gravimetric Calibration (Isokinetic Calibration)

The STACK 710 measures the opacity of dust and smoke emissions. As explained in the Reference section of the manual, this may be converted to Dust Density using calibration constants. To determine these calibration constants, it is necessary to collect and weigh samples of the particulate matter from the flue gases. This procedure must be carried out in accordance with relevant USEPA Methods or CEN or ISO Standards. It is generally known as Gravimetric or Isokinetic Sampling.

STACK 710 provides a facility to simplify the collection of readings during Gravimetric Calibration.

Press

Unlock is displayed, press

Use the and arrows until the Supervisor code (Default: 10) is displayed and press

Use the and arrows to select Calibration and press .

Use the ⇧ and ⇩ arrows to select Gravimetric Test  and press ⏎ .

Start  is displayed. When the Gravimetric Test is started, press ⏎ .

The display will show the Average Optical Density since the start of the test.

Stop  is displayed. When the Gravimetric Test is complete, press ⏎ .

The Average Optical Density during the last test is shown. Record the value.

Note: Do not press while the Gravimetric Test is running, as this has the same effect as pressing. The test is terminated, and the current Average Optical Density is stored.

Start  is displayed. To start a new test (and lose the saved value), press ⏎ .

To leave the Gravimetric Test menu, press ✕ .

Press ✕ twice to return to the main display.

The procedures for formally calculating the calibration constants are given in USEPA Performance Specification 11, or CEN Standards EN 13284-2 and EN 14181. A simplified procedure using Microsoft Office Excel is given below:

For each measurement point, determine the Dust Density at the reporting conditions from the Gravimetric Test procedure and the average Optical Density indicated by the STACK 710 during the test.

Plot a Scatter Chart of Dust Density (Y-axis) against Optical Density (X-Axis). Add a Linear Trendline through the origin (0,0) and show the equation of the Trendline on the chart. The slope of the Trendline is the Dust Gain calibration constant. Dust Offset and Dust Gain 2 are zero.

If the Trendline is not a good fit to the data, try removing the constraint for the Trendline to go through the origin. The Trendline offset is the Dust Offset calibration constant. Dust Gain 2 is zero.

If the data points form a marked curve rather than a straight line, change the Trendline to a Polynomial of order 2. The coefficient of the x2 term is the Dust Gain 2 calibration constant.

To enter the Dust Gain and Offset values into the STACK 710, press Unlock is displayed, press ⏎ .

Use the ⇧ and ⇩ arrows until the Supervisor code (Default: 10) is displayed and press ⏎ .

Use the ⇧ and ⇩ arrows to select Settings and press ⏎ .

Use the ⇧ and ⇩ arrows to select Dust Settings and press ⏎ .

Use the ⇧ and ⇩ arrows to select Dust Gain and press ⏎ .

Use the ⇧ and ⇩ arrows to change the Dust Gain value as required and press ⏎ .

Use the ⇧ and ⇩ arrows to select Dust Gain 2 and press ⏎ .

Use the ⇧ and ⇩ arrows to change the Dust Gain 2 value as required and press ⏎ .

Use the ⇧ and ⇩ arrows to select Dust Offset and press ⏎ .

Use the ⇧ and ⇩ arrows to change the Dust Offset value as required and press ⏎ .

Press ✕ three times to return to the main display.

5.5 Setting Calibration Constants Manually

If the STACK 710 is miscalibrated, it is possible to recover the situation by replacing the erroneous calibration constants. The Previous constants and the constants determined during Factory testing are stored in the instrument.

To replace the Current Calibration constants with the Previous constants:

Press ⏎

Unlock is displayed, press ⏎ .

Use the ⇧ and ⇩ arrows until the Supervisor code (Default: 10) is displayed and press ⏎

Use the ⇧ and ⇩ arrows to select Calibration and press ⏎ .

Use the ⇧ and ⇩ arrows to select Previous Calibration  and press ⏎ .

Use the ⇧ and ⇩ arrows to select Use Previous Calibration  and press ⏎ .

Confirm  is displayed. Press ⏎ .

The Previous Calibration constants are copied into the Current Calibration constants.

The Tick ✓ in the top left corner of the display indicates that the operation was successful.

Press ✕ three times to return to the main display.

To replace the Current Calibration constants with the Factory constants: Press ⏎ .

Unlock  is displayed, press ⏎ .

Use the ⇧ and ⇩ arrows until the Supervisor code (Default: 10) is displayed and press ⏎ .

Use the ⇧ and ⇩ arrows to select Calibration  and press ⏎ .

Use the ⇧ and ⇩ arrows to select Previous Calibration  and press ⏎ .

Use the ⇧ and ⇩ arrows to select Use Factory Calibration  and press ⏎ .

Confirm  is displayed. Press ⏎ .

The Factory Calibration constants are copied into the Current Calibration constants.

The Tick ✓ in the top left corner of the display indicates that the operation was successful.

Press ✕ three times to return to the main display.

In the event of a major malfunction resulting in loss of the calibration data, the STACK 710 provides a facility for entering the calibration constants manually. The original calibration data determined during factory testing are recorded on the

Calibration Report. This may also show calibration data determined during later clear stack calibrations. To enter the calibration constants, C, X and B:

Press ⏎

Unlock  is displayed, press ⏎ .

Use the ⇧ and ⇩ arrows until the Engineer code is displayed and press Use the ⇧ and ⇩ arrows to select Calibration  and press ⏎ .

Use the ⇧ and ⇩ arrows to select the C Constant  and press ⏎ .

Use the ⇧ and ⇩ arrows to change the displayed value as required and press ⏎ .

Use the ⇧ and ⇩ arrows to select the X Constant  and press ⏎ .

Use the ⇧ and ⇩ arrows to change the displayed value as required and press ⏎ .

Use the ⇧ and ⇩ arrows to select the B Constant  and press ⏎ .

Use the ⇧ and ⇩ arrows to change the displayed value as required and press ⏎ .

Press ✕ three times to return to the main display.

6. Theory of Operation and Application

6.1 General Outline

When a light beam crosses a medium containing smoke or dust particles, some light is transmitted, and some is lost due to scattering. The fraction which is transmitted is called the transmittance, and the fraction which is lost is the opacity.

In the early days of emissions measurement, the opacity of the smoke leaving a stack was measured by the Ringelmann method, in which a trained observer makes a visual estimate of its appearance.

Modern methods for opacity measurement are far more sophisticated than the Ringelmann method, but many of the specifications relate to the way the human eye sees smoke emissions. The wavelength response of an opacity monitor must mimic that of the human eye. An instrument must have a nearly photopic response. The STACK 710 uses a high-intensity green LED light source to achieve this.

6.2 Beer-Lambert's Law

The mathematical relationship between the light transmitted by a medium and the quantity of pollutant present is known as the Beer-Lambert Law and may be written:

$$\tau = \frac{I}{Io} = e^{-acL}$$

where:

τ	=	Transmittance
I_o	=	Intensity of light into the medium (see 1 below)
I	=	Intensity of light out of the medium (see 3 below)
A	=	Attenuation Coefficient
c	=	Concentration of Pollutant
L	=	Distance light beam travels through the medium (see 2 below)

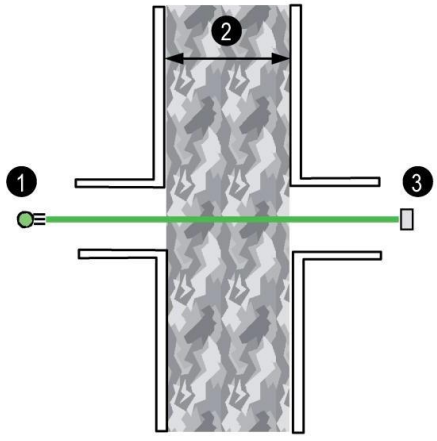


Figure 17: Beer-Lambert's Law.

Since opacity (Op) = 1 – τ, the above equation becomes:

$$(1 - Op) = e^{-acL} \quad \text{or} \quad Op = 1 - e^{-acL}$$

Note that quantity c is the amount of dust in the optical path. Optical Density (or extinction) is defined as:

$$OD = -\log_{10} \tau$$

$$= -acL/2.303$$

$$c = k \times OD \text{ where } k = -2.303$$

$$aL$$

By comparing a series of optical density measurements with gravimetric dust measurements taken at the same time, it is possible to determine the value of k.

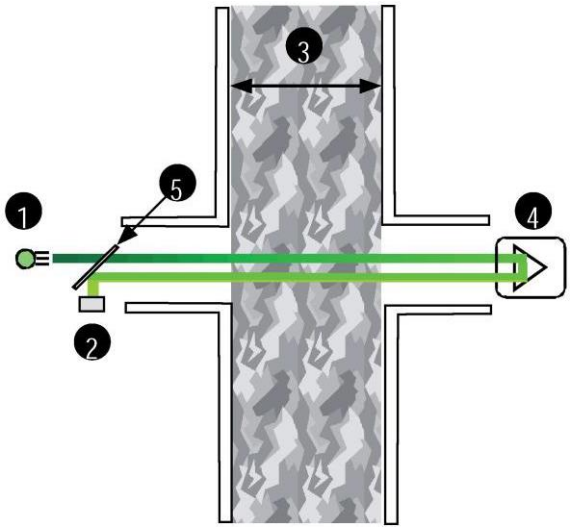
6.3 Pathlength Correction Factor (PLCF)

The last item that we need to address is that opacity monitors may not always be mounted at the exit of a stack. Since the Ringelmann observer always views opacity at the exit of a stack, we must also introduce a factor to correct for the change in pathlengths between the measurement and exit diameters of the stack. It should also be pointed out that the STACK 710 Dust (opacity monitor) is a double-pass instrument. This means that the light beam crosses the medium twice and experiences twice the amount of absorption, as illustrated in **Figure 18**. This must also be corrected in our system.

The Pathlength Correction Factor (PLCF) is only relevant for Opacity measurements. It is the ratio between the diameter of the stack exit and the diameter of the stack at the point where the instrument is installed. For a parallel stack, the PLCF is 1.0. For a tapering stack that is narrower at the exit than the base, the PLCF is less than 1.0.

The Optical Pathlength Ratio (OPLR) is the ratio between the diameter of the stack exit and the distance travelled through the stack gases by the beam. For a double-pass instrument like the STACK 710, the OPLR is equal to half the PLCF, for example,

$$OPLR = \frac{PLCF}{2}$$



Key

1. Light source lo
2. Detector
3. Distance light beam passes through a medium (L)
4. Reflector
5. Beam Splitter

Figure 18: Double pass system.

We can use the previous equations to calculate the opacity at the stack exit, if we define the pathlength correction factor (PLCF):

$$PLCF = \frac{L_e}{L_m}$$

where: L_e = the exit pathlength

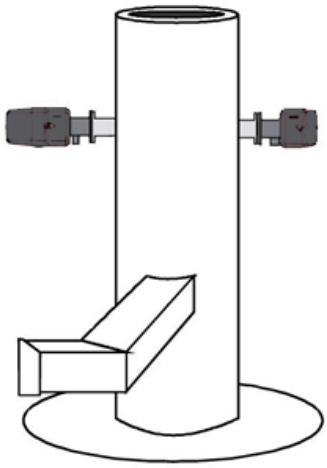
L_m = the measurement pathlength

$$OPLR = \frac{PLCF}{2}$$

$$Ope = 1 - 10^{-OD \times OPLR}$$

Note: The STACK 710 applies the PLCF correction only to the measured opacity. Optical density is shown as the double-pass value.

6.4 Examples of Different Pathlength Correction Factors (PLCF)



Straight stack.

Measurement pathlength and exit pathlength are equal.

PLCF = 1.00

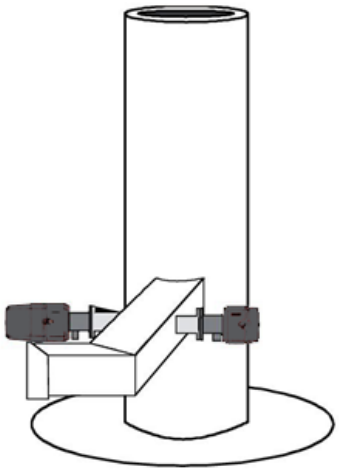
Example 1

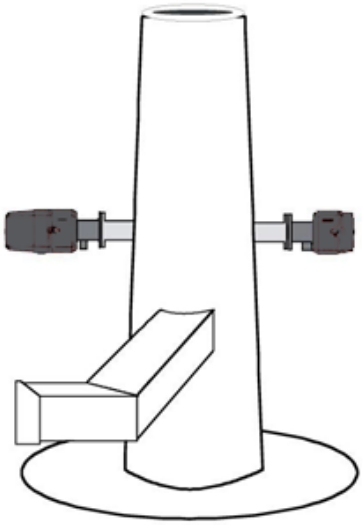
Straight stack, monitor on the narrow duct.

Measurement pathlength is less than exit pathlength.

PLCF > 1.00

Example 2





Stack narrows towards the exit.

Measurement pathlength is greater than exit pathlength.

PLCF < 1.00

Example 3

Figure 19: Examples of Different Pathlength Correction Factors (PLCF).

6.5 Requirements for Environmental Legislation

The STACK 710 meets or exceeds the requirements of U.S. 40CFR60 AppB PS1 and ASTM Standard Practice D6216.

6.5.1 General Description

The STACK 710 measures opacity by shining a light beam through flue gases. An internal microprocessor calculates opacity, dust density and other parameters. The instrument comprises the following parts:

- The Transceiver- contains all the optical and electro-optic components
- the Retro-reflector- contains a glass reflector and an air purge system.

The air purge system can take several forms depending upon individual site requirements. Single and dual electric blowers are available, as are compressed-air driven devices. The continuous purge air supply is essential to prevent dust and corrosive gases from affecting the optical system. Automatic fail-safe shutters can also be fitted for temporary protection in the event of a purge air failure.

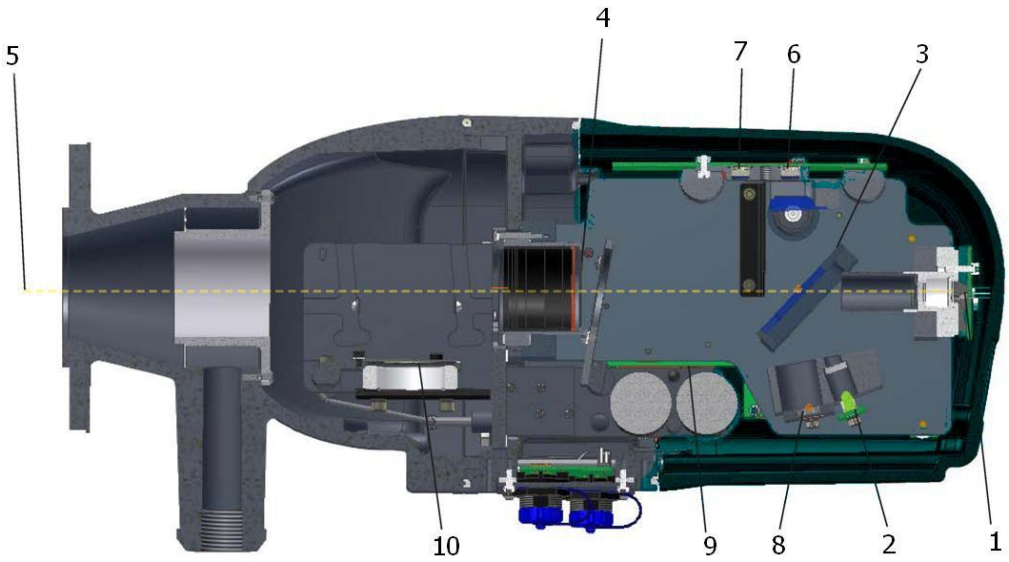
The entire system is designed for continuous operation in all weather conditions, with minimal maintenance.

Figure 20: STACK 710- overview.

6.5.2 Principle of Operation

The main light source uses three green LEDs in a special configuration (patent pending) to ensure homogeneity over the entire transmitted light beam. The light source is modulated at a frequency of 1 kHz to reduce electrical noise and eliminate errors due to ambient light. A second light source, the (patented) "Flood LED" is used to reduce the effect of temperature drift in the detectors to an almost immeasurable low level.

Electronic modulation eliminates the need for a mechanical chopper, and so the only moving parts are the motors used in the calibration system. These motors have a very low duty cycle and are very reliable.



Key

1. LED light source
2. Flood LED
3. 50/50 Beam Splitter
4. Collimating Lens
5. Collimated Beam
6. Measurement Detector
7. Reference Detector
8. Concave Mirror
9. Upscale Filter
10. Zero Reflector

Figure 21: STACK 710- Transceiver.

The Transceiver is illustrated in **Figure 21**. Light from source LED1 (1) passes through the diffuser (11) and onto the 50/50 beamsplitter (3). The transmitted portion passes on to the lens (4), which projects a well-defined, collimated beam (5) across the measuring path to the distant Retro-reflector. Light returned from the Retro-reflector is focused by the lens (4) onto the measurement detector (6). The portion of light originally reflected by the beamsplitter (3) falls on the concave mirror (8), which focuses it on to reference detector (7). The opacity value can be calculated from the ratio of the signals from the two detectors.

This is true only as long as the responsivity of the detectors (6 and 7) and the gain of their associated electronics remains constant. In practice, temperature variations and ageing of the components means that this cannot be guaranteed. The STACK 710 uses a novel method to compensate for such changes by using Flood LED (2) to illuminate both detectors (6 and 7). Because it uses no focusing optics, there is no possibility of misalignment, and so any relative change in sensitivity between the detectors (6) and (7) will lead to a change in the ratio of signals from the Flood LED (2). By alternating light sources (1) and (2), the normalisation procedure is then continuous.

The microprocessor performs the calculations required to perform the normalisation and to convert the opacity measurement into optical density or dust density as required.

6.5.3 Calibration Check

The Transceiver periodically performs a two-step calibration check. In the first step, a zero reflector (10), mounted on the outside of the Transceiver is placed into the optical beam. In the second step, the upscale filter (9) is also placed in the light path. The monitor reads the difference in signal level between the current value and that established during the last clear stack calibration and corrects any contamination on the lens. The opacity value of the span filter (9) is shown on the calibration certificate which accompanies the instrument.

6.6 System Specification

6.6.1 STACK 710

Measuring	
Technique:	Double pass/path transmissometry
Operating Wavelength:	520 ± 20 nm
Light Source:	High Intensity LED
Range:	Opacity 0 - 10 % to 0 - 100% Optical Density 0 - 0.1 to 0 - 3.0 Dust Density 0-10 to 0 to 10000 mg/mg³ User Selectable
Linearity:	< 2% of range
Resolution:	0.1 % Opacity; 0.001 Optical Density; 1 mg/m³ Dust
Drift:	< 3% of range per month
Angle of Projection:	< 2°
Angle of View:	< 2°
Response Time:	6 seconds to 95% of final value
Averaging:	Selectable from 10 seconds to 24 hours (in seconds)
Pathlength:	0.5 to 10 m / 20'' to 33 ft
Calibration:	Automatic zero and upscale calibration (Selectable interval 1 to 24 hours in (in 1-hour increments)
Zero Correction:	Automatic correction for zero drift

Control Panel	
Display:	128 x 64-pixel reflective backlit LCD
Keypad:	4 keys for data input
Indicators:	Power on, System OK, Calibration, Alarm

Environmental	
Operating temperature:	-20 to 55 °C / -4 to 131 °F (-40 °C / -40 °F with optional heater)
Maximum Flue Gas temperature:	600 °C / 1112 °F
Maximum Flange Temp:	200 °C / 392 °F
Environmental rating:	IP65 / NEMA4X

Compliance	
Measurement standards:	Meets or exceeds US EPA requirements for 40CFR60 Sections 13, 17 and App. B PS1 Meets or exceeds ASTM Standard D6216 - 07
Safety:	Conforms to EN-61010-2
EMC:	Conforms to E-50 081 & EN-50 082

Outputs	
Modbus Interface:	RS485. Opacity, Optical Density, Dust Density, and Status information available
Analogue Outputs:	Isolated 4-20mA current output. Configurable as Opacity, Optical Density, Dust Density
Relay Outputs:	System OK, Calibration, Alarm

Power Supply		
DC Power:	18 to 30 V DC	0.25A (without heater) 2.25A (with heater)

Weight	
Transceiver:	7kg (15.5lb)
Retro-reflector:	3.2kg (7lb)

Continuous product development may make it necessary to change these details without notice.

7. Maintenance

7.1 Identifying Faults

The STACK 710 Dust (opacity monitor) has been designed to assist the user in finding and correcting many possible problems. If the instrument detects a problem, it will switch off the Green System OK LED and de-energise the System OK relay.

The further diagnostic information may be obtained as follows:

Press

Use the and arrows to select Diagnostics and press .

The number of faults present is shown in the top left corner of the display.

If the number of faults is not zero, use the and arrows to select List Faults and press .

The first Fault Number is displayed. Its meaning and the recommended action are listed in the table in section **7.2**.

Use the and arrows to see any other Fault Numbers. If there are no other faults, the number will not change.

Press .

To clear the faults, use the and arrows to select Clear Faults and press .

The number of faults present will be updated. If there are still faults present, this will not be zero.

Note: The list of displayed faults is only updated on entry to the diagnostics menu and in response to a Clear Faults instruction. Changes in fault status while the Diagnostics menu is in use, may not be visible.

Press to return to the main screen.

7.2 Fault Number List

Fault Number	Description	Recommended Action
1	Zero motor jammed.	Check the Zero Reflector drive mechanism. Warning - Do not move the mechanism by hand or the precision gearbox may be irreparably damaged.
2	Upscale motor jammed.	Check the Upscale Filter drive mechanism. Warning - Do not move the mechanism by hand or the precision gearbox may be irreparably damaged.
3	Source LED failed	Check the Source LED connections. Replace the Source LED Assembly.
4	Flood LED failed	Check the Flood LED connections. Replace the Flood LED Assembly.
5	ADC Over-range	The signal arriving at the Analogue-to-Digital Converter is too large. Check that the correct reflector element and aperture plate are fitted in the Retro-reflector. Replace the Detector PCB. Warning - The Detector PCB must be optically aligned.
6	ADC Fault	The Analogue-to-Digital Converter is not working. Replace the Detector PCB. Warning - The Detector PCB must be optically aligned.
13	Negative Opacity	Check that the installation pathlength is correct. Perform a Clear Stack Calibration.
14	Checksum Error	The microprocessor's program memory is defective. Re-program the Main PCB. Change the Main PCB. Warning - All the instrument settings and calibration constants are stored on the Main PCB. Re-enter this data after changing the PCB.
15	Lens Contamination Limit	The zero drift correction system has reached its limit. Clean the main lens. Perform a Calibration Check. If the problem persists, make sure the Zero Reflector is clean. Note that this fault can only be cleared by a successful Calibration Check or Clear Stack Calibration.
16	Failure during Calibration	Something has prevented the completion of calibration. User actions can cause this fault. Perform a Calibration Check. If the problem persists, check the Zero Reflector and Upscale Filter drive mechanisms. Warning - Do not move either mechanism by hand or the precision gearbox may be irreparably damaged

Note: When contacting ENVEA Service Department, please have the Instrument Type and Serial Number available. This will ensure a more accurate and efficient response.

7.3 Maintenance

The STACK 710 has been designed for a minimal amount of routine maintenance. To ensure a maximum monitor lifetime, however, the following maintenance schedule has been developed. Remember that the air purge system should always be left on, even if the boiler is off, to prevent any optics contamination. In exceptionally dirty facilities, the time periods shown below should be shortened. Frequent "Lens Contamination limit" alarms or blower faults may indicate a need to shorten the maintenance period.

Item	Part number	Maintenance	Procedure
Air Hoses	306.046	90 Days	Examine hoses for holes or leaks. Test all hose clamps for tightness.
Pre-filter (Where fitted)	317.560	90 Days	Dust level should be below the line. Remove, empty, wipe out, and replace.
Filter Element	317.561	90 Days	Remove the filter from the filter housing. Remove the cap. Empty the cap and wipe it out. Wear eye protection, tap gently to remove dust. Clean carefully with a blowgun. Examine for holes or rips. Re-fit.
Safety Filter (where fitted)	317.604	Annually	Replace with a new filter.
Blower		90 Days	Check for bearing noise. (Bearing failure, and subsequent blower failure, can be detected early.) Check blower air flow to be sure that the blower is performing normally. (Dirty air filters may reduce air flow and cause undue stress on the blowers.)
Optics	N/A	90 Days	Check and clean the optics as described in section **7.4**.
Air Purge Adapter	N/A	90 Days	Unclip and hinge open the Transceiver and Retro-reflector and check that there is no ash buildup inside the purge adapters that could block the light path.

During the regularly scheduled maintenance periods, any optional equipment (shutters, pressure switches, weather covers) should be checked for correct operation. If any potential problems are noted, the equipment should be repaired or replaced if necessary.

7.4 Cleaning the Optical Surfaces

After prolonged use, some contamination will likely occur on the optical surfaces of the STACK 710. The time taken for significant contamination to occur depends very much on the nature of the installation, but in a typical situation, it should be sufficient to clean the optics every 90 days.

CAUTION

Always use a lint-free lens cloth to clean the optical surfaces. Ensure the cloth is kept clean. A dirty lens cloth can scratch the optical surface and cause permanent damage to the instrument. Replacement lens cloths can be purchased from ENVEA.

Ordinary tissues and dusters are not suitable and can scratch the delicate optical surfaces.

To clean the Retro-reflector, open the housing by undoing the two quick-release clamps. Carefully wipe the glass surface of the Retro-reflector with the lens cloth. Close the housing and fasten the two quick-release clamps.

To clean the mains lens, open the Transmissometer housing by undoing the two quick-release clamps. Wipe the lens using the lens cloth. Close the housing and fasten the quick-release clamps.

CAUTION

Do not attempt to move the zero reflector by hand. The precision gearbox will be irreparably damaged.

7.5 Transceiver Cover

7.5.1 Removing the cover

If it is necessary to open the STACK 710 Transceiver cover, for example, to change communications option links or switches, proceed as follows:

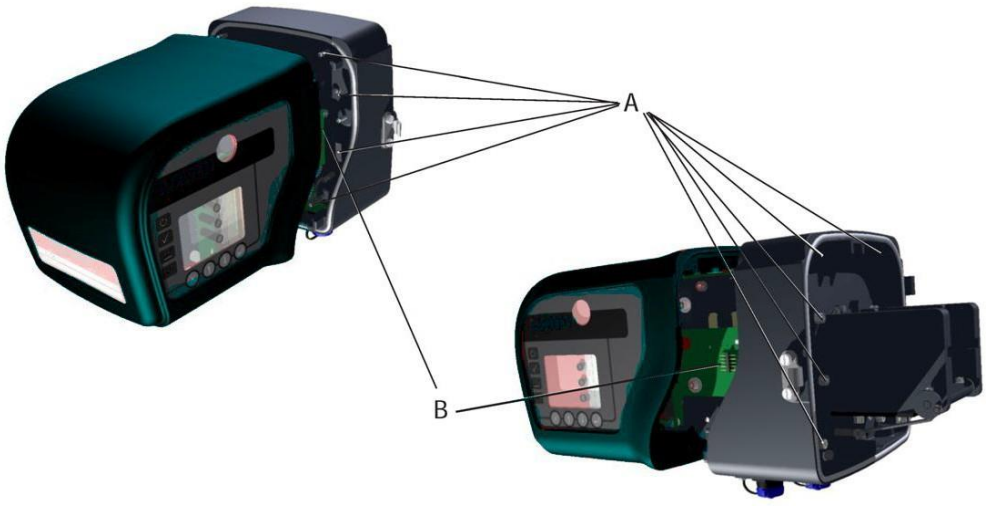


Figure 22: STACK 710- removing the cover.

Undo the eight screws (A). Pull the cover back about 50 mm (2”). Reach in and disconnect the touch panel connector (B) by pulling it towards the rear. Remove the cover completely.

7.5.2 Replacing the cover

First, check that the sealing cord (D) is clean, evenly pressed down into its channel, continuous and undamaged. Replace the cover, ensuring that the touch panel cable is extended towards the front. Stop when the cover is nearly in place and plug the touch panel connector onto the pins on the display board (C). Push the cover fully into place and tighten the six screws firmly and evenly. Finally, check that the sealing cord is evenly compressed round the case. The gap between the metal parts should be 0.5 mm.

7.6 Configuration Record Sheet

Please complete the Configuration Record Sheet.

General Information	
Instrument Serial Number	
Date of Purchase	
Technical Information	
Pathlength	

Service History	
Date	**Action**

Service History			
Date	**Action**	**Part Replaced**	**Part No.**

Notes:

Notes:

Notes:

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