G8100

Black Carbon Monitoring System

User Manual

Green Instruments

Green Instruments A/S
Erhvervsparken 29
DK-9700 Brønderslev Denmark

Tel.: +45 9645 4500
Fax: +45 9645 4501

Email: spares@greeninstruments.com

Email: service@greeninstruments.com

Website: www.greeninstruments.com

For safe and proper use of the G8100 Black Carbon Monitoring System, read this user manual carefully and keep it for future reference.

For spare parts information, see section 8.1

Green Instruments A/S reserves the right to adjust and improve its products and systems, and the user manual is subject to change without notice.

Green Instruments A/S has taken all measures to ensure the information in this user manual is accurate and comprehensive. Green Instruments A/S reserves the right to make corrections and cannot be held liable for any errors or omissions in this manual.

Address all claims and spare parts inquiries to Green Instruments A/S or our distributors. In all correspondence or when ordering spare parts, carefully state the equipment type, vessel IMO number, and the serial number, which can be found on the label on the equipment.

If you have questions or comments relating to the user manual, contact Green Instruments A/S.

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1. Introduction

1.1 About the System

The G8100 Black Carbon Monitoring System from Green Instruments is an in-situ continuous emission monitoring system. The system enables customers to track black carbon emissions in real time.

The G8100 Black Carbon Monitoring System is designed to detect black carbon particles by applying the extinction minus scattering method, according to the MEPC.394(82) - 2024 Guidelines on recommendatory Black Carbon emission measurement, monitoring and reporting.

The values measured by the G8100 system with the extinction minus scattering method are correlated to the FSN method, to see the equivalent black carbon concentration. The data obtained from the stack monitoring is shown on the system's HMI, where operators can see the status of the system as well as the black carbon values measured both in mg/m3 and FSN. You can download this data to an SD card and export it to analyze it on a computer. Data can also be retrieved in real time via modbus connection.

Although black carbon is not yet regulated, its environmental impact — particularly in the Arctic — is under increasing scrutiny. Current IMO guidelines offer recommendations for monitoring and mitigation, and future regulations may follow. In this context, aligning fleet operations with environmental goals is not only a matter of compliance but also of strategic positioning, especially as penalties for emission non-conformity become more common in sensitive regions. The G8100 system will help you demonstrate that your ship is fit to sail the planned routes, complying with regulations in force.

You can make a difference by ensuring your ship is emitting less than the allowed limits and lead the way towards a cleaner ocean shipping, setting your brand at the forefront of black carbon pollution reduction.

The G8100 Black Carbon Monitoring System is easy and cost-efficient to maintain, as it is set-up with purge air, preventing the optical windows from being stained from use throughout time. The system's thorough design and simplicity make it safe and easy to operate, if safety guidelines are followed. In addition, the G8100 system is designed to be accessed remotely for user support, merely by having internet connection to the system.

All measurements are compensated for variations in temperature and pressure.

The following image shows an overview of the G8100 Black Carbon Monitoring System.

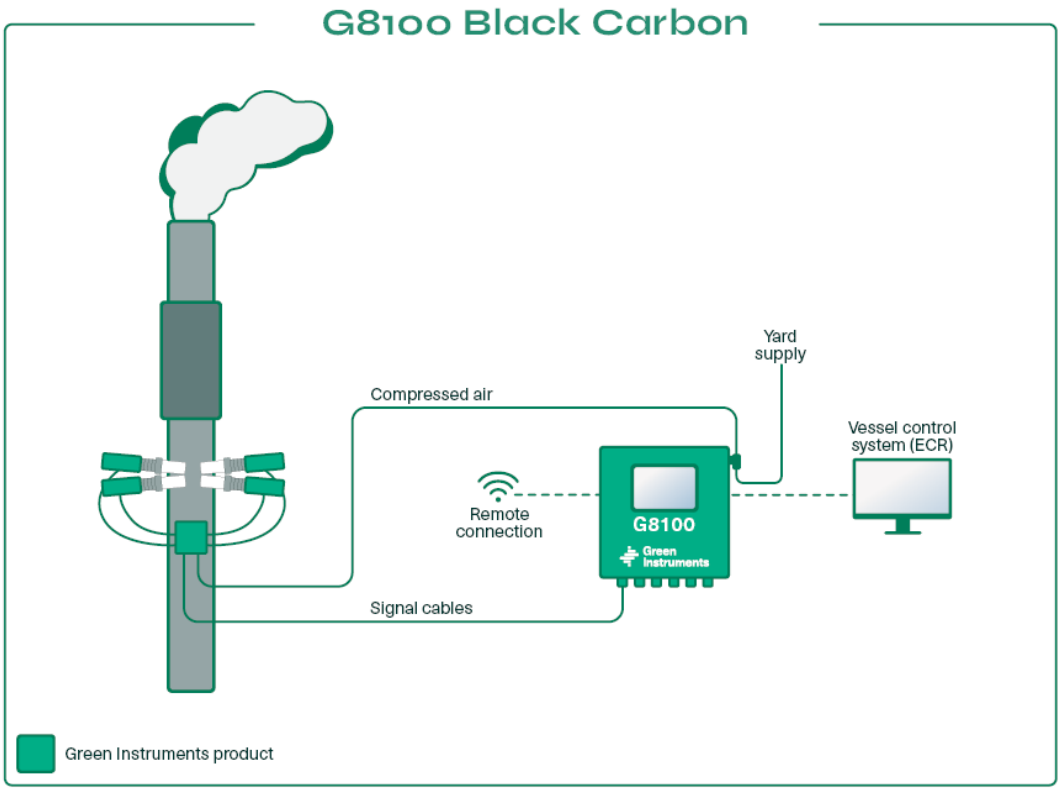


Figure 1-1, G8100 Black Carbon Monitoring System in context

1.2 Proposed Field of Application

The G8100 Black Carbon Monitoring System is designed for exhaust gas monitoring onboard vessels where continuous tracking of black carbon emissions is relevant. It is especially recommended for ships operating in or near the Arctic, with diesel engines that have 130 kW power output or over, as stipulated by MEPC.394(82). Nevertheless, black carbon regulations are currently developing and sensitive areas become more restrictive with future ECAs consolidating, prompting fleets to control their emissions. The global warming effect of black carbon is estimated to be 460 over a hundred-year period[1], as per the ICCT (2009), making it the second strongest warming agent only after CO2. Due to this, regulators in EU and the IMO deliberate incorporating Black Carbon as a greenhouse gas.

1.3 Technical Specifications

NOTE: Specifications are subject to change without notice.

G8100 Black Carbon Monitoring System	
Type	G8100
Function	Monitoring of Black Carbon
Equipment including	Transmitter module, Receiver modules, Temperature transmitter, Pressure transmitter, Flow transmitter, air filter regulator and oil/particle separator, HMI, PLC.
Certification	N/A

[1] International Council on Clean Transportation. (2009). *A policy-relevant summary of black carbon climate science and appropriate emission control strategies.* London.

Power Supply	230 VAC – 50/60 Hz	
Power Consumption	See the electrical documentation	
Display	7" TFT LCD color display with touch screen	
External Communication	Modbus TCP/IP (RJ45) 1 x Analog output (4-20mA) [mg/m3] 1 x Analog output (4-20mA) [FSN] 4 x Digital output (Alarms) Optional Modbus RTU	
Electrical connection	See the electrical documentation	
Purge air supply	ISO 8573-1 Class 3-3-3 160 L/min. 4-10 bar	
Ambient temperature	5°C to 55°C	
Humidity	Max 96% RH	
Material/Enclosure Class	Painted mild steel RAL 7035, IP54	
Dimensions/Weight (Controller Unit)	400 x 400 x 300 mm (H x W x D) Approx. 16 kg	
Stack diameter	0,5m – 1m	
Transmitter and Receiver Modules		
Material	Aluminum EN-AW 6082	
Weight	Transmitter: 0,65 kg Receivers: 0,6 kg	
Flue gas temperature	Above dewpoint up to 460°C	
Flue gas pressure	-50 to + 50 hPa	
Measuring principle	Extinction and scattering	
Measuring range	Soot Concentration	0-70 mg/m3
	FSN	0-2,5
Resolution	Soot Concentration	0,01 mg/m3
	FSN	0,01
*Accuracy	Max. ±3% of sensor range	
*Reference FSN Correlation factor R^2	0,91	
Compensations	Compensated for the effects of temperature and pressure in the stack.	
Laser Class	3B	

*Based on testbed data using an FSN reference instrument.

1.4 Storage and Handling

1.4.1 Storage

The ambient temperature must be 0–60 °C, and the relative humidity must be 20–90% RH. Keep the equipment stored in its original packaging. Store indoors in a dry room where the equipment will not be exposed to vibration or dust.

1.4.2 Handling

See the relevant technical specifications for the weight of controller unit when unpacking, moving, and installation.

1.5 Delivery Check

Check the equipment upon arrival to ensure that the equipment has been transported properly.

Check for any damage. If any damage is found, immediately make a note on the delivery document. Remove the packing and check for intrusive water or signs of humidity.

Check for missing parts against the packing list. Any discrepancies or damage should be reported to Green Instruments A/S immediately.

1.6 Terms and Abbreviations

The following table lists terms and abbreviations used in this user manual.

Description	Abbreviation
Human Machine Interface	HMI
International Maritime Organization	IMO
Marine Environment Protection Committee	MEPC
Programmable Logic Controller	PLC
Black Carbon	BC
Filter Smoke Number	FSN
Emission Control Area	ECA

2. Safety

ATTENTION

Read and understand the contents of the entire user manual before operating the system.

2.1 Symbols and Warning Labels

This manual uses the following symbols to identify essential information related to the correct and safe operation of the G8100 Black Carbon Monitoring System. Follow the safety warnings to minimize the risk of electrical shock, burns and equipment damage when operating the system.

Symbol Identification			
	General warnings sign		Hot surface hazard
	Electric shock hazard		Protective earth
	Laser radiation hazard		

ATTENTION

Failure to follow the instructions can lead to serious injury or death. Follow the instructions:

- Do not install the system in hazardous and explosive environments such as EX-zones. It is not safe.
- Do not use the system for sampling and measurements of explosive media. It is not safe.
- Install equipment on a robust structure that minimizes vibration and is strong to support the load.
- Ensure all power and signal cable connections are correct before operating the system.
- Hot surface hazard: The welding bracket and part of the air module become hot during operation and may cause burns. Avoid contact with hot components and allow components to cool down before performing work on these.
- Wear personal protective equipment. The system must only be installed in a safe, non-hazardous area. It must not be used with flammable media. This manual describes the most common and known situations. It does not describe every possible situation or circumstance relating to the installation of the system. This manual does not replace the specific training and education of personnel who will be installing the system.

Should a situation arise that is not described in this manual, and which cannot be resolved by normal known practice and good workmanship, then contact Green Instruments A/S.

ATTENTION

Electric shock hazard

Disconnect the power before installing or servicing the equipment. Failure to do so can cause damage to materials. Read the installation instructions carefully to ensure all power and signal leads have been correctly connected.

Ensure that the correct supply voltage is connected to the system.

Circuit Breaker

The installation must include a means of isolating electrical power by a clearly marked external switch or circuit breaker. The external switch or circuit breaker must be located near the system and within easy reach of the operator.

The G8100 Black Carbon Monitoring System has a safety switch positioned on the side of the cabinet. This switch disconnects power to downstream components.

Overload and Short Circuit Protection

In accordance with the safety requirements in IEC 61010-1 (2010), the installation must include a means of overcurrent and short circuit protection to provide protection against excessive energy being drawn from the system power supply if the equipment has a fault. See the electrical documentation for more information.

Protective Earth

ATTENTION

The system must be connected to protective earth.

Installation and Fault Finding

ATTENTION

Electrical installation and system fault finding may only be carried out by a trained and qualified engineer.

EMC

In accordance with the EMC product standard IEC 60533 (2015), connection cables for communication signals must be shielded or have equivalent protection.

ATTENTION

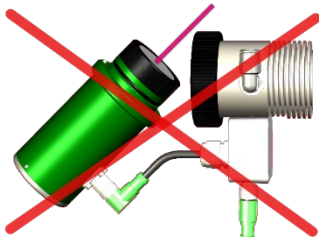
Purge air must always be applied when the system is installed on stack, or any other application where there is a risk of contamination. Lack of purge air may damage components.

Laser Radiation

ATTENTION

Class 3B Laser! – risk of permanent eye damage:

NEVER connect power to modules without being inserted into air module!



Always disconnect the power from the transmitter module before servicing it. Removing power from any module will switch all modules off.

Class 3B visible-light lasers are hazardous for eye exposure. They can cause burns to the retina.

3. HMI Structure

The HMI structure is designed to ease the setup, operation, and maintenance of the G8100 system.

3.1 Navigation Bar

The navigation bar at the top of the screen provides easy access to various system functions.

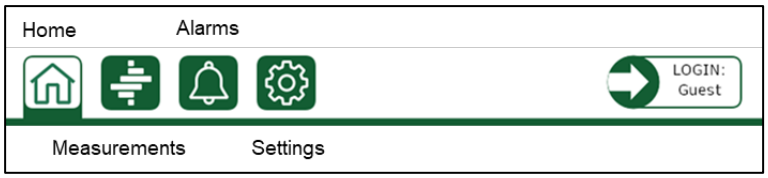


Figure 3-1, Navigation Bar

3.2 Security and Login

The G8100 Black Carbon Monitoring System supports the following user access levels:

Level	Access	Username	Password
1	Standard access on power up	Guest	
2	Service access	Service	1234
3	Admin access	Admin	Generated one-time password

- **Level 1 – Guest**: users can view system status, measurement values, alarms, and maintenance plan.
- **Level 2 – Service**: access system settings, sample line setup, calibration, software update, and manual activation of components during trouble shooting. This is for trained personnel only. The system automatically logs off Service level access after 20 minutes of inactivity.
- **Level 3 – Admin:** modify system parameters.

NOTE: The system is case-sensitive and distinguishes between lower- and upper-case letters.

ATTENTION

Access to Level 3; Admin access requires consent and a password from Green Instruments. Your administrator must contact Green Instruments and share the information shown on the login screen. Green Instruments can then generate a one-time password that will be active for 30 minutes after login.

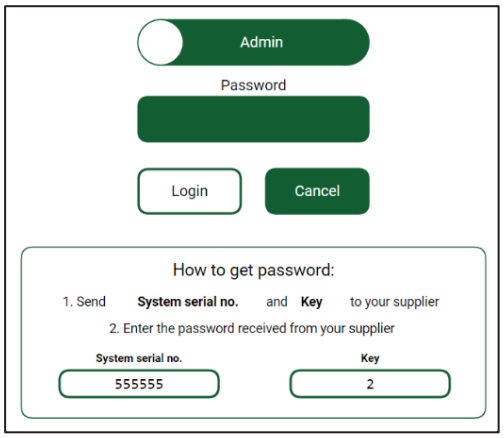


Figure 3-2, Level 3 Password

3.3 Home Page

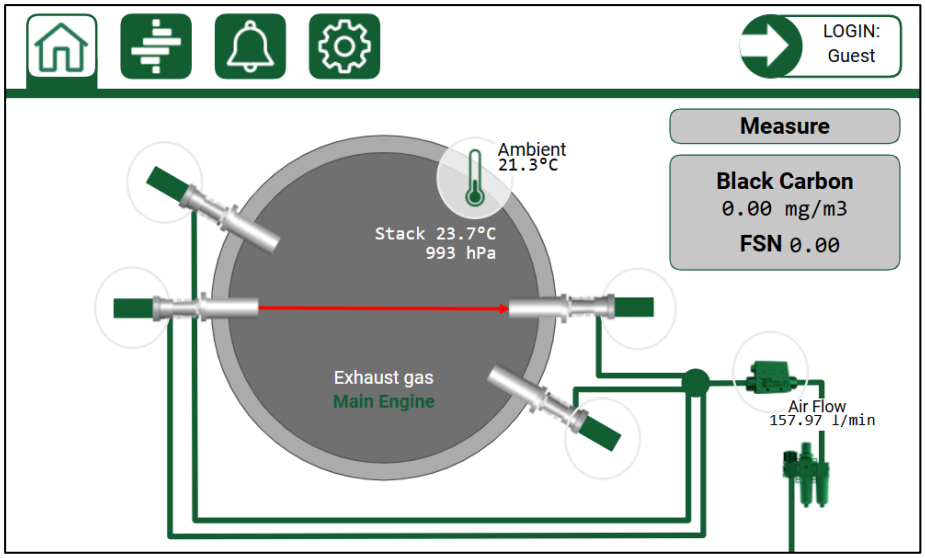


Figure 3-3, Home Page

On the Home page you can do the following:

- Get an overview of the system layout and components.
- View system status.
- View live operational status of components, purge air flow, stack temperature and pressure, and ambient temperature.
- View component parameters such as limits and setpoint settings.

Home Page Indicators

- A circle around a component indicates that an operator with Level 2 Service access can control the component.
- No circle around a component indicates that control is not possible. However, information about the component is available when it is pressed.
- A green line indicates that purge air flow is OK. Grey = flow NOT OK
- A green component indicates that the component is ready for operation or active.

3.4 Measurements Page

The Measurements page displays live measurements for black carbon as mg/m3 and FSN, as well as temperature and pressure on a trend graph. You can adjust the ranges you want each parameter to be shown within by setting the maximum and minimum. You can also select the timeframe that you want the data from.

To download the data, go to the Settings Page. The data can be extracted via an SD card located on the front of the PLC. Open the cabinet to locate the ethernet ports. The SD card slot is beside them.

When there is accumulated data in the system, it will operate slower. In this case, it is recommended to export the data and liberate system space.

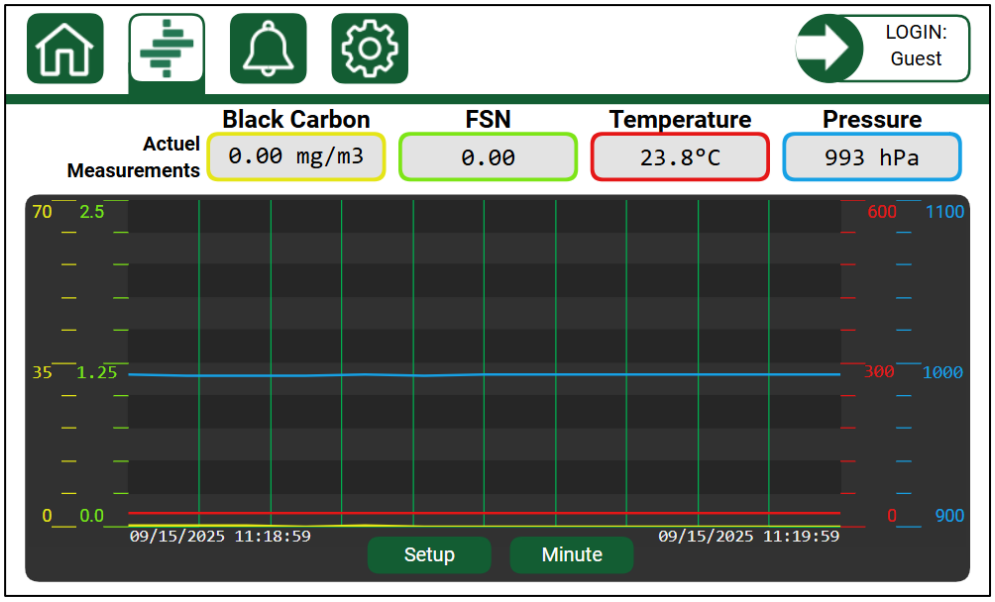


Figure 3-4, Measurements Page

3.5 Alarm Page

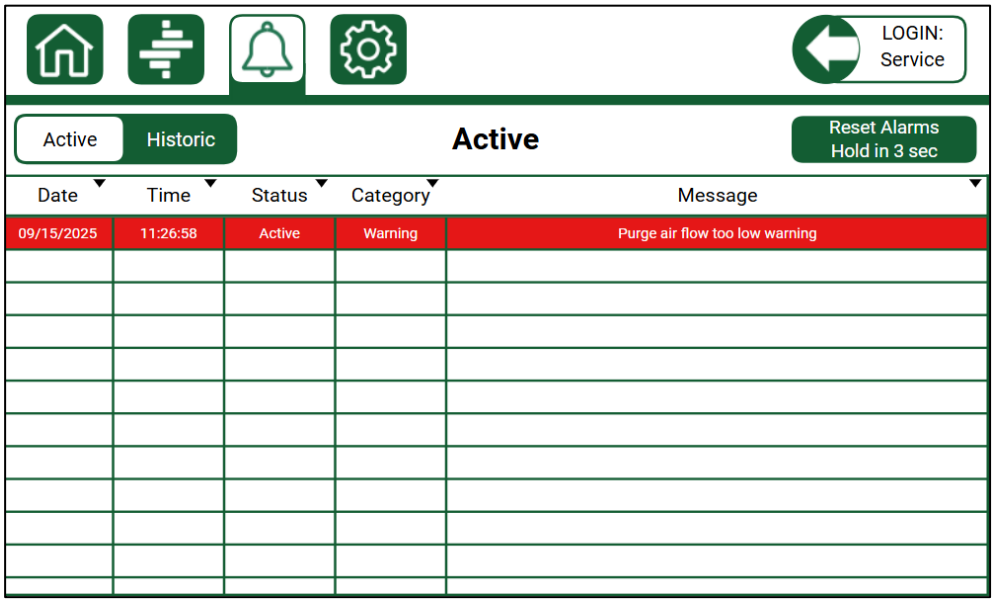


Figure 3-5, Alarm Page

On the **Alarm** page you can view both active and passed alarms.

- Red indicates an active alarm/warning.
- Green indicates that the criterion for an alarm or warning is not being met anymore.
- To switch between the **Active** and **Historic** view, use the button in the top left corner.
- To perform a system reset for active alarms or warnings, tap the Reset Alarms button in the top right corner for 3 seconds.
- To sort and filter alarms, tap the black arrow on the header of the relevant column.

3.6 Settings Page

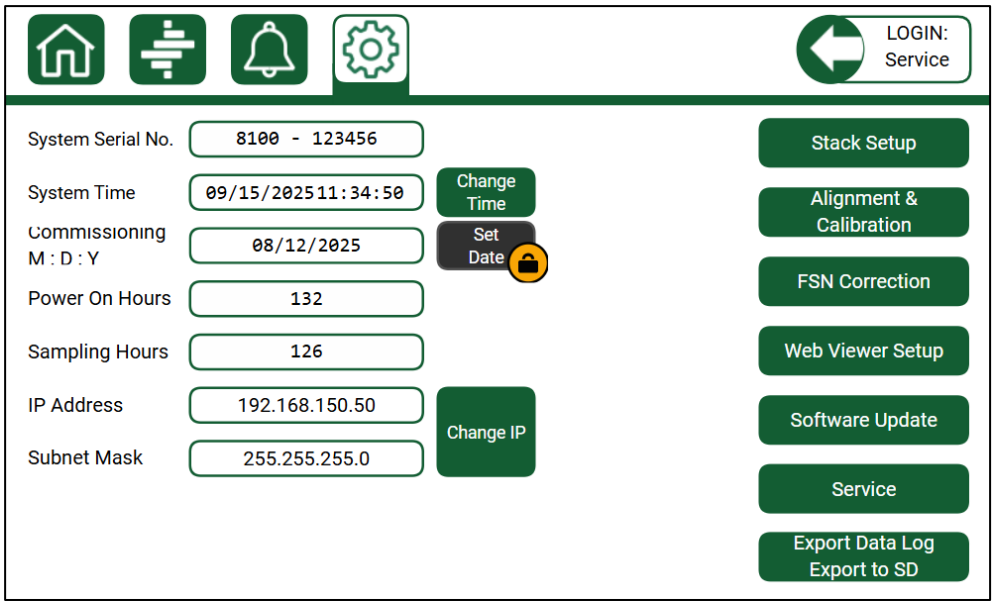


Figure 3-6, Settings Page

You must have **Service** access level to access the **Settings** page. The page displays relevant system information and enables you to edit system settings and update software. On the **Settings** page, you can do the following:

- View system serial number
- View and change system time and date
- View and set the commissioning date. When the date is set, Admin access is required to change it.
- Monitor how many hours the system has been powered on and total hours of sampling.
- View and change the system IP address and Subnet Mask.
- Update software and see software revisions
- Perform calibration and activate alignment mode.
- Configure Web Viewer
- View Service information
- Export data

3.6.1 FSN Correction

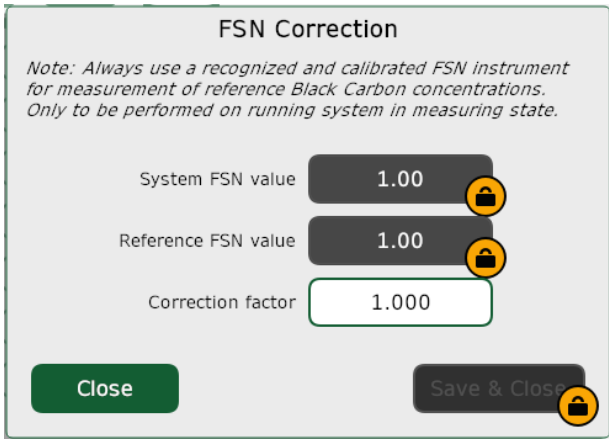


Figure 3-7, FSN correlation window

In this menu, it is possible to adjust the G8100 Black Carbon Monitoring System using a calibrated reference FSN instrument. If the G8100 Black Carbon Monitoring System and the reference FSN instrument do not conclude to the same measured value in FSN, both values can be entered into the input fields, and a correction factor will be applied to the G8100 FSN calculation.

The G8100 Black Carbon Monitoring System is proven to measure in correlation with FSN instruments, so trends from each will be parallel. The operating context of the G8100 Black Carbon Monitoring System impacts the measured value and may cause this to be higher or lower than a value from an external FSN measuring instrument. Therefore, for your convenience, you can adjust the values so the FSN number shown on the HMI is equivalent to values from an external FSN device.

ATTENTION

Admin login is required to utilize FSN Correction feature.

3.6.2 Software Update

1. Copy the HMI software files received from Green Instruments onto an empty USB stick.
2. Copy the PLC software files received from Green Instruments onto an empty SD memory card.
3. Go to the system **Settings Page**, tap the Software Update button. Perform the steps in the order specified in the window and follow the on-screen instructions.

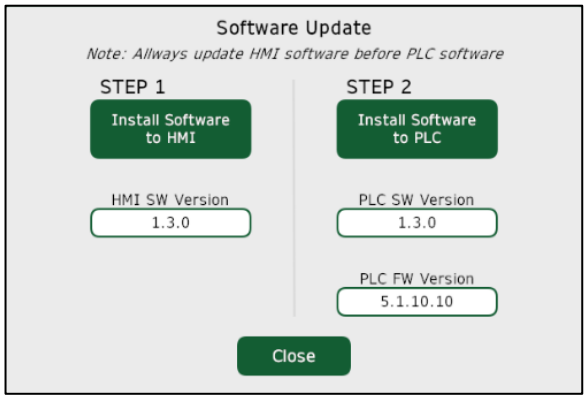


Figure 3-8, Software Update

Figure 3-9, Software Update Step 1 - HMI

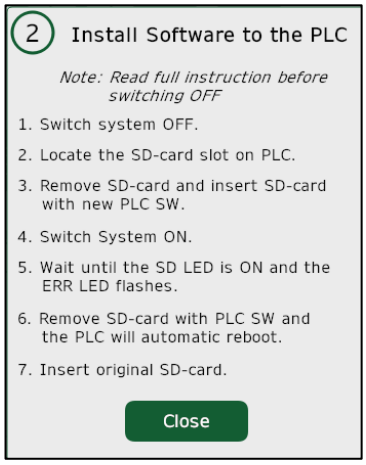


Figure 3-10, Software Update Step 2 - PLC

3.6.3 Service Info

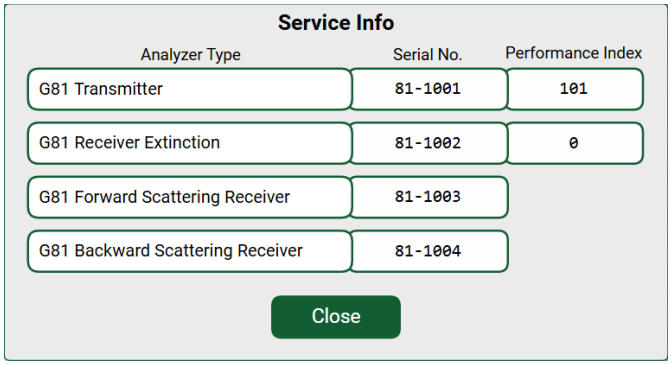


Figure 3-11, Service Information

In the Service Info window, you can view the following information:

- The available modules
- The serial number of each module
- The Performance Index of G8100 Transmitter and G8100 Receiver Extinction.
- The transmitter's performance index is a quantitative measure of the lifetime.
  0%: transmitter is obsolete; 0% lifetime remaining.
  100%: new transmitter or in perfect conditions.
- The receiver module's performance index shows the signal strength:
  0%: complete loss of signal; the receiver captures no light.
  100%: no contamination and/or perfect alignment.

NOTE: We recommend that you have this information ready if you contact Green Instruments' Service for support or system troubleshooting.

3.6.4 Log and Data Export

All measurement data and relevant system data are being logged and saved on an SD card located on the PLC in the cabinet, every 24 hours.

- To export the latest data to the SD card, tap the **Export Data Log** button on the **Settings** page. If no SD card is inserted, this is written on the button.

The data on the SD card is saved in csv format.

4. Installation

WARNING/ATTENTION

Faulty operation/system failure hazard

Read this section carefully as it contains critical information regarding the installation of the system. Incorrect or improper installation can lead to system failure or faulty operation. Missing to comply with the installation requirements can result in personal injury and/or damage to equipment and will render the warranty void.

Follow the instructions and comply with the requirements stated in Chapter 2 and throughout this manual and consult the relevant technical documentation to ensure correct installation.

- Ensure the correct connection of power, signal cables, and air connections before operating the system.

WARNING

Electric shock hazard

Review the electrical drawings for the system before proceeding with the electrical installation.

4.1 Terminals, Cables, and Wires Marking

Cable types for each system are clearly defined in the electrical drawings. Make sure that you comply with the specification and best practice for the installation of cables. All terminals, cables and wires are marked with a unique number in accordance with the electrical documentation.

4.2 General

To avoid possible damage to the equipment or errors in the monitoring readings and alarm function, it is important to observe the following points carefully:

- The system is not to be used without purge air. Doing so might result in monitoring errors or equipment failure.
- The transmitter and receiver modules must be placed in areas with low vibration and with ambient temperatures below 55°C. The location must be suitable for servicing the system.
- The transceiver and reflector with air modules are screwed on the welding sockets welded to the gas uptake in the selected location. The transceiver and reflector must be properly aligned and mounted firmly and stable direct opposite each other. Take consideration of the minimum distance between any walls or construction elements to the cabinet. Please refer to the system installation layout in the technical drawings to see the allowed minimum distance.

4.3 Choosing a Suitable Location

4.3.1 Modules - on-stack

When choosing a suitable location to install the G8100 Black Carbon Monitoring System, consider the following.

ATTENTION

The G8100 Black Carbon Monitoring System will not measure correctly in wet gases. Therefore, the system must be installed in a section on the stack where the flue gas is always dry.

- Choose a location that is indoors where the system is protected from the weather.
- Choose a location in which condensation, aerosols or droplets are not present.
- In the case of a wet scrubber: the G8100 system must be installed upstream from the scrubber where the flue gas is still hot and dry.
- Choose a location in which the exhaust gas is homogenously mixed for best measurement performance.
- The system must be installed on a section of the stack where ambient light inside the stack is not reaching, as this will affect the measurement. Choose a location upstream from any equipment that blocks ambient light from reaching the measuring path, such as a scrubber, economizer etc.
- Choose a location where it is possible to access the modules for maintenance.

4.3.2 Control and Monitoring Unit

When choosing a suitable location to install the control and monitoring unit, consider the following.

- The control and monitoring unit must be easily accessible and at a comfortable height to interact easily with the HMI.
- G8100 is delivered with 15m cable and air hose between the control and monitoring unit and the on-stack modules. Install the unit close to the on-stack modules without compromising the accessibility of the HMI.

4.4 Control and Monitoring Unit

The control and monitoring unit must be installed according to the technical drawings. It must be accessible for operators to work with it.

Once the cabinet is fixed on its definitive placement, the compressed air supply must be connected to a filter regulator situated on the right side of the cabinet. A flow transmitter monitors the air flow during the operation of the G8100 Black Carbon Monitoring System and triggers an alarm in case this changes. The filter regulator enables operators to adjust the air flow, to set the level required, as specified on the HMI.

4.5 Electrical Connections

ATTENTION

You must consult the installation layout drawing before installing the G8100 Black Carbon Monitoring System. Before connecting the external power supply to the system, make sure that it complies with the power supply rating.

Cable types for each system are clearly defined in the electrical drawings. Make sure that you comply with the specification and best practice for the installation of cables. All terminals, cables and wires are marked with a unique number in accordance with the electrical documentation.

4.6 Welding brackets

4.6.1 Placement

To achieve optimal system performance, it is important when installing the welding brackets on the stack that they are all placed in the same plane in relation to each other and on the correct angle; 90º in regards to the stack, as shown on Figure 4-2. You will need the perforated metal strip to help you align the welding brackets.

Step 1:

Cut out a section of the stack insulation all around the stack to expose the stack wall. It is necessary to make a cut out all the way around to make the correct layout and installation of the welding brackets.

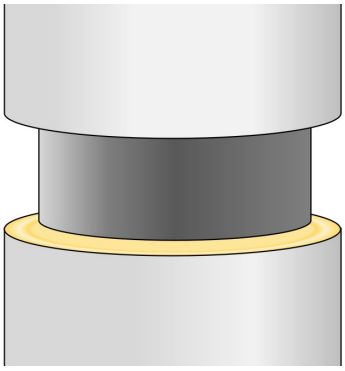


Figure 4-1, Stack insulation removal

Step 2:

Wrap the perforated metal strip (provided in the installation kit) around the stack and tighten it using a bolt and a nut as shown in the illustration below. The metal strip should be placed as close as possible to 90 º in relation to the stack.

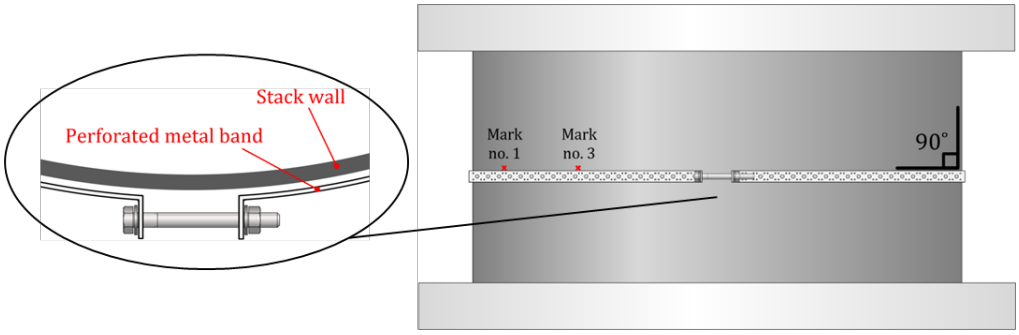


Figure 4-2, Metal strip allocation

Step 3:

Make mark no. 1 and mark no. 2 precisely opposite each other over the perforated metal strip which works as a guide so that all marks are in the same plane. Calculate the distance between the marks by dividing the stack's outer circumference by 2.

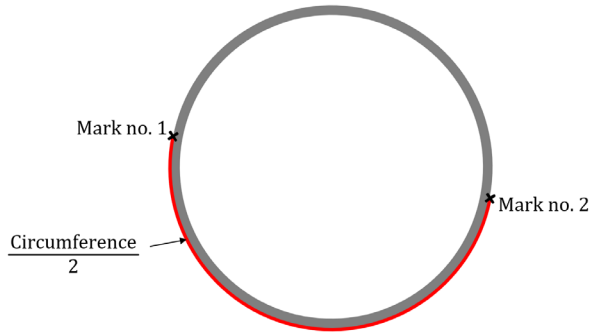


Figure 4-3, Setting marks 1 and 2 for modules placement

Step 4:

Proceed to indicate marks 3 and 4. The arc distance between mark 1 and 3 and mark 2 and 4 as shown in the illustration below, is calculated using the following formula:

C = Circumference

$$\text{Arc distance} = \text{C} * \frac{22{,}5}{360}$$

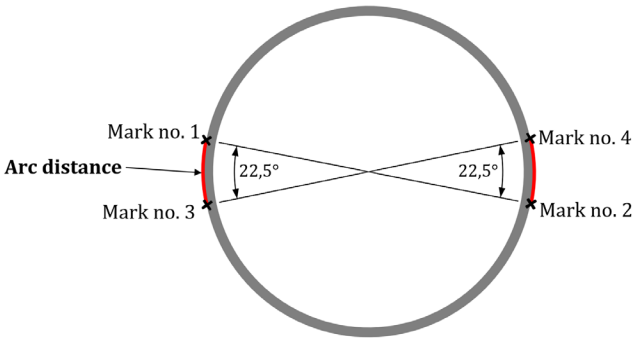


Figure 4-4, Cross-stack modules placement

Step 5:

Remove the perforated metal strip and use a Ø62mm hole saw to make the holes the final size to accommodate the welding brackets.

ATTENTION

Be careful not to drop anything inside the stack as it may cause damage to the engine.

4.6.2 Alignment

When installing the welding brackets, it is important that they are properly aligned for the system to perform correctly. To achieve a good alignment, the best way is to use a pipe of 52mm outer diameter, as shown in Figure 4-7. The pipe will keep the welding brackets aligned and make it easier to adjust the correct insert length in the stack.

Step 1:

A.

Insert the welding brackets into the pre-drilled holes. Once positioned in the stack, rotate them so that one hole is aligned above and the other below along the vertical axis, as shown underneath.

B.

The welding brackets must be inserted in the stack at a length of 10% of the stack diameter as shown in the following illustration. If the diameter (Di) is unknown and cannot be easily measured, you can calculate with the following formula:

π = 3,14159

$$Di = \frac{C}{\pi}$$

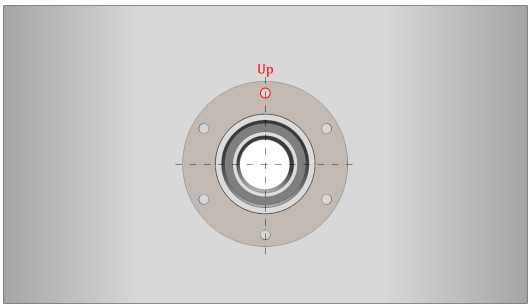


Figure 4-5, Flange alignment on stack

A.

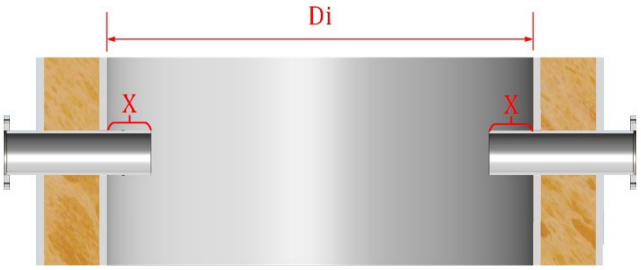


Figure 4-6, Insert length of welding brackets into stack

B.

Step 2:

If possible, use a 52mm pipe to align two opposite welding brackets. This will ensure proper alignment while welding them to the stack.

If there is not enough room for the alignment pipe, jump to step 3.

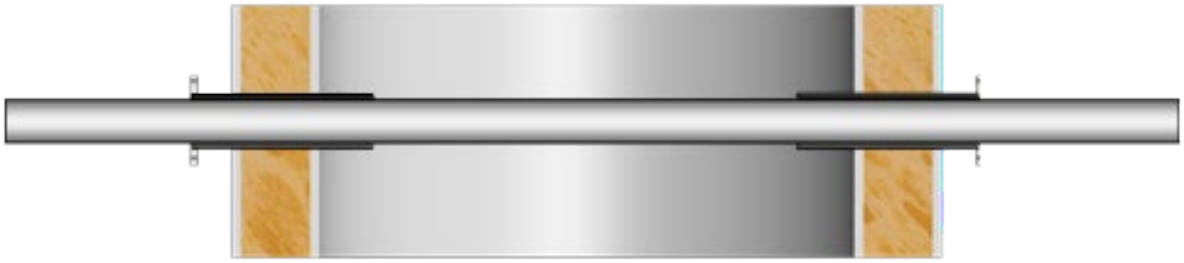


Figure 4-7, Opposite welding bracket alignment

Step 3:

If there is not enough room at the installation site to use a pipe during installation, it is possible to align the welding brackets by eye. The illustration below illustrates how a bad alignment looks like, compared to a good alignment when looking through both welding brackets.

A.

Align each welding bracket with its opposite one through the hole. All welding brackets should result in being at a 90 degrees angle to the stack. To ensure the correct alignment, look through them and see the opposite welding bracket centered in this view.

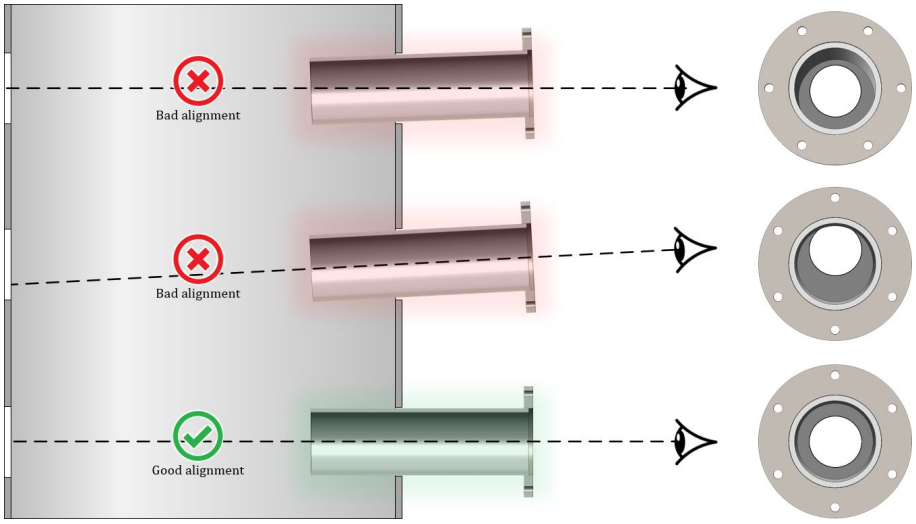


Figure 4-8, welding bracket alignment by eye

B.

Align second welding bracket with first welding flange

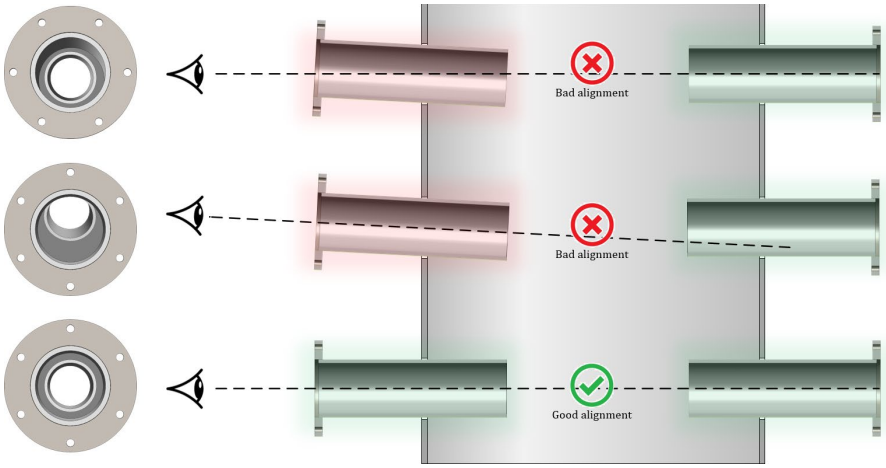


Figure 4-9, Opposite welding bracket alignment by eye

4.7 Air module

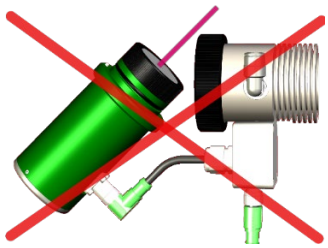
Alignment of the air module assembly is the final step of the alignment process and is used for finetuning and rectifying small misalignments of the welding brackets.

There are 6 bolts used on the flanged connection between the air module assembly and the welding bracket. 3 of the 6 bolts are mounted with disk spring washers stacked opposite each other and are used for alignment. The remaining 3 bolts together with locknuts between the brackets are used to lock the air module in position when the alignment is finished.

WARNING

Class 3B Laser! – risk of permanent eye damage:

NEVER connect power to modules without being inserted into air module!



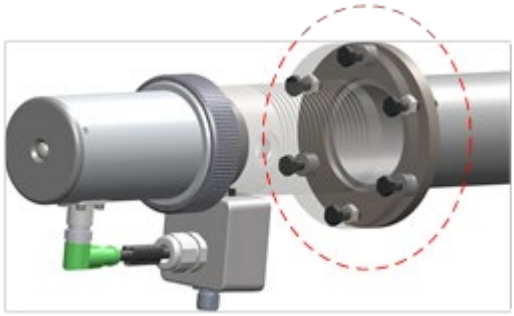


Figure 4-10, Adjustment assembly

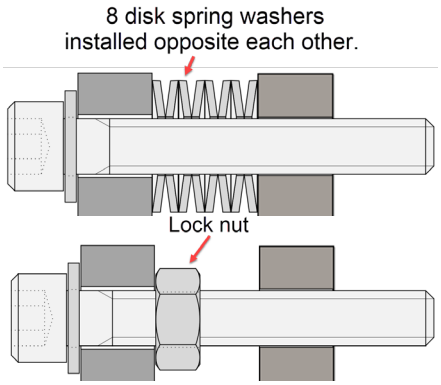


Figure 4-11, Spring washer and lock nut side view

4.7.1 One module setup example

1. Start by installing all four air modules loosely on the welding brackets.
2. Insert and connect the transmitter, receivers and alignment tool in the order as shown in the illustration below and enable the alignment mode on the setting page on the HMI, which will turn on the laser in the transmitter, so it is visible on the target area of the alignment tool.

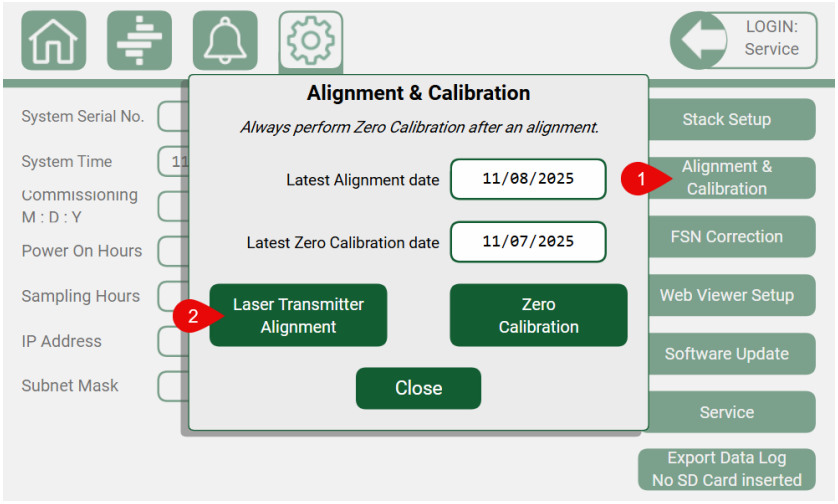


Figure 4-12, Transmitter alignment in HMI

ATTENTION

The red dot on the target area can be hard to see in bright ambient conditions. If this is the case, create a shadow over the alignment tool which makes the red dot more visible.

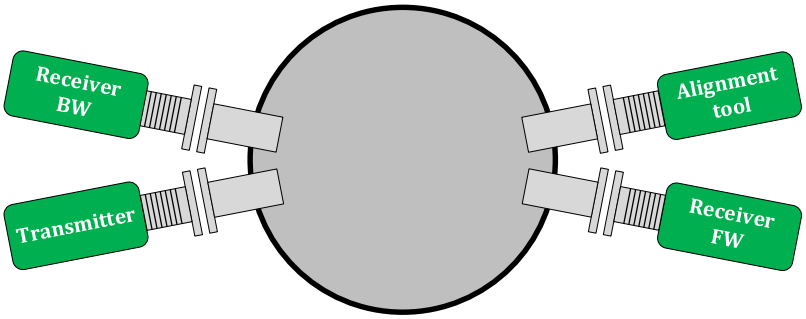


Figure 4-13, Alignment start setup

3. If the red dot is not in the center of the target area, adjust the 3 spring-loaded bolts on the transmitter side until the red dot is within the acceptable target area on the alignment tool as shown below.

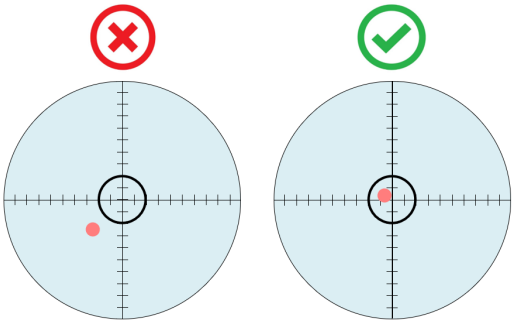
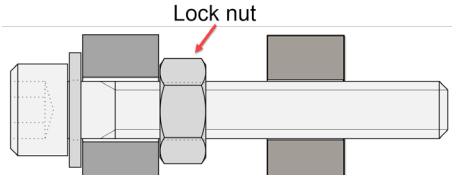


Figure 4-14, Laser alignment on target area

4.7.2 All modules setup

Now repeat the alignment process for all four air modules as shown in the illustration below.

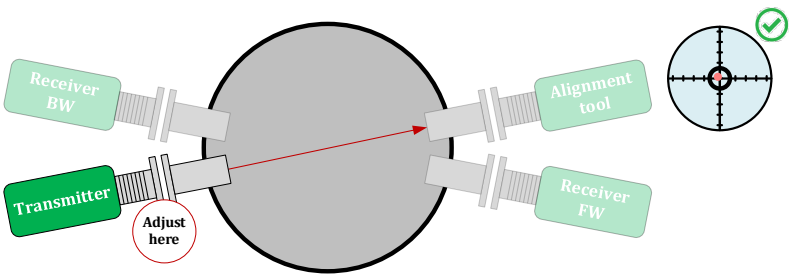
As the transmitter is adjusted, the bracket bolts must be fixed with nuts to lock the alignment in place. Be careful not to affect the alignment when tightening the bolts and lock nuts.



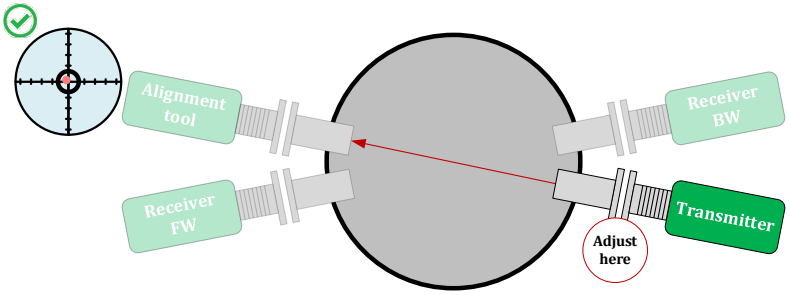
ATTENTION

It is recommended to follow the placement of the modules as shown in this manual, to obtain a result that is reflected in the HMI. This will make it easier to reference the modules shown on the HMI to the modules installed on the stack, as they will be placed in the same way.

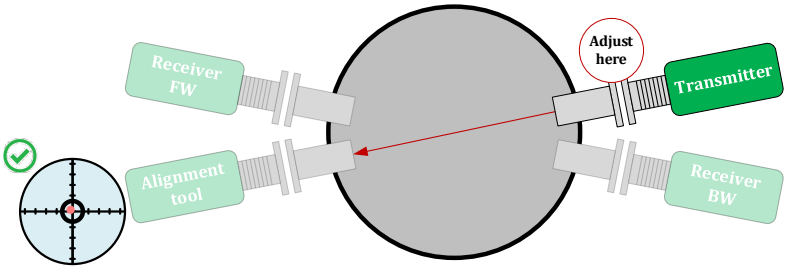
First module alignment



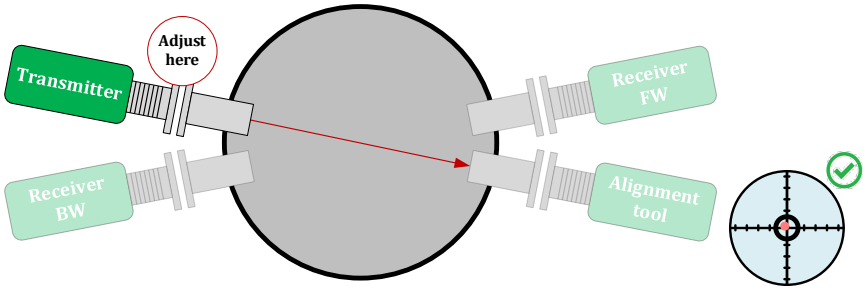
Second module alignment



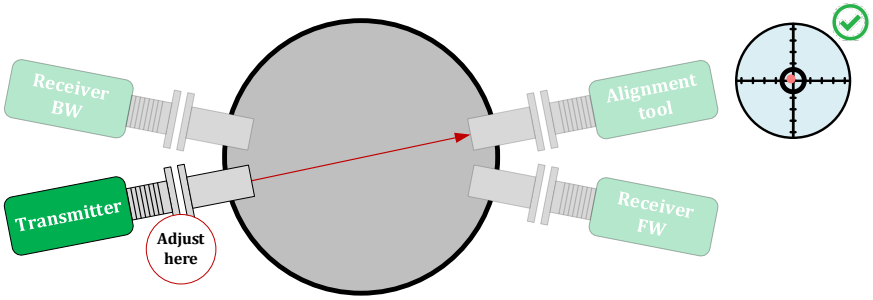
Third module alignment



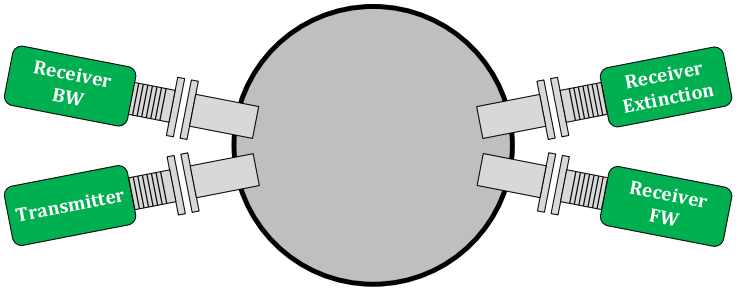
Fourth module alignment



Finetuning of transmitter alignment



Final result



To close the gap between the two brackets, first wrap the provided aluminum tape around the brackets, second wrap the provided glass fiber yarn around the aluminum tape. Finish off by installing the metal power clamp to strengthen the connection.

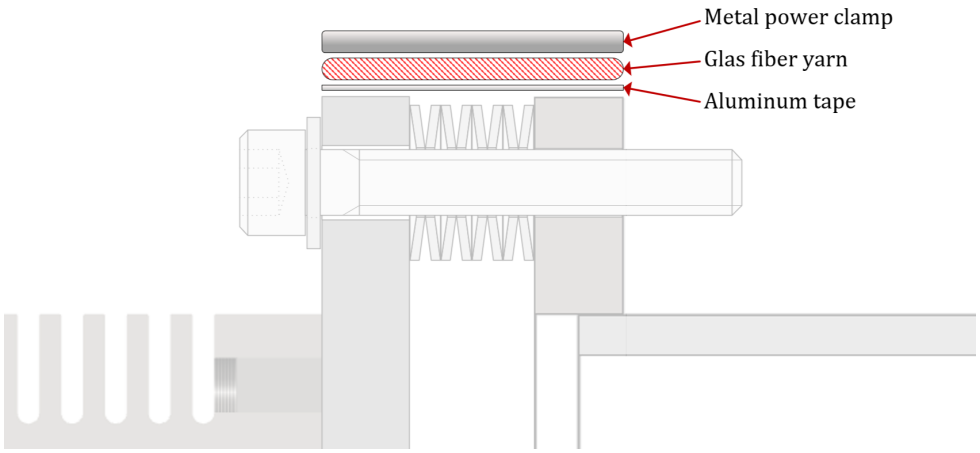


Figure 4-15, Bracket gap sealing

4.8 Purge Air System

Purge air is a crucial part of the G8100 Black Carbon Monitoring System and serves two main purposes. It ensures that flue gas does not reach the optical windows on the modules, preventing contamination. It keeps the modules from overheating by cooling the air modules and welding brackets. Because of this, it is very important that the transmitter and receiver modules always have sufficient supply of purge air. If the modules lose purge air, they can be damaged or contaminated.

The purge air flow is regulated on the adjustment screw on the filter regulator, which is located on the side of the control and monitoring unit together with a flow transmitter that continuously monitors the flow. The system will alert the user if the flow is under or over the set optimal limits.

The filter regulator contains two filters that are very important in assuring sufficient purge air quality. These filters must be changed regularly. Find suggested intervals in the planned maintenance program.

Installation steps:

1. Install the purge air distribution manifold on the stack close to the air modules.
2. Install air hoses between all four air modules and the distribution manifold.

ATTENTION

Make sure that there are no kinks, bends or other restrictions in any of the hoses, as this will prevent sufficient purge air reaching the module which will cause damage to the system.

It is recommended that the purge air hoses are the same length to have equivalent pressure conditions.

3. Install purge air between the control and monitoring unit and the distribution manifold.
4. Connect instrument air to the filter regulator and adjust the purge air flow to 160 l/min.

4.9 Communication

G8100 Black Carbon Monitoring System communication is available via a Modbus TCP/IP communication line, where it acts as a client device.

- The system IP address can be configured from the settings page on the HMI.
- The default system IP address is: 192.168.1.10.

Note: When setting up the connection to the G8100 Black Carbon Monitoring System, make sure to establish an internet connection to the Control and Monitoring unit. This will enable a remote connection by Green Instruments A/S to assist you in case issues with the G8100 Black Carbon Monitoring System should arise.

4.9.1 Modbus Map

The following table shows details, values, and the Modbus addresses to access specific parameters.

Beware of the following:

- Only Modbus holding registers are used. The first holding register is address 0.
- Type: *Bit arrays* hold registers where individual bits are named with a function description. When a bit is 1 (true), the function is active.
- Type: *Real* uses two Modbus holding registers. Format is little-endian byte swap.

Address (Holding register Function code 03)	Name	Function Description	Type (Read/Write)	Range or Unit
Measurements				
50	Black Carbon		Real (Read)	mg/m3
52	FSN		Real (Read)	-
54	Ambient temperature		Real (Read)	C°
56	Exhaust gas temperature		Real (Read)	C°
58	Exhaust gas pressure		Real (Read)	mbar
60	Purge air flow		Real (Read)	l/min
62	FSN Corrected		Real (Read)	-
64-68	Reserved			
System Info				
70	System State	0 = Initialization 1 = Check 2 = Measure 3 = Calculation 4 = Alignment mode 5 = Error 6 = Calibration 7 = Reserved 8 = Reserved 9 = System common alarm 10 = System common warning	Bit array. Active high (Read)	

Address (Holding register Function code 03)	Name	Function Description	Type (Read/Write)	Range or Unit
41	System alarms	0 = Ambient temperature high 1 = Ambient temperature no connection 2 = Exhaust temperature no connection 3 = Exhaust pressure no connection 4 = Purge air flow low 5 = Purge air flow high 6 = No measurement from modules received 7 = Transmitter module error 8 = Receiver Extinction error 9 = Receiver FW error 10 = Receiver BW error 11 = Transmitter communication error 12 = Receiver Extinction communication error 13 = Receiver FW communication error 14 = Receiver BW communication error	Bit array. Active high (Read)	
42	System warnings	0 = Ambient temperature high 1 = Purge air flow low 2 = Purge air flow high 3 = Transmitter temperature high 4 = Receiver Extinction temperature high 5 = Receiver FW temperature high 6 = Receiver BW temperature high	Bit array. Active high (Read)	

4.9.2 Web Viewer (VNC)

The web viewer function is available by default from the G8100 Black Carbon Monitoring System and enables you to access and control the HMI via a web browser when you are on the same network.

ATTENTION

For some actions you must by located physically in front of the system. When using remote control, always proceed with caution.

Web Viewer Setup

1. Connect a network to the remote connection port. Consult the electrical documentation to see the location of the port.

2. On the **Settings** page, tap the **Web Viewer** button. The **Configuration** page opens.

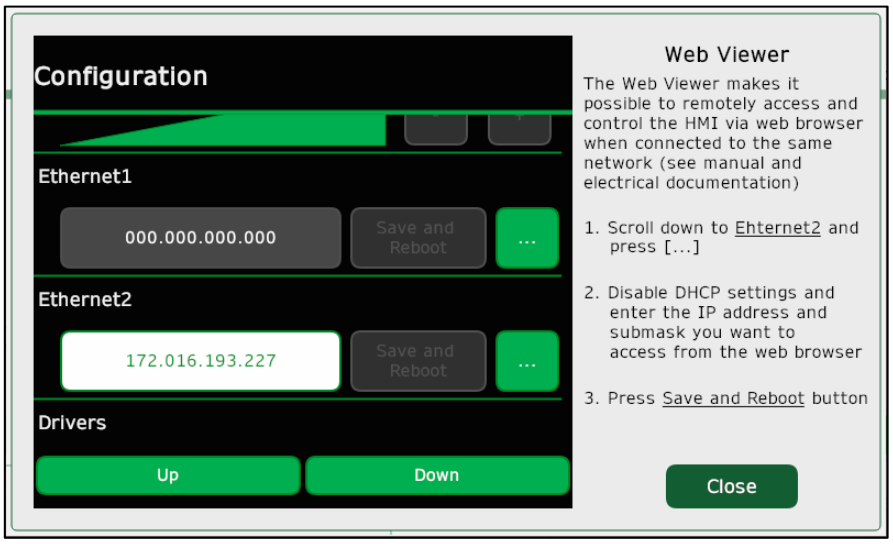


Figure 4-16, Web Viewer Configuration

3. Use the **Up** or **Down** buttons to navigate to Ethernet 2, and then tap the ellipsis button (...).
4. Under **DHCP settings**, make sure DHCP is **disabled**, and then enter the relevant IP address and subnet mask.

   As default the following web viewer configuration can be used:

   -IP address: 192.168.050.100

   -Subnet mask: 255.255.255.000

   -Port number: 8082

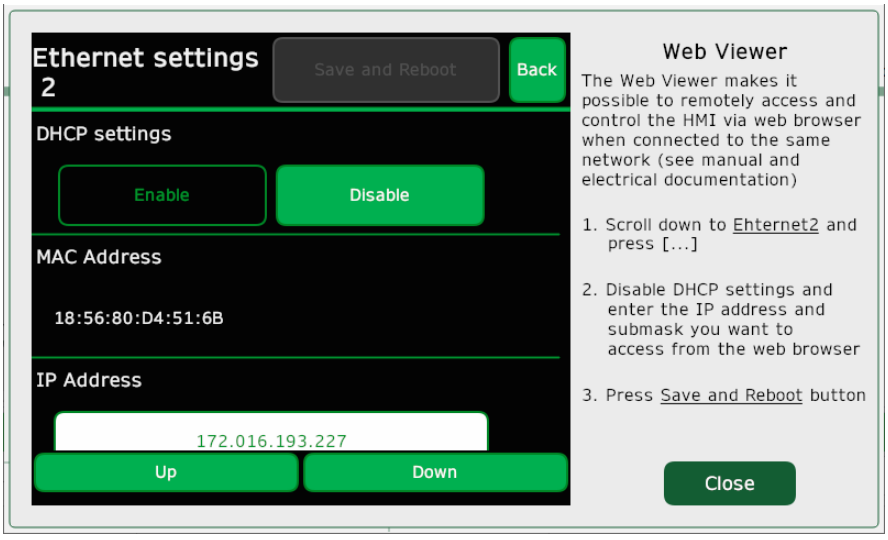


Figure 4-17, Web Viewer Configuration IP

5. Tap the **Save and Reboot** button. The HMI reboots with the updated configuration.
6. On your computer, enter the following in the address bar in a web browser:
   "Ethernet 2 HMI IP-address" + ":port number" + "Webviewer/index.html"
   Example: 192.168.50.100:8082/webviewer/index.html

When the connection is successful, a login window appears in the browser.

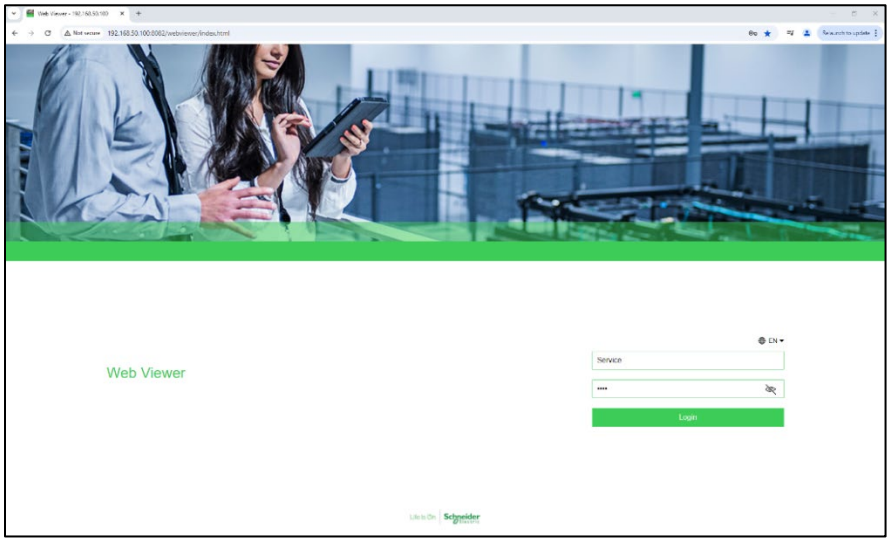


Figure 4-18, Web Viewer Login Window

7. You must login with Service username and password. See 3.2 Security and Login.
   When the login is successful, you will see the G8100 Black Carbon Monitoring System HMI in the browser window.
8. In the green menu bar, click the **Operation** icon in the upper left corner to switch to Operation mode.
   You can now operate the HMI with your mouse from the browser.
9. To end the Web Viewer session, log out, or close the browser.

4.9.3 Remote Connection

ATTENTION

The G8100 Black Carbon Monitoring System allows remote support if an internet connection is established in accordance with the electrical documentation.

When established, this connection allows Green Instruments technicians and programmers to remotely monitor, diagnose, control, and program the system if needed. Remote access is achieved by means of a secure, point-to-point connection. Access to this connection is strictly controlled and all data that is sent and received is encrypted.

The following outbound rules must be granted to the remote connection:

- TLS through Web proxy (TLS to remote IP address and port of Web proxy)
- HTTPS (HTTP over TLS) to remote IP address of GateManager, remote port 443
- TLS over HTTP to remote IP address of GateManager, remote port 80

4.10 Commissioning

ATTENTION

After completing the system installation, verify the setup by ensuring all connections are made according to the installation instructions. Review the relevant section in this manual for the unit you need to verify. Note that the commissioning checklist is not exhaustive as it only lists the typical acceptance criteria.

4.10.1 Check System Installation

ATTENTION

Check the following:

- The system has been installed in accordance with the instructions. There is sufficient space for operation, maintenance and door opening.
- The system is in a location where the ambient temperature is always between 5–55° C.
- The electrical connections have been made in accordance with the instructions.
- Protective earth is connected.
- The communication connections that have been made are in accordance with the instructions and the functions have been tested.
- The purge air supply is installed, and the air quality is in accordance with ISO 8573-1 Class 3-3-3 or better.
- The system powers up and starts properly without any alarms or warnings.

4.10.2 Commissioning Checklist

Signature by Installation Contractor: The installation contractor must sign the commissioning checklist once all checks have been completed.

Submission to Green Instruments A/S

A scanned copy of the commissioning checklist along with the results and any remarks must be sent to Green Instruments A/S.

NOTE: The commissioning checklist is also included in the documentation package so that you can easily copy and scan it.

- Send the scanned document to: service@greeninstruments.com
- Add the following information in the subject field: *G8100 checklist, IMO no., System Serial no.*

Action	Observed criteria	Evaluation	Note
Install G8100 Black Carbon Monitoring System.	▪ Stabile/no vibrations. ▪ Ambient temp. is OK. ▪ Well-ventilated area. ▪ Free space for operators, door opening, and ventilation flow. ▪ Installation layout drawing has been consulted.	☐ Accepted ☐ Not accepted ☐ Not done	See chapter 4 Installation
Connect purge air supply to filter regulator.	▪ Set flow to 160 l/min ▪ Air quality must be according to specifications.	☐ Accepted ☐ Not accepted ☐ Not done	See chapter 4 Installation
Install purge air hoses.	▪ Hoses are without kinks, bends or other restrictions. ▪ Hoses length is the same.	☐ Accepted ☐ Not accepted ☐ Not done	See chapter 4 Installation.

Action	Observed criteria	Evaluation	Note
Connect power cable to G8100 cabinet.	▪ Power voltage has been verified with multimeter. ▪ Power is ready to be switched on.	☐ Accepted ☐ Not accepted ☐ Not done	See chapter 4 Installation.
Connect ethernet cable to the G8100 cabinet.	▪ IP address has been configured. ▪ Connection has been tested with a cable tester or by “pinging” system.	☐ Accepted ☐ Not accepted ☐ Not done	See chapter 4 Installation.
Connect ethernet cable to cabinet for remote connection. Failing to do so will result in restricted remote suppport.	▪ IP address has been configured. ▪ Connection has been tested with a cable tester or by “pinging” system. ▪ Internet connection is available and relevant outbound rules are granted for remote connection. ▪ For service reasons it is mandatory to establish this communication line.	☐ Accepted ☐ Not accepted ☐ Not done	See chapter 4 Installation.
Implement communication protocol via MODBUS TCP/IP.	Verify that all functions have been implemented by performing a test.	☐ Accepted ☐ Not accepted ☐ Not done	See section 4.9 Communication
Configure HMI	▪ Commissioning date is set. ▪ Inside stack diameter is set. ▪ Alias for samples are defined. ▪ Check that date and time corresponds to UTC. ▪ Check that IP-address is configured.	☐ Accepted ☐ Not accepted ☐ Not done	See chapter 3 HMI Structure.
Alignment and Zero Calibration	▪ Alignment procedure has been performed. ▪ Zero calibration has been performed after alignment.	☐ Accepted ☐ Not accepted ☐ Not done	See chapter 4 Installation. See chapter 3 HMI Structure.
G8100 system serial number.			
Installation contractor.			
Ship name / hull no./ IMO no.			
Ship owner.			
Checks performed by (date / sign)			
Checks verified by (date / sign)			

5. Operation

5.1 Normal Operation

After being turned on, the G8100 Black Carbon Monitoring System automatically assumes measuring mode and the observed values are displayed on the Home Page and available via Modbus.

The system can be on different modes:

- Measure: the system is operating and alternates between retrieving measured values and calculating the data. Under this mode, the system automatically compensates for the temperature and pressure swings inside the stack. The transmitter and receivers' LED will shine blue while measuring.
- Alignment: at installation and over time, the system setup needs to be aligned. You can access alignment mode through the Settings Page on the HMI, where you can activate it as well as end it once all the modules are aligned. The modules LED will shine blue while aligning.
- Error: when the system recognizes an issue that affects its ability to measure, it will show it by entering "Error mode". The modules LED will shine red while on error.
- Calibration: a zero calibration might be needed to adjust the measured values correctly over time. Go to section Calibration for more information.

ATTENTION

The integrity of the G8100 Black Carbon Monitoring System is conditioned by the supply of compressed air. This will prevent the lenses from contamination and direct damage, which will enable the system to measure more accurately and protect product lifetime.

5.2 G8100 Modules State LED

LED color	Behavior	Meaning	Laser ON / OFF
Green	Flashing	Start-up	Laser OFF
	Constant	Ready	Laser OFF
Blue	Flashing	Alignment Mode	Laser ON
	Constant	Sampling	Laser ON
Red	Flashing	Module Error	Laser OFF
	Constant	System Error	Laser OFF

ATTENTION

When LED is blue, the system is measuring, and the laser beam is on. Extreme precautions to avoid eye damage.

Any service or operation on the modules must be done after the power is cut off by unscrewing one of the modules' power supply.

6. Calibration

It is possible to perform a zero calibration of the G8100 Black Carbon Monitoring System if the measurements are no longer reaching zero when the engine is turned off.

ATTENTION

When performing a zero calibration it is important that the stack is completely empty of any flue gas and particles. It can take several hours for the reading to reach zero, as all the flue gas inside the stack must be evacuated and replaced by ambient air.

It may be necessary to wait for the stack to cool down to ambient temperatures before performing a zero calibration. Any flue gas or particles present while performing zero calibration will result in a measurement offset.

To perform a zero calibration, go to the Settings Page on the HMI and press the “Alignment & Calibration” button. Thereafter, press the “Zero Calibration” button and then press start. The calibration process will take approximately 1 min.

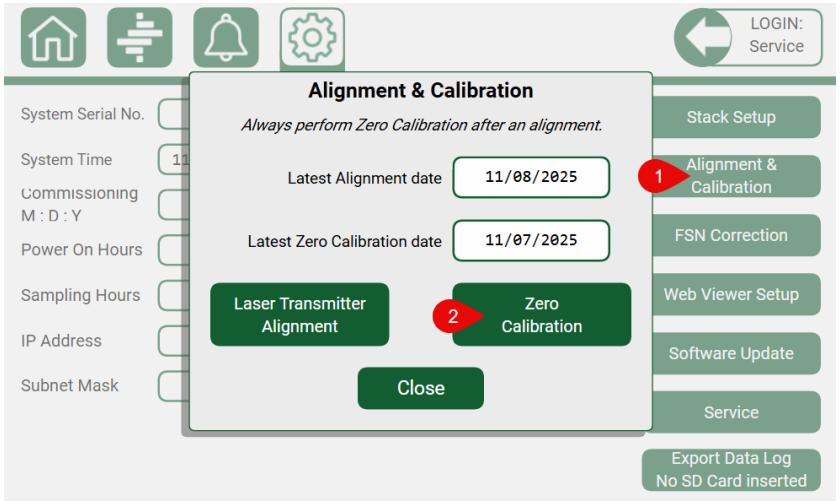


Figure 6-1, Zero calibration selection in HMI

7. Maintenance

7.1 Planned Maintenance Program

ATTENTION

The frequency of maintenance can vary depending on specific conditions. For example:

- The purge air supply is of a suboptimal quality.
- The system, spares, or components are not handled properly.
- Operation outside and near the system specification limits.

Action	When necessary	Every 14 days	Monthly	Every 2 months	Every 3 months	Every 6 months	Every 9 months	Every 12 months	Every 2 years	Maintenance Instruction
Zero calibration						X				Chapter 6
Alignment check	X					X				Section 4.7.2
Optical window replacement								X		MI-8100-0001
G8100 Transmitter module replacement									X	-
Filter elements replacement						X				MI-8100-0002
Filter bowl inspection		X								Section 7.2

7.2 Lifetime Considerations

Regardless of application, the lifetime can be reduced by various operational factors of which the most common are:

- Insufficient purge air flow.
- Exposure to liquids such as condensate, aerosols, acids, or similar.
- All mechanical forces including vibration, shock, drop, impact, and bends.
- Exposure to substances with content of organics with low boiling point, unburned fuel, lead, phosphorus, silicon, or halogens.
- Contaminants such as soot, dust, salt, ash, or similar deposits.
- Pressure including over- and under pressure and pulsations.
- Thermal stress due to temperature variations including power on/off cycles.
- Long-term storage of system or parts including storage when uninstalled or non-operational.

Furthermore, installation, operation, and maintenance must follow best practices and the latest version of the user manual and must respect the limitations of the product type approval. Failure to comply with service letters can also affect lifetime and warranty.

The information provided about the lifetime of the product shall in no case be interpreted as a guarantee of the product's condition or quality.

Filter bowl inspection

This procedure describes how to inspect the filter bowl in the purge air filter regulator and empty it from water if necessary. The operation must be carried out by a skilled technician.

1. Look at the filter bowl and verify that there is no water content.
2. If there is water, your supply of compressed air is contaminated and must be fixed.
3. High amount of water or debris will require a filter replacement, as described on maintenance instruction MI-8100-0002.

8. Services

With assistance from our global service network, we offer a wide range of customer services and support. To find out more about our service offerings, contact our service department at service@greeninstruments.com.

8.1 Spare Parts

Place your original spare parts order directly with Green Instruments. Our dedicated spare parts team ensures effective handling of your order, and we offer fast worldwide delivery to stock or directly to vessels. Contact spares@greeninstruments.com.

Sales No.	Description	QTY.
GI-G8100-105563	PLC	
GI-G8100-03221	DO Module - Relay	
GI-G8100-105564	4 Analog Input Module	
GI-G8100-103958	4 Analog Output Module	
GI-G8100-02237	24VDC Power Supply	

GI-G8100-105566	7" Touch Panel Display	
GI-G8100-105567	Safety Switch	
GI-G8100-105569	Filters for the Purge Air Regulator Assembly	
GI-G8100-105570	Flow Transmitter	
GI-G8100-105571	Temperature Transmitter	
GI-G8100-105572	Pressure Transmitter	
GI-G8100-105573	G81 Transmitter	
GI-G8100-105574	G81 Receiver Extinction	

GI-G8100-105575	G81 Receiver FW	
GI-G8100-105576	G81 Receiver BW	
GI-G8100-105579	G81 Alignment Module	
GI-G8100-105580	Filter Elements for filter regulator ■ 1 pc. 5 µm Filter Element ■ 1 pc. 0.1 µm Filter Element	
GI-G8100-105581	Replacement window kit ■ 4 pcs. Optical window ■ 4 pcs. O-ring ø46 x 1 ■ 4 pcs. O-ring 45 x 3.0	
GI-G8100-105582	Maintenance kit 1-year ■ 1pc. Optical window replacement kit ■ 2 pcs. Filter elements for filter regulator	

8.2 Commissioning

Our service team offers supervision of your Green Instruments equipment installation. We offer startup assistance, checkpoint functionality as well as surveyor assistance, sea trial support, and training of onboard crew before final delivery.

8.3 Field Service

Our skilled and certified service engineers offer the best service onboard and provide authorized service for installed Green Instruments equipment. Services include calibration, troubleshooting, inspections, technical advice, and maintenance.

8.4 Support

- Our skilled instructors facilitate training both online and in-person. Training is product specific and ensures that end users and onboard crew become familiar with system operation and maintenance in a controlled environment.
- We offer full technical support for all our products throughout their entire lifetime. Our dedicated experts provide 24-hour service support to ensure timely assistance.

8.4.3 Remote Support

The G8100 Black Carbon Monitoring System allows remote support if an internet connection is established in accordance with the electrical documentation.

When established, this connection allows Green Instruments technicians and programmers to remotely monitor, diagnose, control, and program the system if needed. Remote access is achieved by means of a secure, point-to-point connection. Access to this connection is strictly controlled and all data that is sent and received is encrypted.

The following outbound rules must be granted to the remote connection:

- TLS through Web proxy (TLS to remote IP address and port of Web proxy)
- HTTPS (HTTP over TLS) to remote IP address of GateManager, remote port 443
- TLS over HTTP to remote IP address of GateManager, remote port 80

8.5 Service Agreements

Our transparent service agreements are tailored to the needs of your organization and offer a predictable yearly cost. A service agreement includes relevant spare parts, training, as well as remote and onsite assistance.

8.6 Return of Equipment

You must contact Green Instruments to coordinate equipment return. You will then receive a Return Form that you must fill out and return along with the equipment.

Use a secure transport container suitable for the equipment that you are returning. Carefully clean the equipment prior to return to ensure that it is free of any hazardous substances (acids, alkalis, solvents, etc.).

IMPORTANT: Clearly mark the equipment with the system serial number and return confirmation number.

9. Troubleshooting

Troubleshooting must always be carried out by trained professional personnel. Follow the recommended actions for each issue in the listed prioritized order.

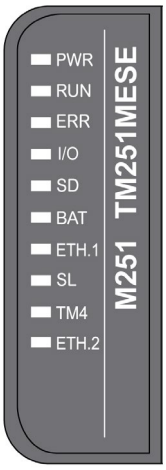
Issue	Possible Causes	Action
▪ Unrealistic black carbon value measured	▪ Replaceable optical module windows contaminated ▪ Misalignment	▪ Replace optical windows ▪ Check alignment
High temperature alarm/warning for: ▪ Transmitter ▪ Receivers	▪ Ambient temperature too high ▪ Loss of purge air	▪ Check/Reduce ambient temperature ▪ Check purge air flow and check if there are any restrictions in the air hoses to air modules.
Hardware error for: ▪ Transmitter ▪ Receivers	▪ An unexpected error has occurred inside a G8100 module.	▪ Contact Green Instruments
Ambient temperature too high	▪ Ambient temperature too high	▪ Reduce the ambient temperature
Ambient temperature signal alarm	▪ Wire brake or broken sensor ▪ Wire disconnected	▪ Replace sensor ▪ Reconnect wire
Purge air flow signal alarm	▪ Wire brake or broken sensor ▪ Wire disconnected	▪ Replace sensor ▪ Reconnect wire
Exhaust pressure signal alarm	▪ Wire brake or broken sensor ▪ Wire disconnected	▪ Replace sensor ▪ Reconnect wire
Exhaust temperature signal alarm	▪ Wire brake or broken sensor ▪ Wire disconnected	▪ Replace sensor ▪ Reconnect wire
Purge air flow too high alarm/warning	▪ Main air hose broken or disconnected ▪ Wrong flow adjustment	▪ Check all air hoses and connections. Check flow of air modules. ▪ Readjust flow
Purge air flow too low alarm/warning	▪ Clogged pressure regulator filters ▪ Purge air flow restricted due to air hose being blocked or kinked. ▪ Wrong flow adjustment	▪ Change filters ▪ Check all air hoses ▪ Readjust flow
No communication alarm for: ▪ Transmitter ▪ Receivers	▪ Power/signal cable to modules broken or disconnected	▪ Reestablish connection
Extinction Receiver no light received	▪ Modules are out of alignment ▪ Light path obstructed	▪ Check alignment ▪ Check for obstructions between transmitter and receiver extinction
No measurement data received from modules	▪ No communication to modules ▪ Defect module ▪ Highly misaligned ▪ Bad connections	▪ Power cycle system ▪ Check all connectors ▪ Check alignment
Laser Performance Index alarm (Laser lifetime warning)	▪ Limited lifetime remaining on the laser in the G8100 transmitter module	▪ Start making plans to replace the G8100 transmitter module

Issue	Possible Causes	Action
Laser Performance Index alarm (Laser lifetime alarm)	▪ Laser in G8100 transmitter soon to reach its end of life	▪ Replace the G8100 transmitter module as soon as possible
Unknown state ▪ Transmitter ▪ Receivers	▪ Unknown	▪ Power cycle system ▪ Contact Green Instruments
Modbus Initialization Error	▪ PLC modbus serial port error	▪ Power cycle system ▪ Replace PLC ▪ Contact Green Instruments
SD Error Warning	▪ SD card missing ▪ SD card defect	▪ Insert SD card ▪ Replace SD card

9.1 PLC error codes

The following figure shows the status LEDs. These indicators show the current status of the system.

9.1.1 System Status LEDs



Label	Function Type	Color	Status	Description
Label	Function Type	Color	Status	Description
			Off	Power is removed.
RUN	Machine status	Green	On	The controller is running a valid application.
			Flashing	The controller has a valid application that is stopped.
			1 flash	The controller has paused at BREAKPOINT.
			Off	The controller is not programmed
ERR	Internal Error	Red	On	An operating system error has been detected
			Fast flashing	The controller has detected an internal error

Label	Function Type	Color	Status	Description
			Slow flashing	A minor error has been detected if **RUN** is ON or that no application has been detected
I/O	I/O error	Red	On	Device errors on the serial line, SD card, TM4 bus, TM3 bus, Ethernet port(s) or CANopen port.
SD	SD card access	Green	On	The SD card is being accessed
BAT	Battery	Red	On	The battery needs to be replaced.
			Flashing	The battery charge is low.
ETH.1 ETH.2	Ethernet port status	Green	On	The Ethernet port is connected, and the IP address is defined.
			3 flashes	The Ethernet port is not connected.
			4 flashes	The IP address is already in use.
			5 flashes	The module is waiting for BOOTP or DHCP sequence.
			6 flashes	The configured IP address is not valid.
SL	Serial line	Green	On	Indicates the status of serial line.
			Off	No serial communication
TM4	Error on TM4 bus	Red	On	An error has been detected on the TM4 bus
			Off	No error has been detected on the TM4 bus

10. System Hibernation

In case the system is to be set off for a long interval of time, we recommend that you keep the following spare parts in stock:

- Optical windows for all modules
- Replacement filter elements for filter regulator

When the system is to be restarted, it is advised to perform a zero calibration of the system. Furthermore, it might be needed to replace the filter elements and four optical windows for each module.

ATTENTION

The zero calibration must be performed on a cold, shut down engine, where the air in the stack is free from exhaust gases and replaced by ambient air.

11. Maintenance Instructions

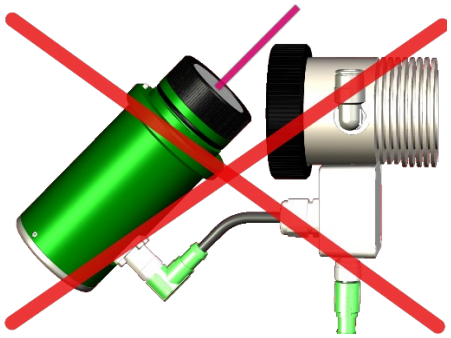
The following is a list of G8100 Maintenance Instructions (MI) available. For more information about the spare parts listed in the maintenance instructions, See the Spare Parts Catalog.

Number	Description
MI-8100-0001	Replacing optical windows
MI-8100-0002	Replacing instrument air filters

System type	G8100 Black Carbon Monitoring System	MI-8100-0001: Replacing optical windows
Description	This procedure describes how to replace the optical windows in the transmitter. The operation must be carried out by a skilled technician.	
Difficulty 1-5	**Overhaul interval**	**Estimated time**
	Every 12 months	10 min.
Spare parts		
▪ Part no.: GI-G8100-105581		

Procedure

WARNING



Class 3B Laser! – risk of permanent eye damage:

NEVER connect power to modules without being inserted into air module!

1. Unscrew power connection from the transmitter module.

1.

2. Unscrew the thread adaptor that unites the transmitter module with the air module.

2.

3. Take the transmitter from the air module.

3.

4. Unscrew the window thread adaptor from the top of the transmitter and set the new one on.

4.

ATTENTION

Avoid any dust or other particles setting on the module heads while replacing the optical windows.

5. Attach the transmitter to the air module and tighten the joining thread adaptor.

6. Reconnect the power supply.

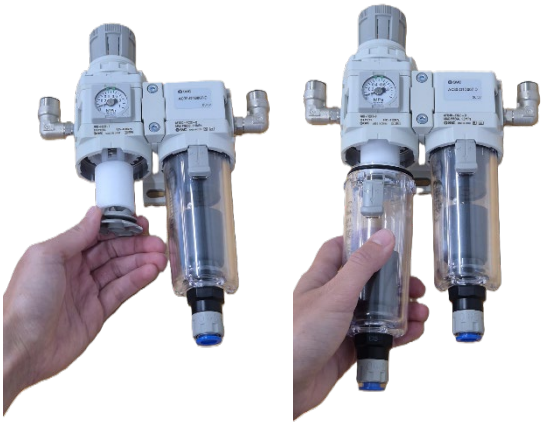
Repeat the procedure for all four modules.

System type	G8100 Black Carbon monitoring system	MI-8100-0002: Replacing instrument air filters
Description	This procedure describes how to replace the filter elements in the purge air filter regulator. The operation must be carried out by a skilled technician.	
Difficulty 1-5	**Overhaul interval**	**Estimated time**
🔧	Every 6 months	5 min.
Spare parts		
▪ GI-G8100-105580		
Procedure		

1. Disconnect the air supply and turn off the air flow on the instrument air filter by pulling the cap and twisting until air flow is zero. You can check the flow on the instrument as well as on the HMI screen.

2. Confirm that the unit has no pressure and then remove the first filter glass by sliding the security flap down and twisting it to the side.

3. Loosen the locking nut by half a turn and replace the filter element with a new one. Then, set the filter glass in place by pressing upwards and twisting to align the security flap.



4. Remove the second filter glass by sliding the security flap down and twisting it to the side.

5. Unscrew the filter element, remove it and set the new one in. Then, set the filter glass in place by pressing upwards and twisting to align the security flap.

6. Turn on the air flow again by pulling the cap and twisting until air flow is correct, as shown on the HMI.

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