Emigreen®
Emission Control Technologies

INSTALLATION MANUAL DPF

PROJECT:

Emigreen® Project No:
Month/Year

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SYMBOLS AND DEFINITIONS

Danger symbol indicating operations which, if not carried out correctly, may cause serious injury, death or long-term health risks

Warning symbol indicating operations which, if not carried out correctly, may cause injury, health risks or irreparable damage to the system

This symbol indicates important information to be taken into account when performing system operations

Hazardous to the environment
Toxic to aquatic life with long lasting effects

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Warranty

The manufacturer guarantees its new products from the installation date, in accordance with the regulations in force and/or the sales contract. At the moment of the first start-up, check that the system is integral and complete.

Failure to observe the information given in this manual, operating negligence, incorrect installation and the carrying out of non-authorised modifications will void the warranty that is supplied with the system.

In particular, the rights to the warranty and the responsibility will no longer be valid, in the event of damage to things or injury to people, if such damage/injury was due to any of the following causes:

- Incorrect installation, start-up, use and maintenance of the system
- Improper, incorrect or unreasonable use of the system
- Intervention of unqualified personnel
- Carrying out of non-authorised modifications on the equipment
- Use of the system with safety devices that are faulty, incorrectly applied and/or not working
- Installation of untested supplementary components on the system
- Faults in the piping system not installed by Emigreen® B.V.
- Intentional use of the system following an error and/or an irregularity
- Insufficient and inappropriate surveillance and care of those system components that are most subject to wear and tear
- Use of non-original components, including spare parts, kits, accessories and options
- Force majeure

Emigreen® B.V. furthermore rejects any and every responsibility for the failure to observe the contents of this manual.

Responsibilities

Please pay attention to the Safety Warnings contained within this instruction manual. Keep this manual for your records and provide it to your qualified service personnel for use in professionally setting up and maintaining your system.

Your system will provide years of efficient operation if it is professionally installed and maintained by a qualified service technician. If at any time the system does not appear to be operating properly, immediately contact Emigreen® for consultation. Emigreen® recommends annual inspection/service of your system by a qualified service technician.

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Safety:

- Do not store flammable or hazardous materials in the vicinity of system components
- Improper installation, adjustment, alteration, service or maintenance can cause property damage, personal injury or death
- Refer to this manual for instructional or additional information
- System shall be installed in accordance with manufacturers' requirements

The system must only be used as expressly described
Any other use is considered improper and therefore dangerous

- Modification of the system is not allowed unless accepted by Emigreen® in writing
- The system must be used in exemplary technical safety conditions. Any disturbances that could compromise safety must be immediately eliminated
- Opening or tampering with the system's components is not allowed, apart from the parts requiring maintenance
- Only those parts envisaged by the manufacturer can be replaced

Personnel

The user is the person, body or company that has acquired the system and intends to use it for the specific purpose. He is responsible for the system and for the training / instruction of the people working around it.

The owner:

- Undertakes to entrust the system exclusively to suitably trained and qualified personnel
- Must take all the measures necessary to prevent unauthorised people gaining access to the system
- Undertakes to inform his personnel in a suitable way about the application and observance of the safety instructions. With that aim, he undertakes to ensure that everyone knows the use and safety instructions for his own duties
- Must inform the manufacturer if faults or malfunctioning of the accident prevention systems are noticed, along with any presumed danger situation

Furthermore:

- Personnel must always use the personal protective equipment envisaged by legislation
- Personnel must not carry out, on their own initiative, operations or interventions that are not within their province
- Personnel are obliged to inform their superiors of every problem or dangerous situation that may arise
- The assembly of parts of other makes, or any modifications, can alter the characteristics of the system and hence compromise operating safety. The manufacturer therefore declines any and all responsibility for any damage that may be caused by the use of non-original parts

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1. SAFETY

1.1. Safety requirements for initial operation

- Prior to operation of the unit read the Operations Manual thoroughly
- Before taking the System into operation, always ensure that all installation, maintenance or repair work is completed

- The location of all manual shutoff valves and disconnect switches should be clearly in mind so the system can be quickly shut down if necessary
- During initial start-up, the operator must be on constant alert for emergency conditions such as fuel leaks, exhaust gas leaks, electrical malfunctions etc.
- Should the burner fail to ignite, **never** manually manipulate the control sequence. The system will automatically enter a purge cycle, followed by a safety control cycle
- Immediately after taking the system into operation, ensure that all control and display instruments as well as the signalling and alarm systems work properly

1.2. Safety requirements for operators

- The procedures for cases of emergency must be practiced regularly
- The operator must be familiar with the control and display elements

- The operator must be familiar with the consequences of any operations performed
- During operation, the display instruments and monitoring units must be permanently observed with regard to present operating status and warning, failure, or alarm messages

In case a malfunction is recognised or reported by the system:

- Inform supervisor(s) in charge
- Analyse the message
- If required, carry out emergency operations or use the emergency system stop

1.3. System operation

The following conditions must be met before starting the system:

- Ensure that the engine room is well ventilated
- Do not inhale engine exhaust gas
- Ensure that the exhaust system is free of leaks and that the gas is properly discharged to the atmosphere
- Clean up any leaked or spilt fuel
- Protect hot components against accidental contact
- When the system is running, never release fuel or exhaust gas lines

1.4. Operation of electric equipment

When electric equipment is in operation, certain components of these appliances are electrically live

Observe the safety instructions for these devices

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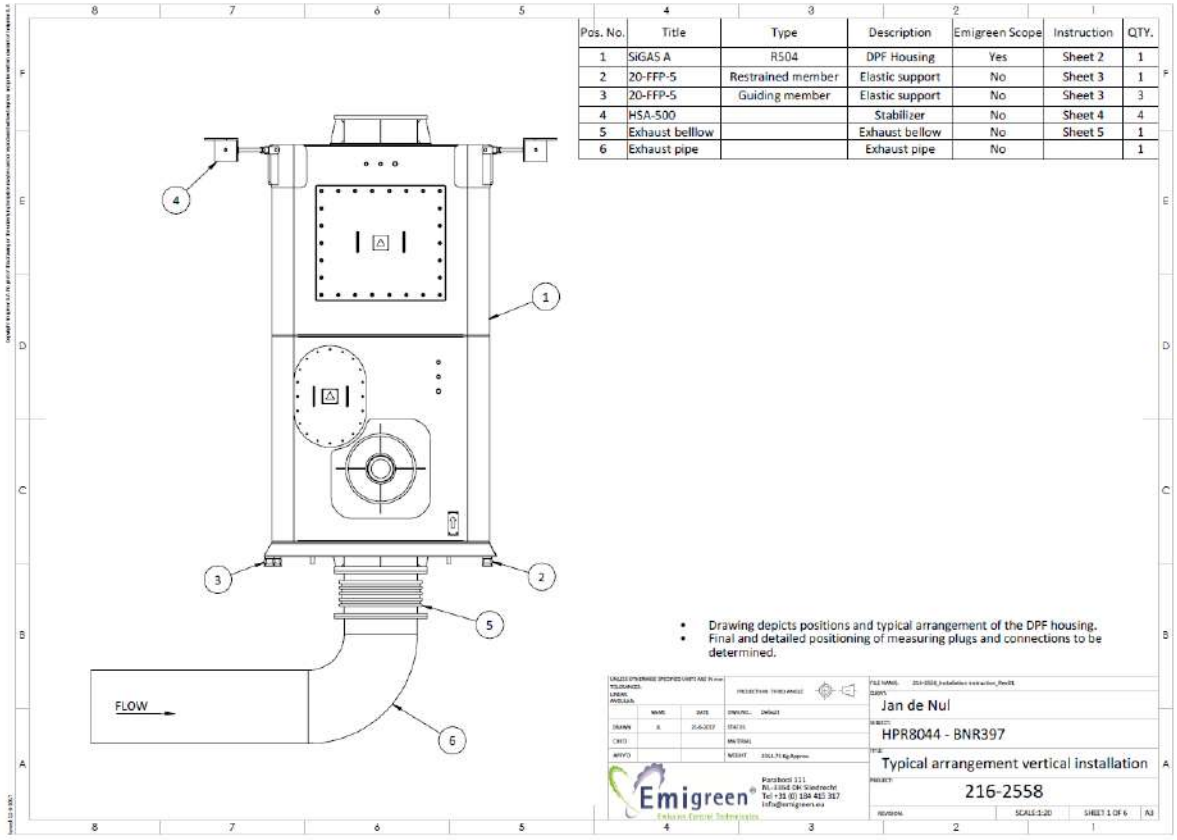
2. INSTALLATION INSTRUCTION HOUSING



Pos. No.	Title	Type	Description	Emigreen Scope	Instruction	QTY.
1	SiGAS A	R504	DPF Housing	Yes	Sheet 2	1
2	20-FFP-5	Restrained member	Elastic support	No	Sheet 3	1
3	20-FFP-5	Guiding member	Elastic support	No	Sheet 3	3
4	HSA-500		Stabilizer	No	Sheet 4	4
5	Exhaust belllow		Exhaust bellow	No	Sheet 5	1
6	Exhaust pipe		Exhaust pipe	No		1

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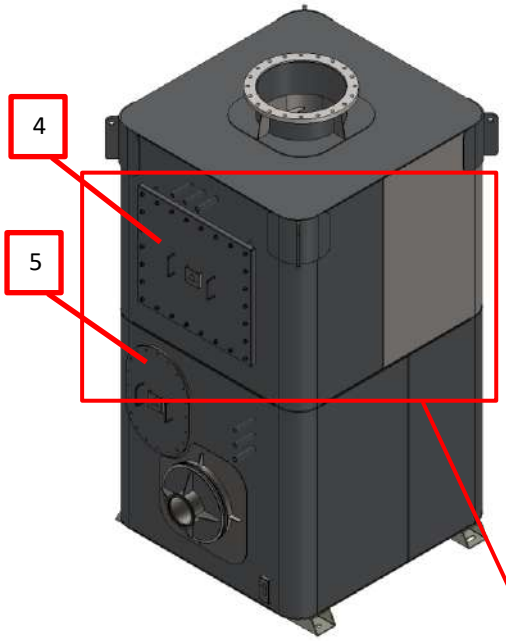
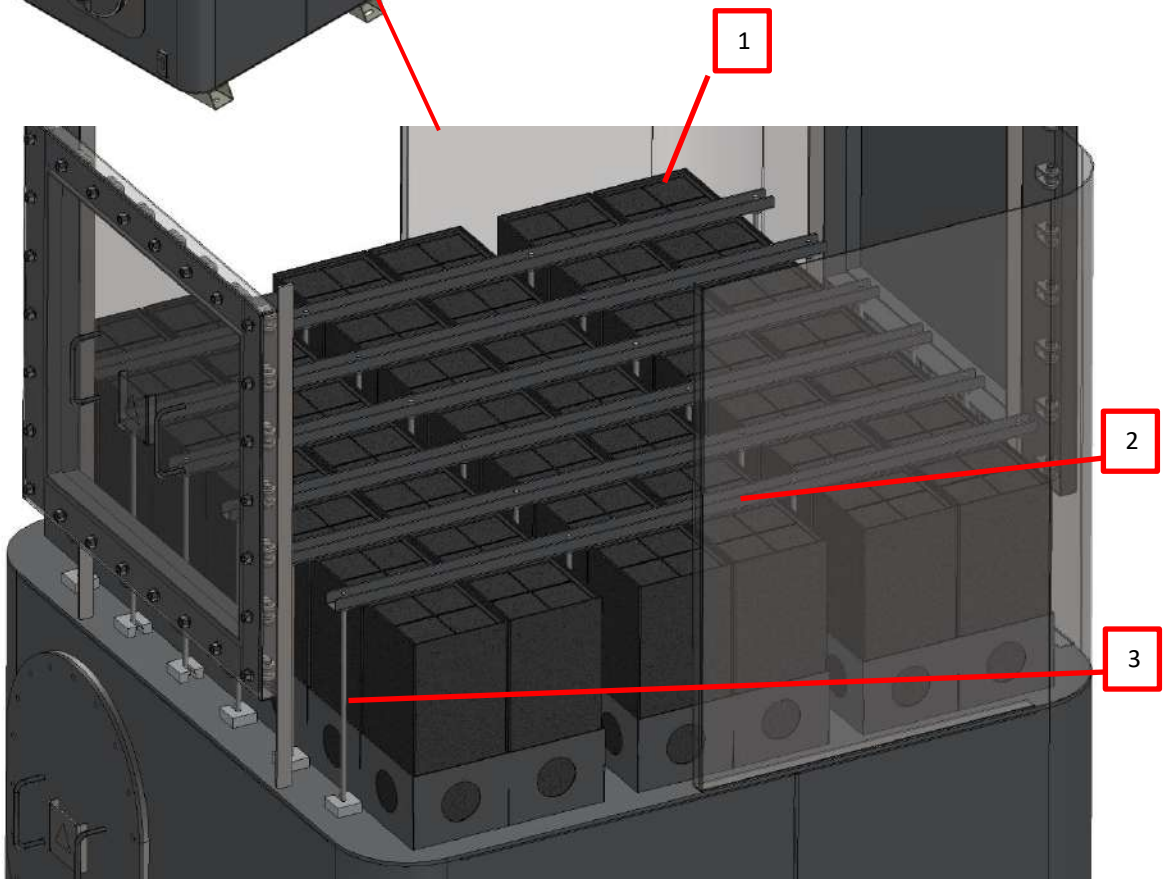
3. INSTALLATION INSTRUCTION FILTER ELEMENTS AND ACOUSTIC MODULES

3.1. Introduction

The soot filter elements are installed in dedicated pockets (one element per pocket) and secured into place by locking bars. The bars are connected to the super structure with studs which on the bottom side are shifted into slots (baffle side) and on the top side secured with nuts (bar side)
All filter elements carry an identification number and an arrow indicating the flow direction.
For service purposes, it is of imperative importance to document the exact location of each element.



#	Description	Quantity
1	DPF Filter elements	42x
2	Locking bars	6x
3	Threaded end	24x
4	Access hatch	2x
5	Manhole	1x



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3.2. Filter elements

Model			
Type	Particulate filter		Silicon carbide
Density	Cell density	CPSI	90
Dimensions	L x W x H	mm	420x192x192
Weight	per piece	kg	20

Image 1 DPF Filter elements

3.3. Gasket

To ensure the correct functioning of the filter elements, it is necessary to direct the gas flow through the filter elements. To seal the filter elements properly, Emigreen designed and supplies a special gasket. This gasket will be installed with the addition of droplets of glue, and then placed on the inlet side of the filter element. This is to secure the position of the gasket on the filter element during the installation in the housing so the sealing function of the gasket is ensured.

The gasket can withstand temperatures up to 1000°C.

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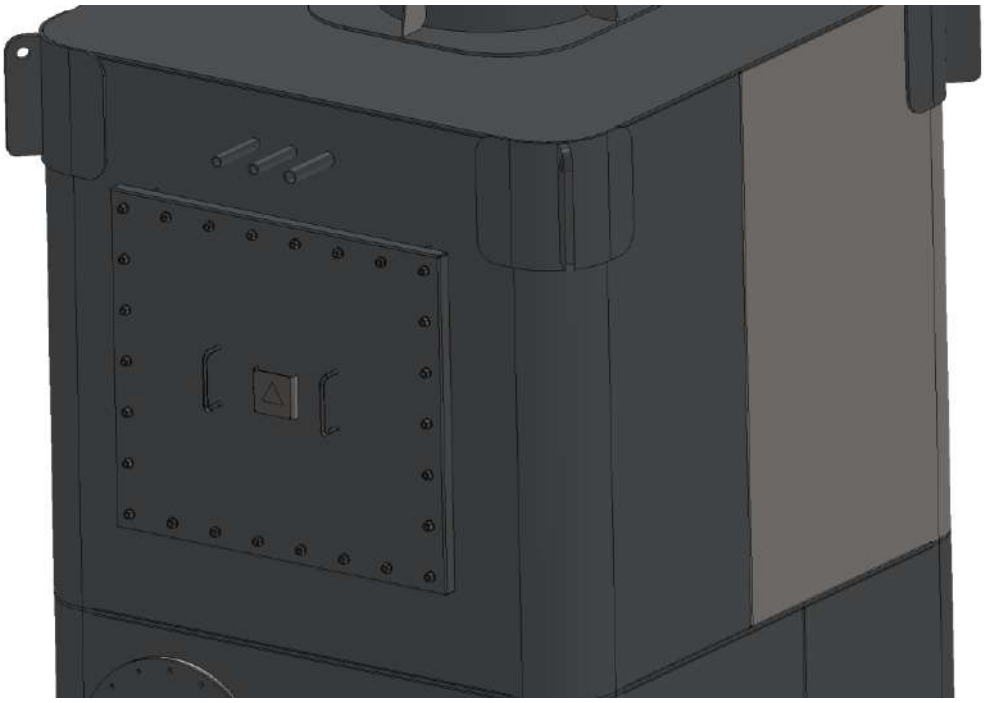
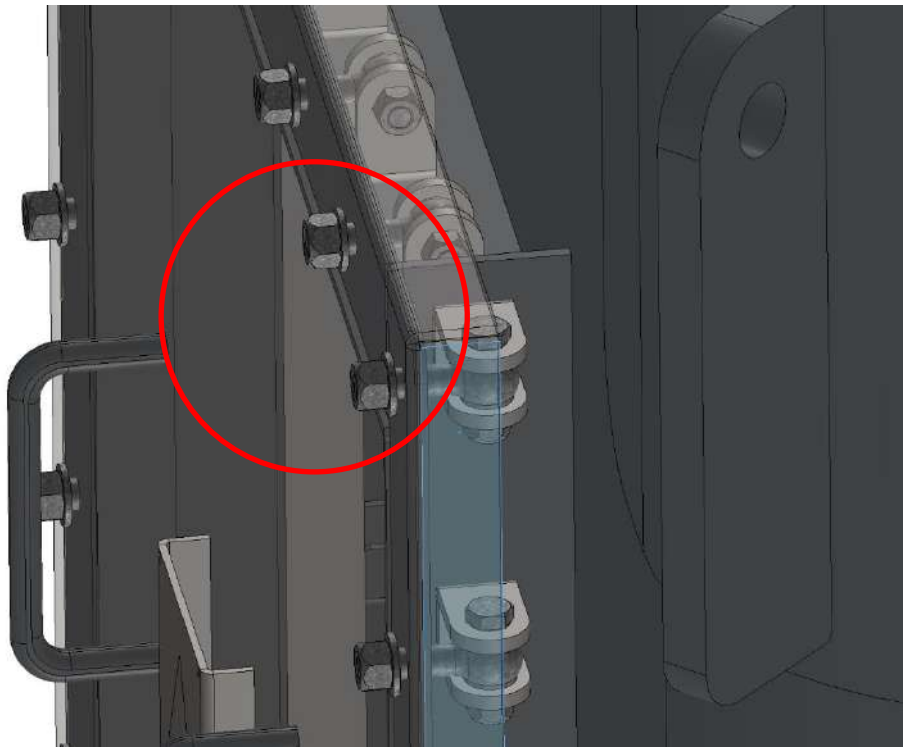
3.4. Installation

1. Locate the access hatch. There are 2 access hatches on the housing, opposite to each other



Ensure the engine is not running, and the DPF housing is cooled down!

2. Release the nuts and open the hatch. *See image for detail of the hatch locking mechanism*



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3. Preparing the filter element:

The filter elements have a small arrow engraved on the outside which indicates the exhaust flow direction through the filter element.
Respect the flow direction!

a. Take a filter element and note the filter number, (see appendix for filter ID numbers)
b. Apply glue from the supplied Loc-Tite bottle to the edges of the inlet side of the filter element *(For best performance bond surfaces should be clean and free from grease)*
c. Take a gasket and position it on the filter element, make sure it seats correctly on the face of the soot filter element *(See image)*
d. Apply some pressure by hand on the gasket and let it dry for approx. 10 minutes
e. Make sure the gasket is positioned correctly on the inlet side of the filter element

Image x Filter element with gasket attached

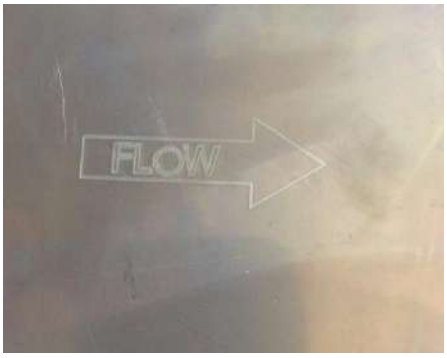
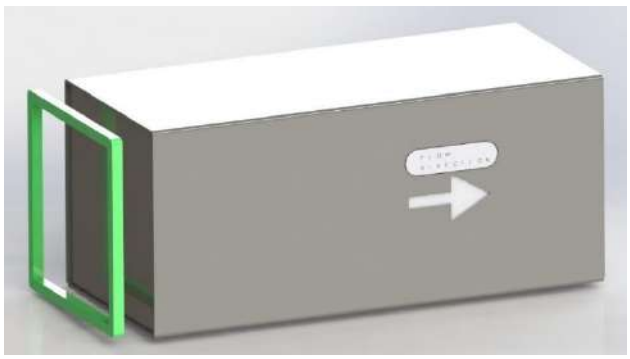


Image x Example of engraved arrow

Image x Customised filter gasket



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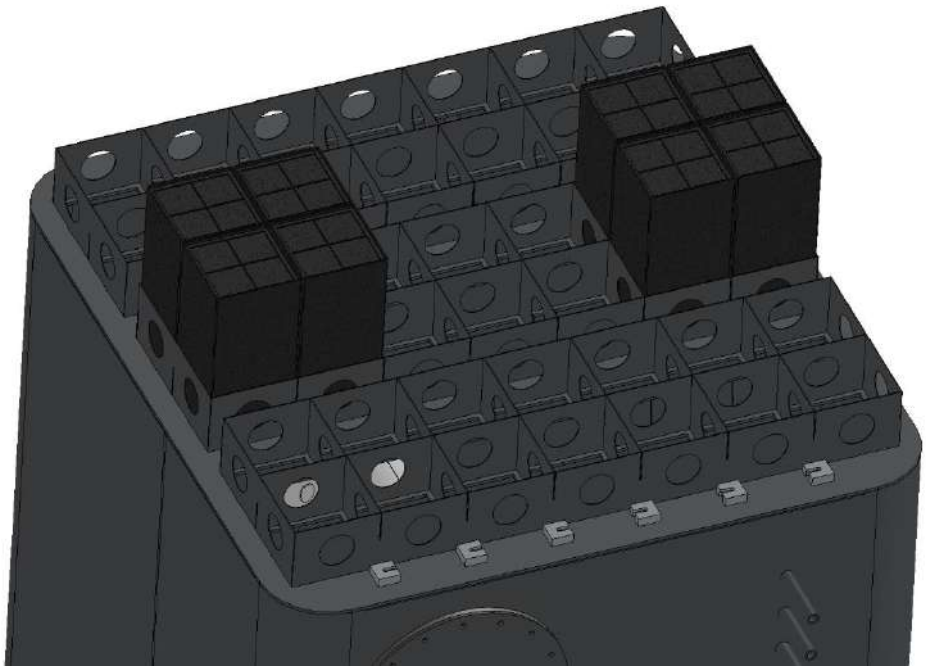
4. Each soot filter element has an individual dedicated pocket. Now carefully insert the filter element in the individual pockets in the housing, with the gasket facing the baffle. Start by installing the middle row, at both sides. Note down which element goes into which pocket



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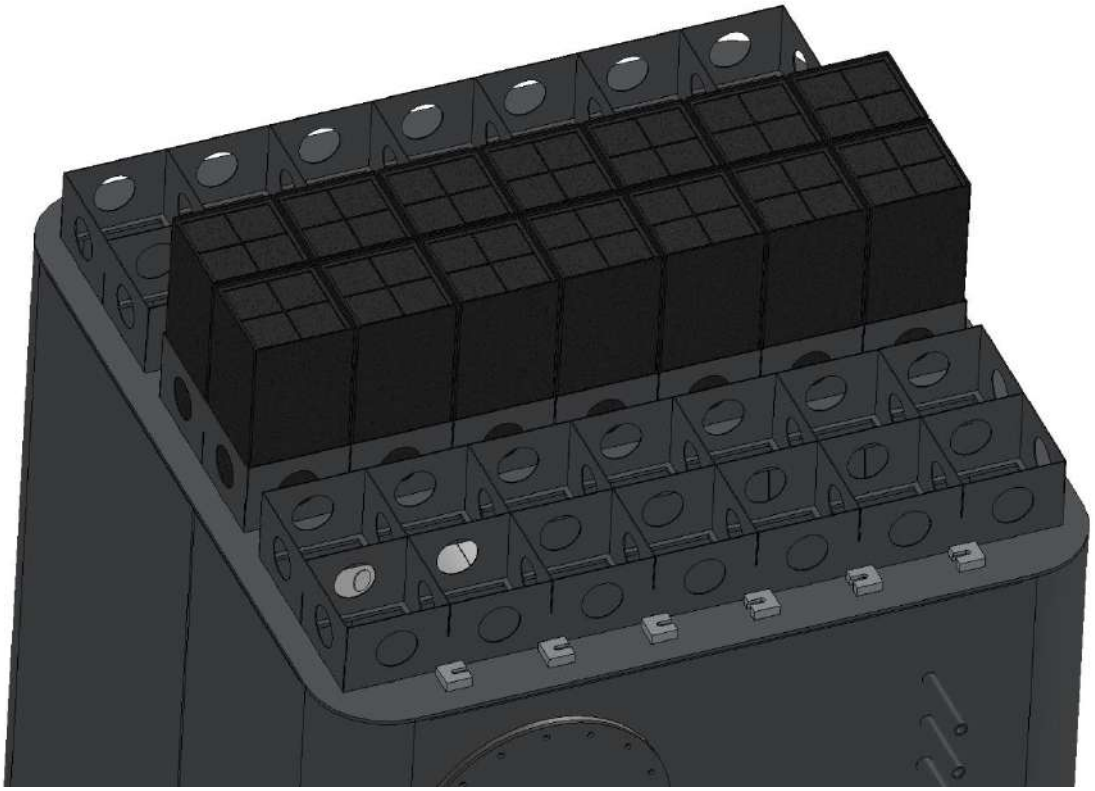

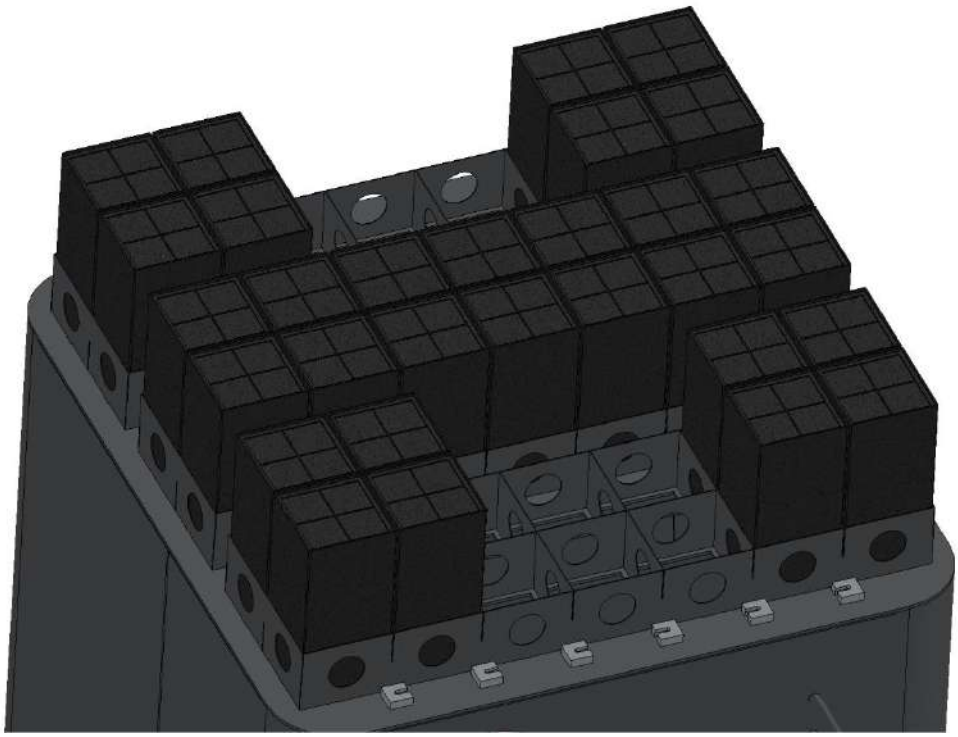

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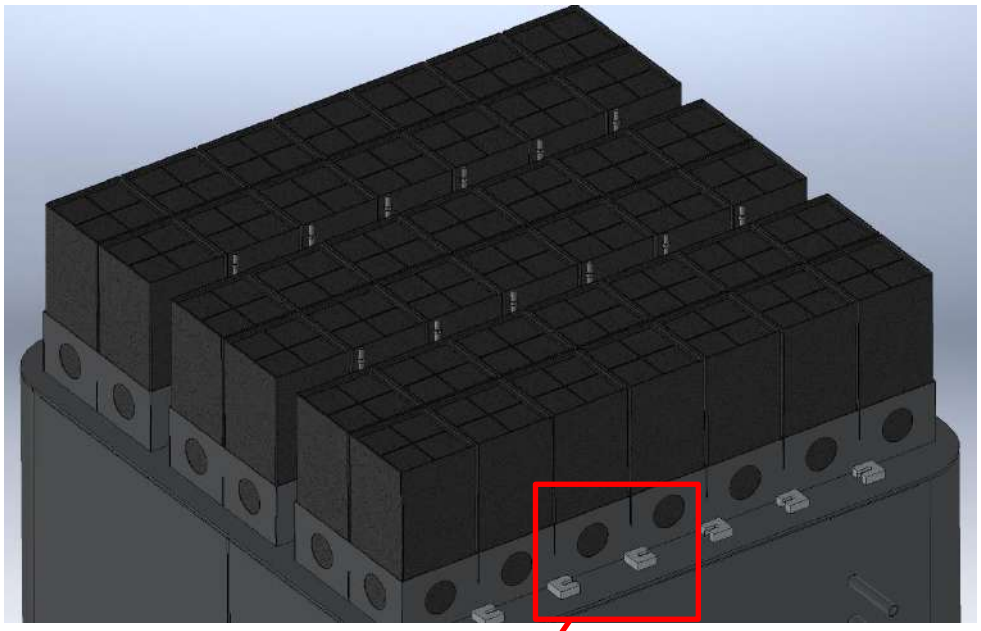
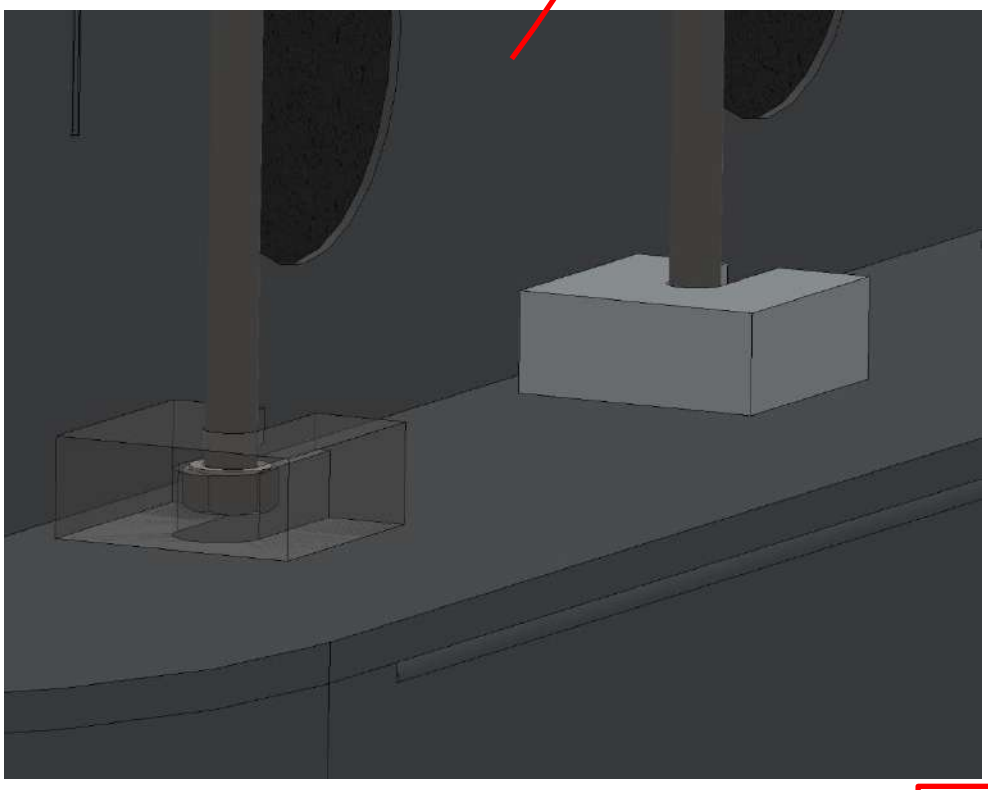
5. Once all the filter elements are in place, the studs must be inserted in the base profile. Put one nut on the end of the stud and turn the nut. Make sure the distance from the end of the stud to the top of the nut is approximately 40mm (see image)

Apply anti seizing compound /ceramic grease while installing the nuts





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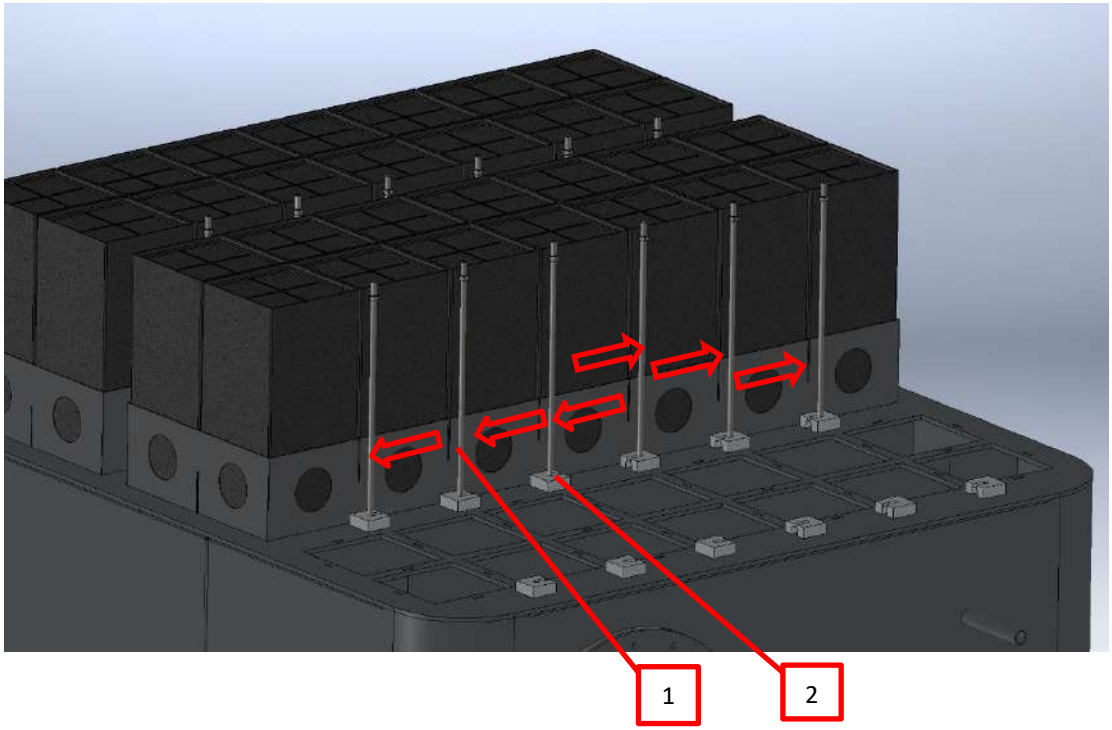
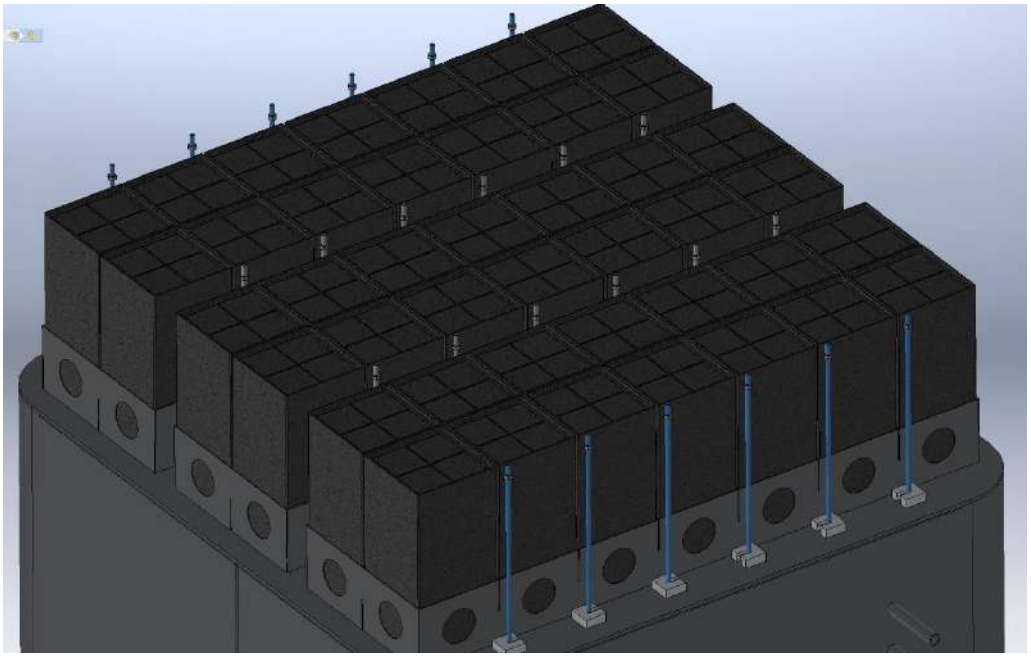
The studs are inserted from the side and directed into their base profile



#	Description	Quantity
1	Stud	24x
2	Base profile	24x

6. Proceed to insert the remaining studs



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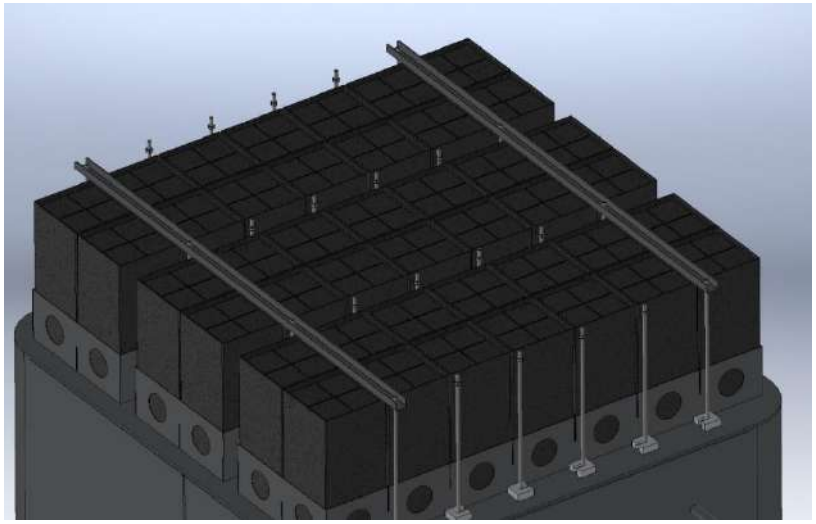
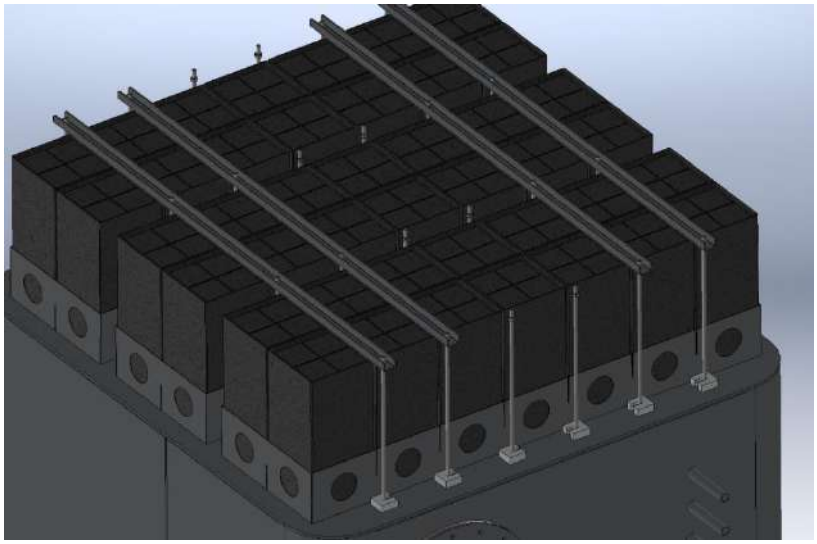
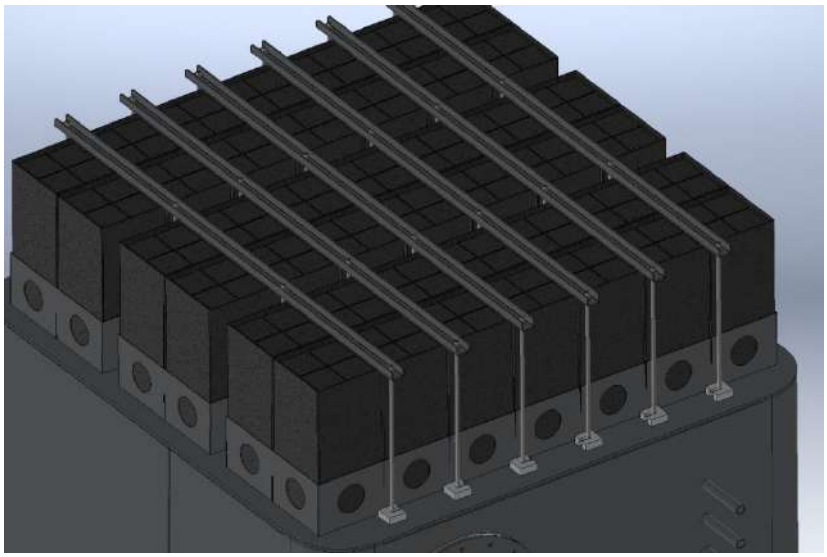
7. Take the locking bars and install as indicated below







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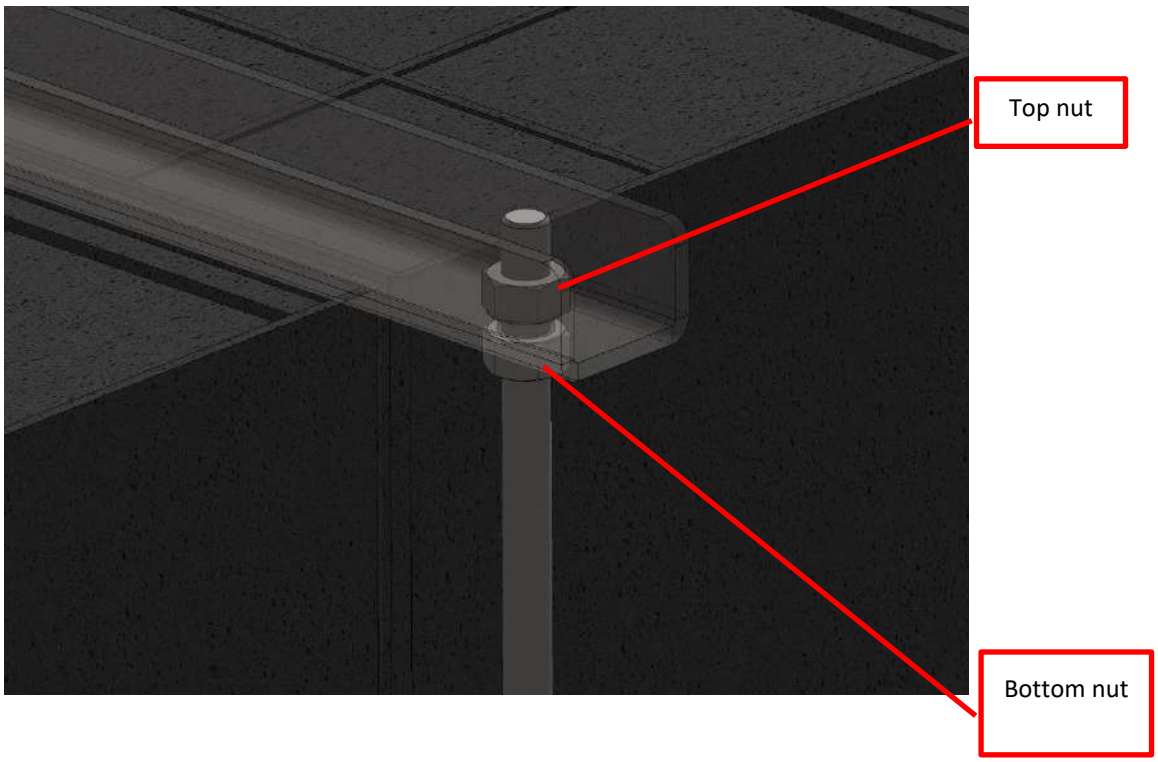
8. Place the top nut and fasten at 5 Nm, centre nut first, then the sides



9. Hand tight the bottom nut until it sits against the locking bar
10. Proceed to retighten the top nut at 10Nm
11. Ensure that the filters and locking bars are secured
12. Proceed to close the access hatch on both sides. Follow the instruction for locking the access hatch

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3.5. Locking the access hatch

The gasket that is used to seal the access hatch is a white fiberglass gasket. It is supplied per roll of 25 meters. The gasket is 6 mm thick and 20 mm wide.

Image x White fiberglass rope gasket

Instructions:

- If present, remove the old gasket.
- Degrease the surface and make sure it is clean and dry.
- Cut the rope on the required length to cover the inside of the hatch.
- Remove the yellow paper from the tape on the back side and stick the gasket on the housing.
- Make sure the corners of the gasket join together, but do not overlap each other! See red circled part in image.

Image x Example of positioning of the gasket on the hatch

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3.6. Fitting the Acoustic elements

The acoustic modules replace the Filter elements and are installed at the first start up when the engine is using run-in lube, as the filter elements must not be contaminated with run-in lube residue.
The acoustic modules can also be used when the filters are removed for a prolonged period of time.

The acoustic modules have similar dimensions as the filter elements. The main difference is that the acoustic modules have a hole in the middle and they don't require a gasket for installation. The rest of the installation is identical to the installation of the filter elements.

Image x Acoustic module, Inlet side

Image x Acoustic module, outlet side

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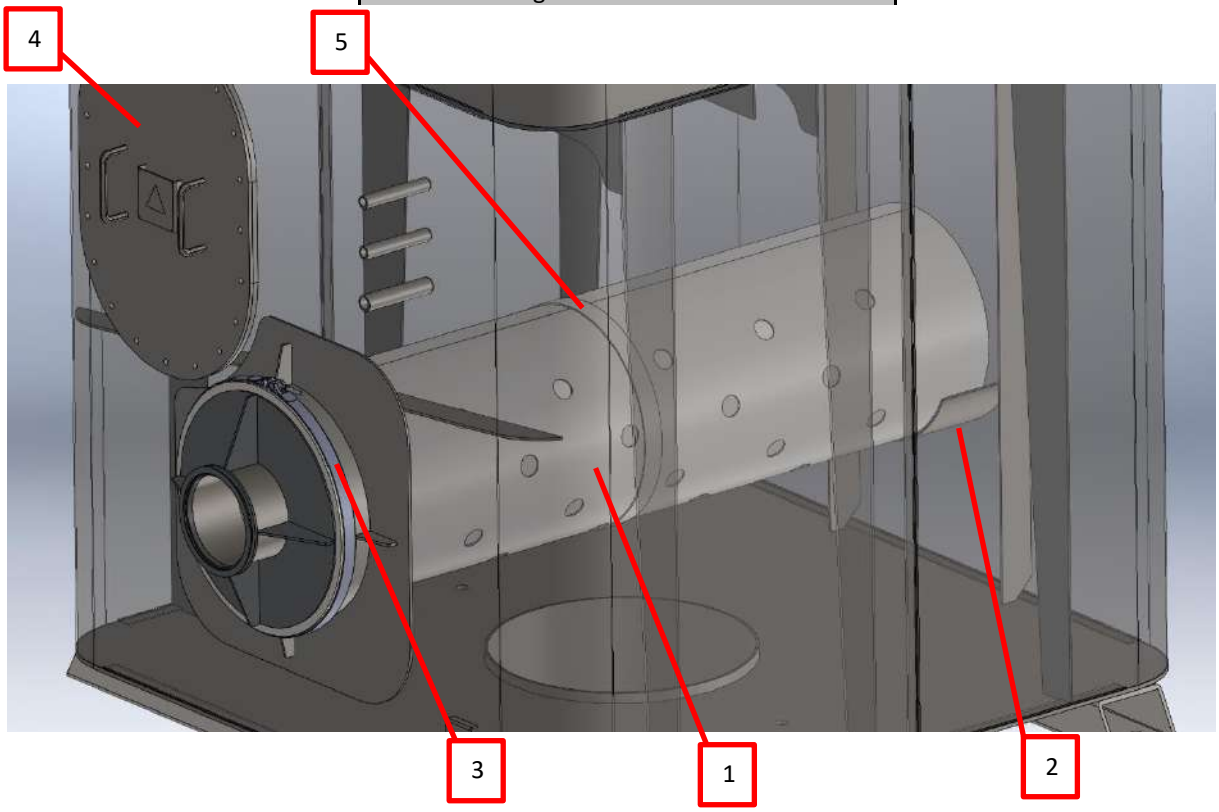
4. INSTALLATION INSTRUCTION FLAME TUBE

4.1. Introduction

The Soot filter housing is equipped with a flame tube. The flame tube is inserted in the housing and secured by a quick release v-clamp. It is supported at the end by a bracket inside the housing.

#	Description	Quantity
1	Flame tube	1x
2	Support bracket	1x
3	V-Clamp 488	1x
4	Manhole	1x
5	Connection ring	1x



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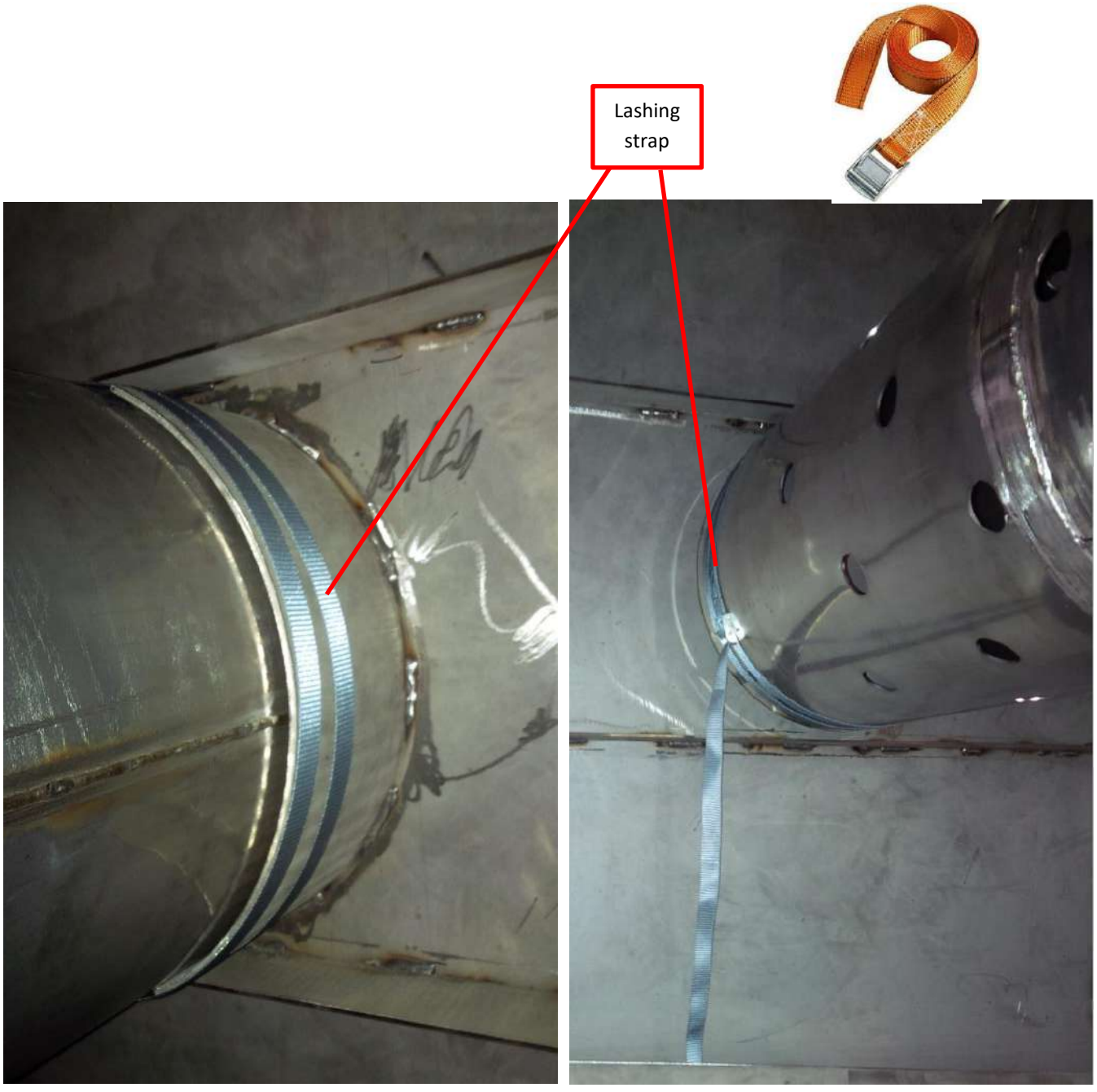
4.2. First installation

Please note that for the first installation, an additional step must be taken. This has to do with the horizontal transportation of the housing, the flame tube is secured to the support bracket by a lashing strap, which is tightened around the flame tube and the bracket so it does not move during the transport.

Once the housing is positioned vertically, this strap must be removed
Failing to remove will lead to melting and possible burning of the material!



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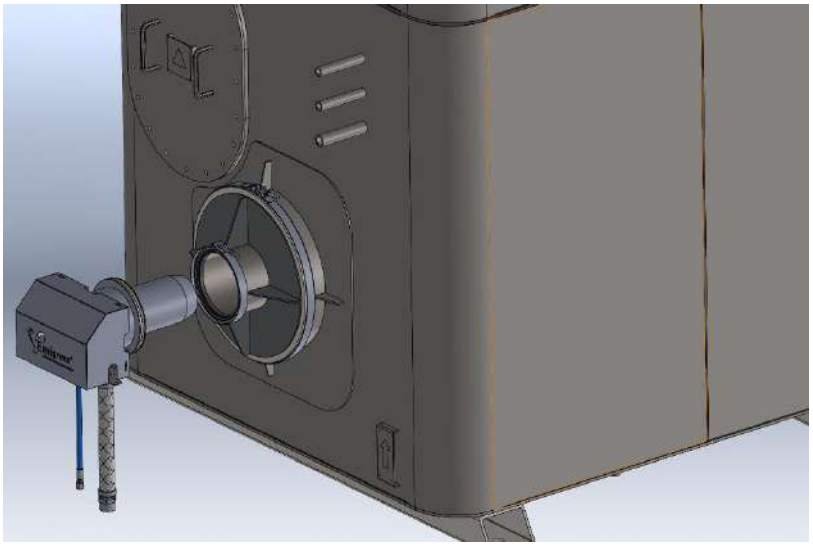
4.3. Removing the Flame tube

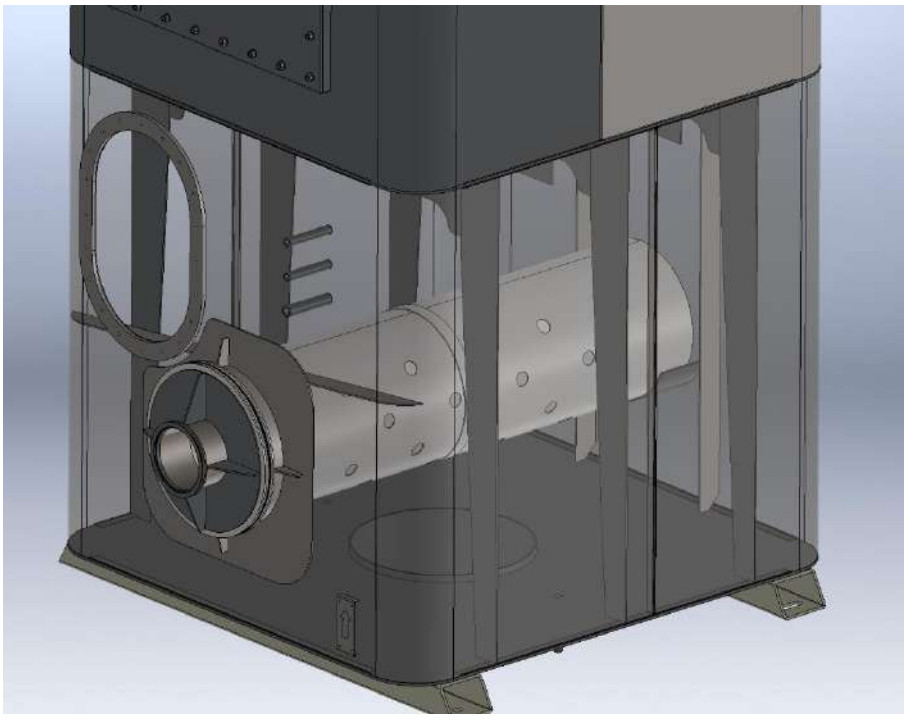
In the unlikely case the flame tube needs to be removed the procedure is as follows

Make sure the engine is off and the soot filter housing is cooled down!

1. Proceed to remove the burner head from the housing, *refer to the section 'Burner head installation'*



2. Open the manhole cover and proceed to enter the housing.
3. Release the V-clamp and remove V-clamp.



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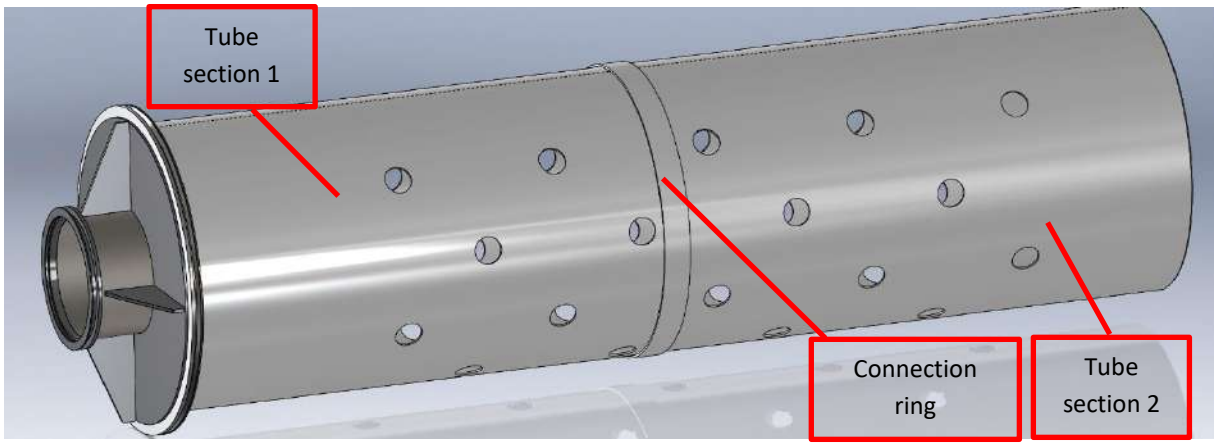
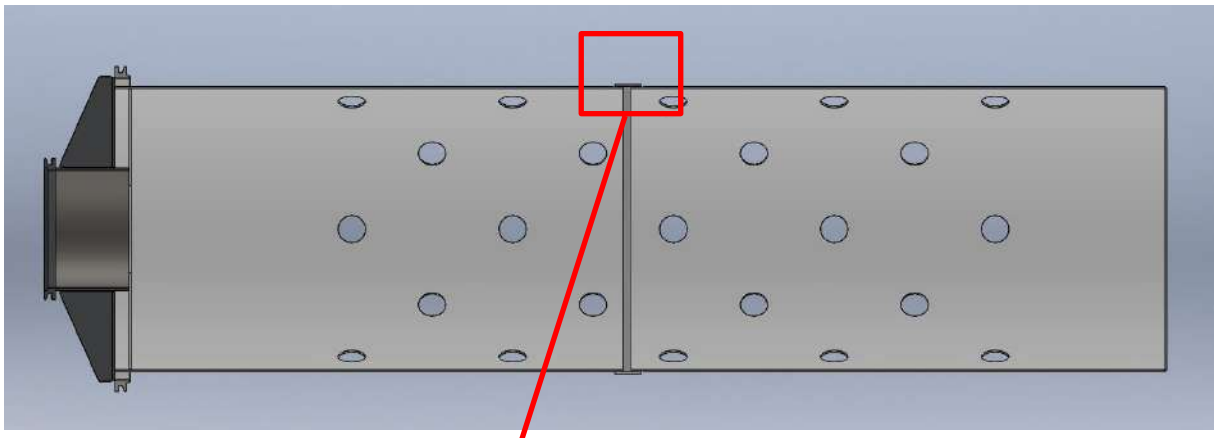
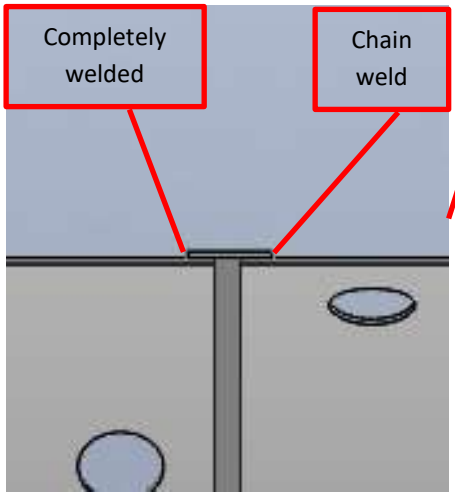
4. Because of the lack of available space around the housing, the flame tube will have to be cut around the back side of the connection ring, so it can be removed in 2 pieces.
   The tube itself is made of 2 parts, and welded together on the connection ring. One side is completely welded around, the back side has a few chain welds, so the welds can be cut/grinded in the unlikely case the tube has to be removed.
   After cutting, the tube section 1 can be removed and subsequently section 2 can be removed.







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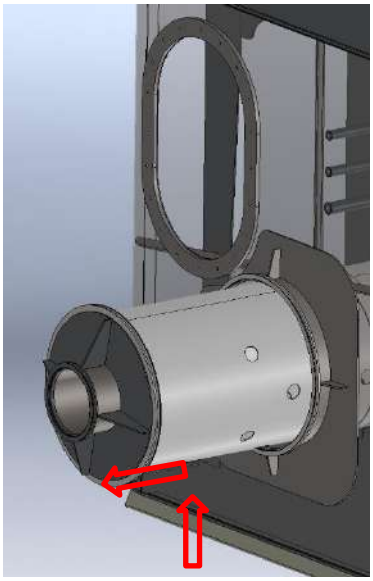
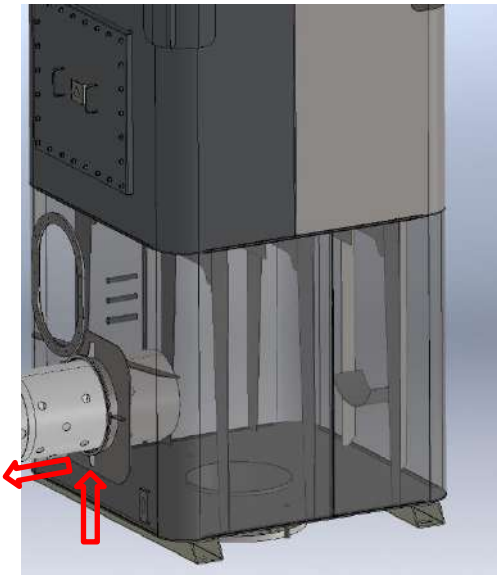
5. Carefully extract both sections of the flame tube



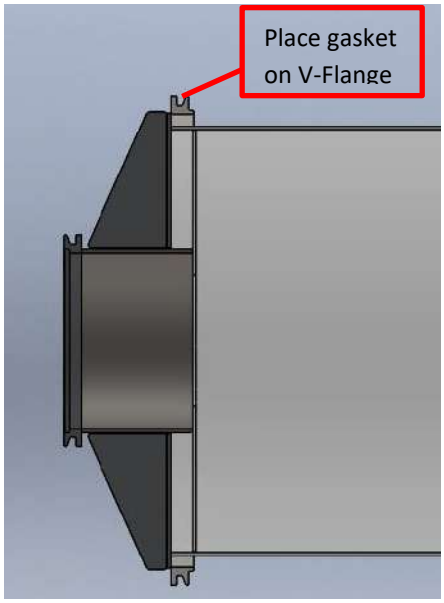


4.4. Installing the Flame tube

Installation of the Flame tube is the reverse procedure as to remove the flame tube.

1. Insert tube section 2 and support it temporarily
2. Take a new gasket for the v-clamp flange and place it on the v-flange, see image below
3. Proceed to insert tube section 1 and make sure the connection ring slides over the tube section 2
4. Make chain welds on the connection ring, joining tube section 1 and 2 together again
5. Proceed to fully insert flame tube and support it on the support bracket on the back of the housing
6. Ensure gasket fits correct and v-flanges join without gaps
7. Tighten V-clamp and close manhole

Use a gasket when reinstalling the flame tube as well as the manhole
Refer to spare part list



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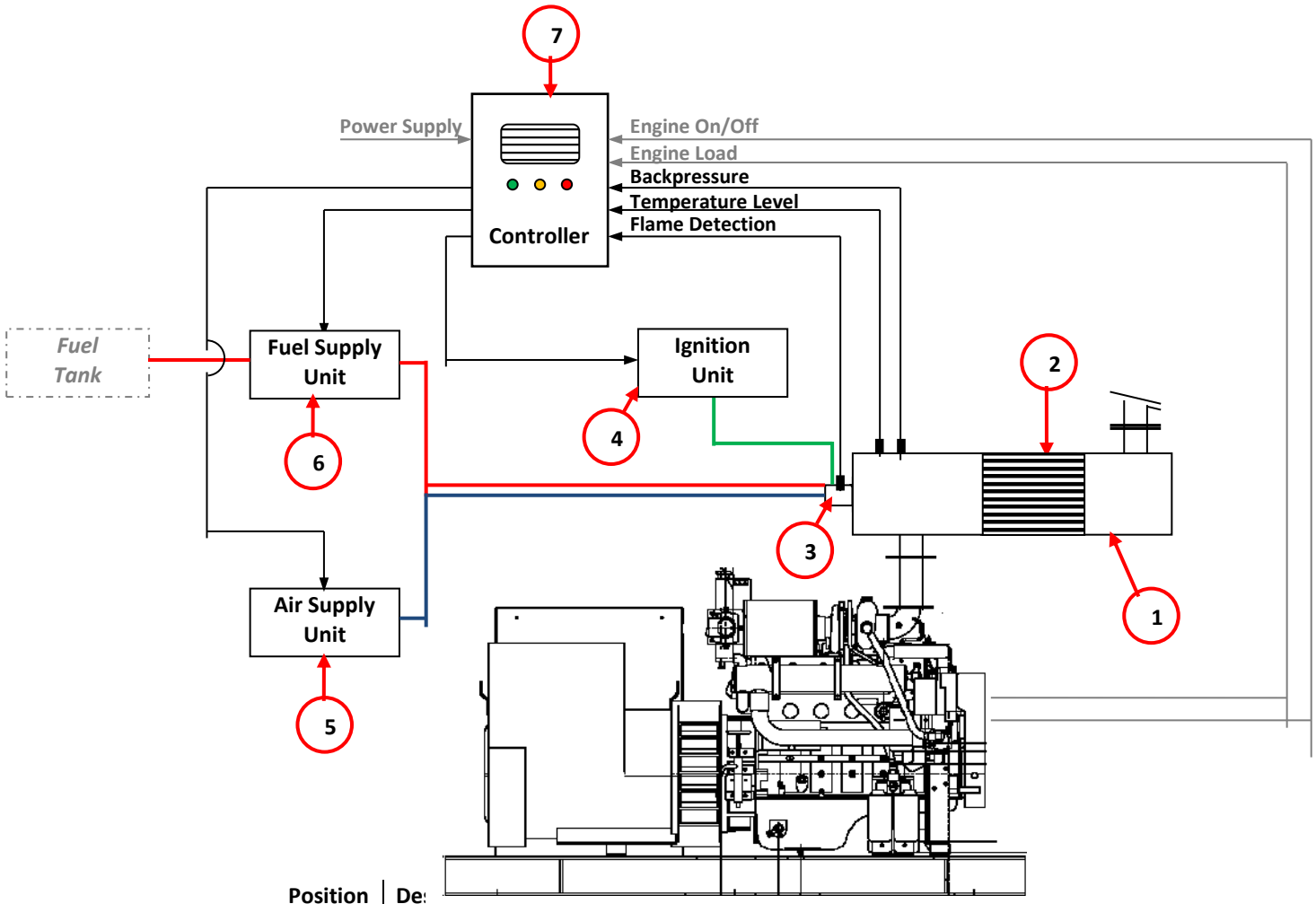
4.5. System Overview



Position	Description
1	Silencer assembly
2	Soot filter elements
3	Fuel burner head assembly
4	Ignition unit (mounted on burner head)
5	Air supply unit (skid mounted)
6	Fuel supply assembly (skid mounted)
7	Control cabinet (including PLC, UPS and communication module)

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5. SYSTEM OVERVIEW

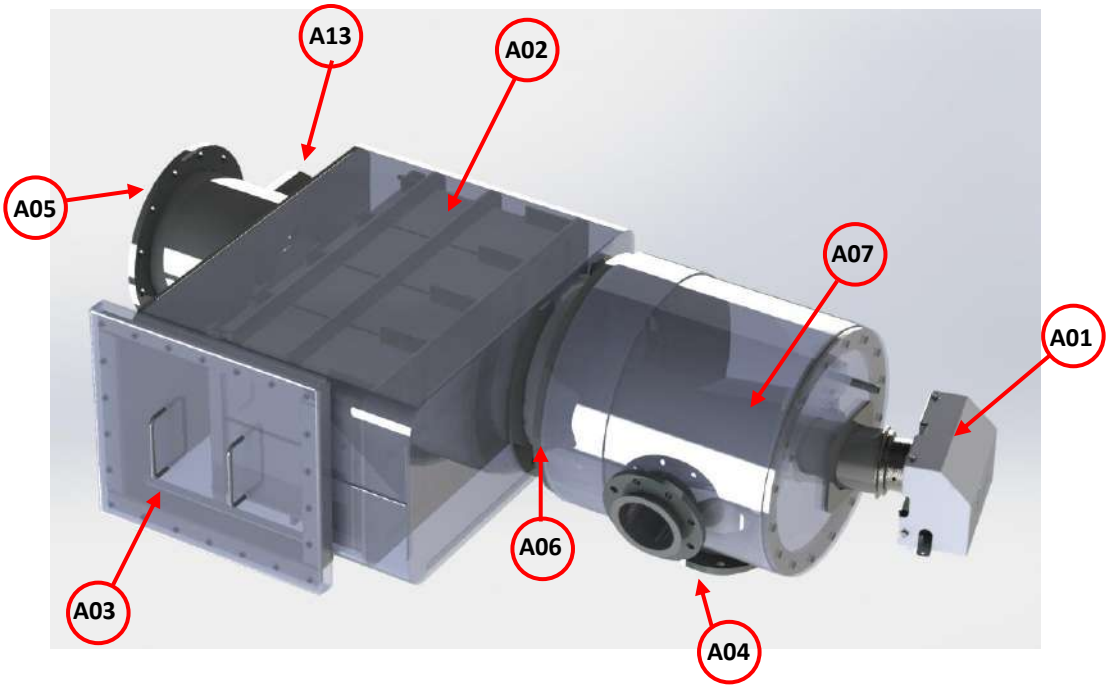
5.1. Soot Filter Housing/Exhaust Gas Silencer

5.1.1. Description

The soot filter housing is designed to function as a high grade exhaust gas silencer. The housing is divided into two compartments, and is detachable as to facilitate installation work.

The first compartment functions as an expansion chamber and facilitates the fuel burner combustion chamber. The filter elements (**A02**) are secured against the baffle in the second chamber.

The soot filter elements are accessible through a bolt locked service hatch (**A03**) located at the side of the housing. An inspection hole (**A13**) on the outlet side of the housing, offers access for inspection.



Position	Description
A01	Fuel burner
A02	Filter elements
A03	Access hatch filter elements
A04	Inlet flanges
A05	Outlet flange
A06	Flange connection (front chamber and rear chamber)
A07	Flame pipe (internal)
A13	Inspection hole (covered with blind flange)

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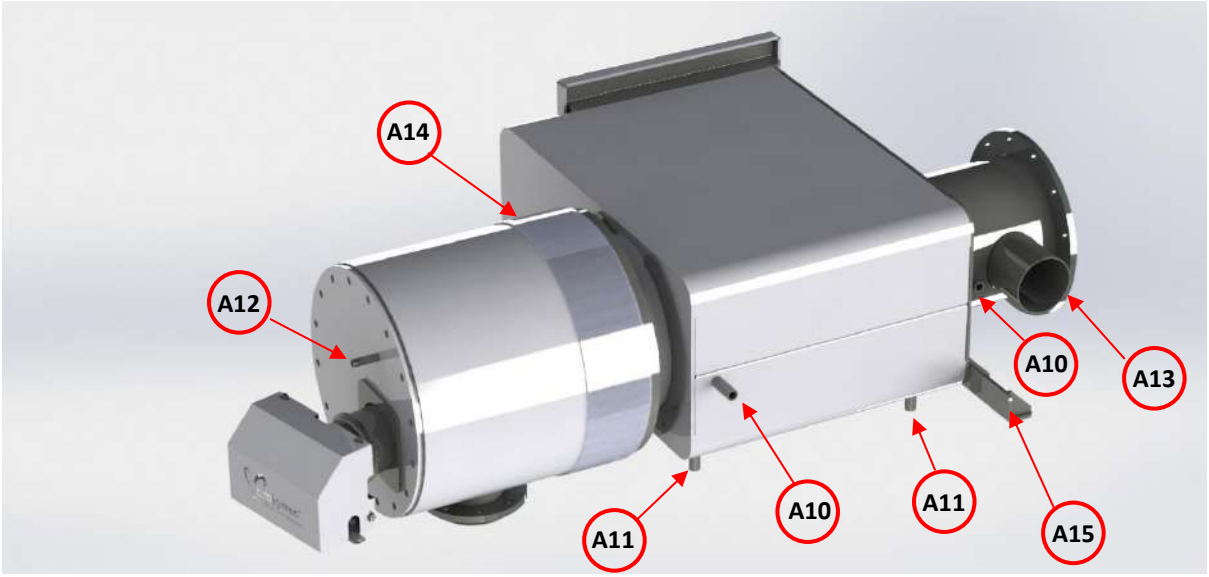
5.1.2. Interfaces



Position	Description	Qty
A10	Socket ½" BSP (Temperature sensor)	2
A11	Socket ½" BSP (Drains)	2
A12	Socket ¼" BSP (Pressure sensor)	1
A13	Inspection hole (covered with blind flange)	1
A14	Double plate for suspension points	1
A15	L-profile for suspension points	1

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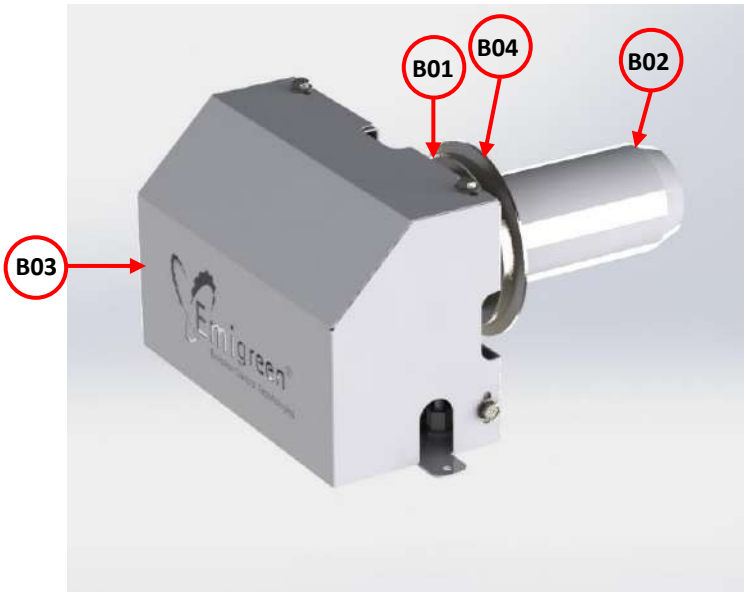
5.2. Fuel Burner Head

The burner head assembly is designed to be gas tight under all circumstances. The assembly is connected to the silencer body through a quick release V-clamp.

Inspect the burner head to silencer connection regularly on gas leaks

Improper installation may cause exhaust leak and consequently suffocation or serious fire hazard

DO NOT remove the cover of the burner head while the burner is in operation



Position	Description
B01	Burner head
B02	Flame tube
B03	Burner head cover
B04	V-clamp flange

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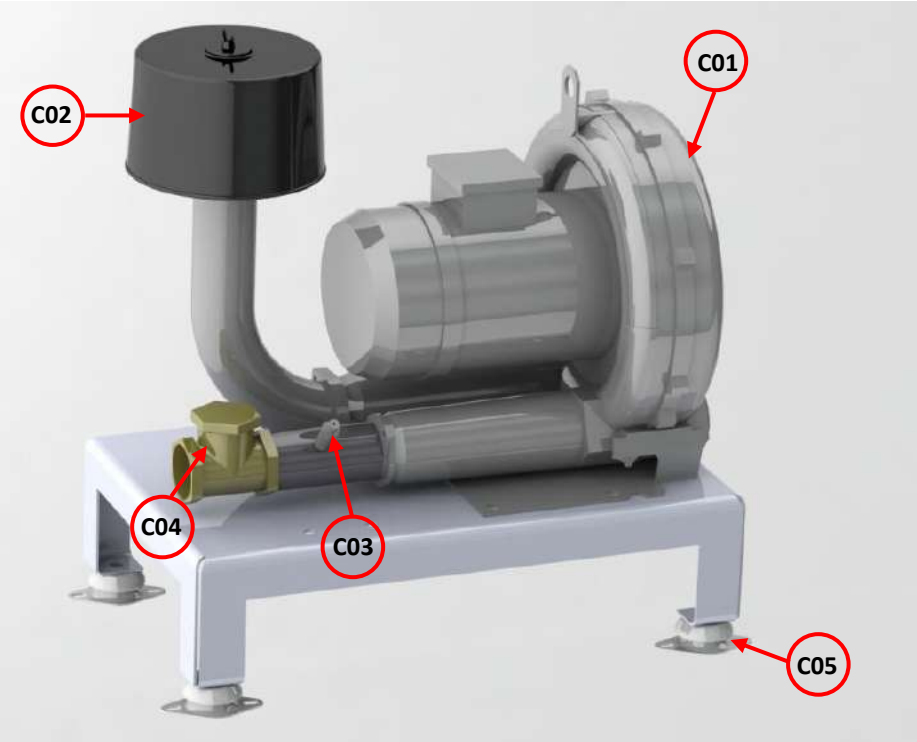
5.3. Air Supply

The air supply unit is a skid mounted assembly.

The air supply unit is connected to the burner head through a stainless steel braided flexible hose.

The blower supplies the fuel burner with air required for:

- Combustion
- Maintaining the burner components clean
- Cooling the components sensitive to heat



Position	Description
C01	Air blower
C02	Air intake filter
C03	Pressure sensor
C04	Non return valve
C05	Anti-vibration mounts

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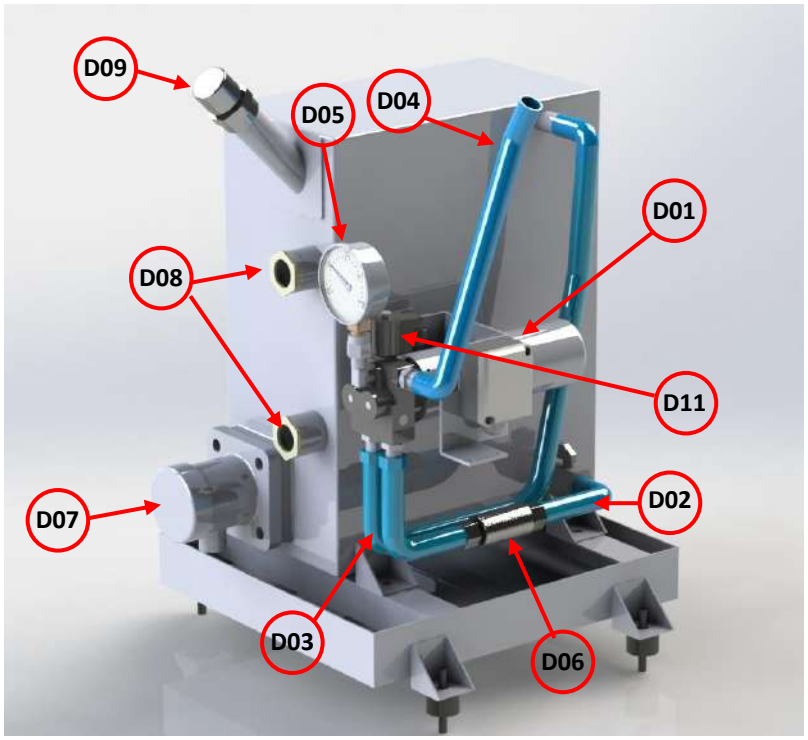
5.4. Fuel Supply

The fuel supply system consists of two assemblies:

- Fuel pump assembly
- The burner head fuel assembly

5.4.1. Fuel Pump Assembly



D02	Fuel supply line
D03	Fuel return line
D04	Fuel feed line to burner head
D05	Pressure gauge
D06	Fuel filter
D07	Level switch
D08	Sight glass
D09	Filling cap
D11	Fuel cut-off valve

Nominal pressure at manometer, stable around 10 bar

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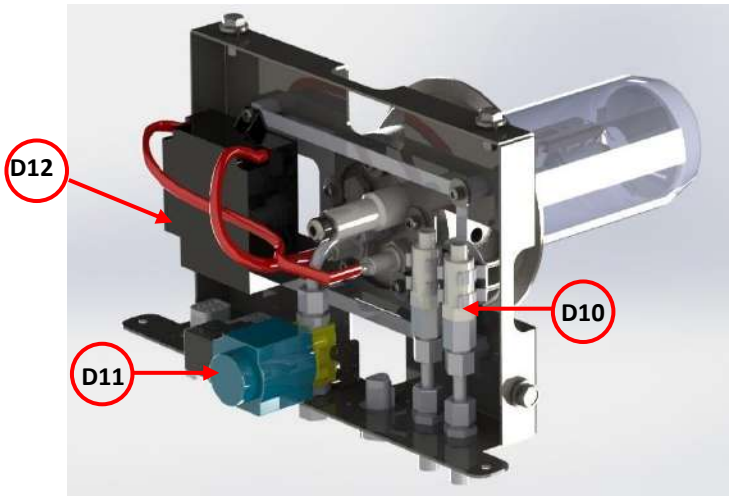
5.4.2. Fuel Components on Burner Head Assembly



Position	Description
D10	Fuel Pressure sensor
D11	Fuel cut-off valve
D12	Ignition transformer

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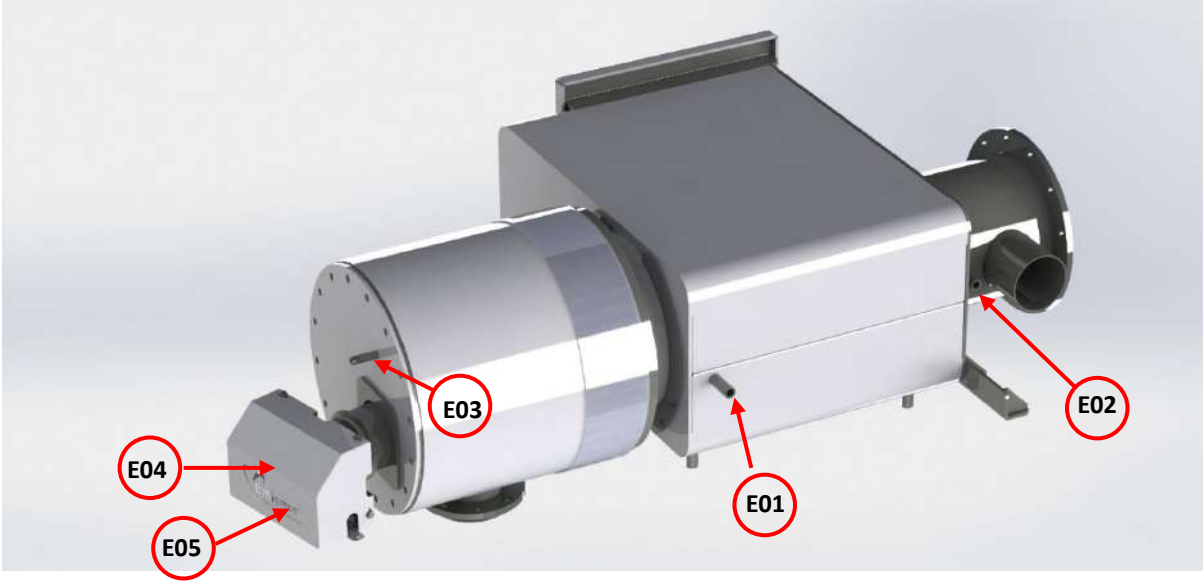
5.5. Sensors and Sensor Location

5.5.1. Filter Housing/Exhaust Gas Silencer



Position	Description
E01	Temperature Upstream
E02	Temperature Downstream
E03	Pressure Upstream (sensor located on burner head)
E04	Flame sensor (on burner head)
E05	Fuel pressure sensor (on burner head)

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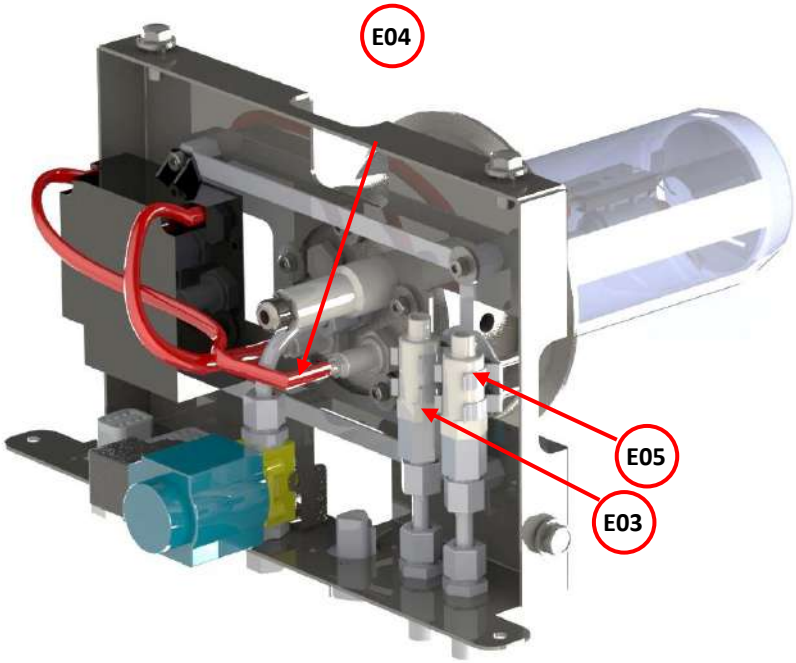
5.5.2. Burner Head



Position	Description
E03	Back Pressure sensor
E04	Flame sensor
E05	Fuel pressure sensor

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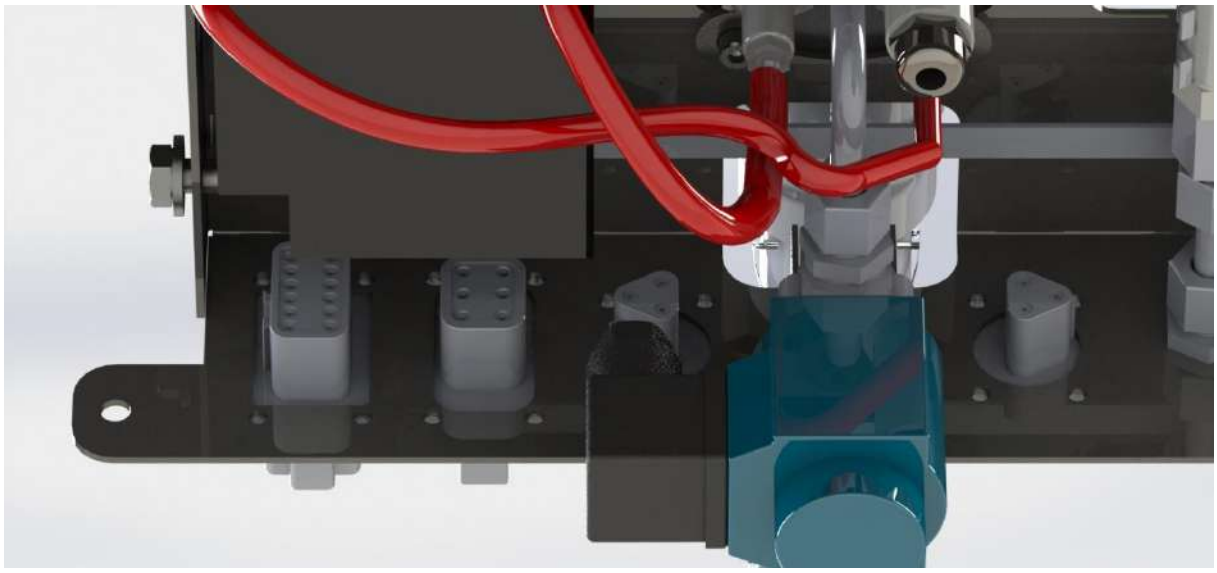
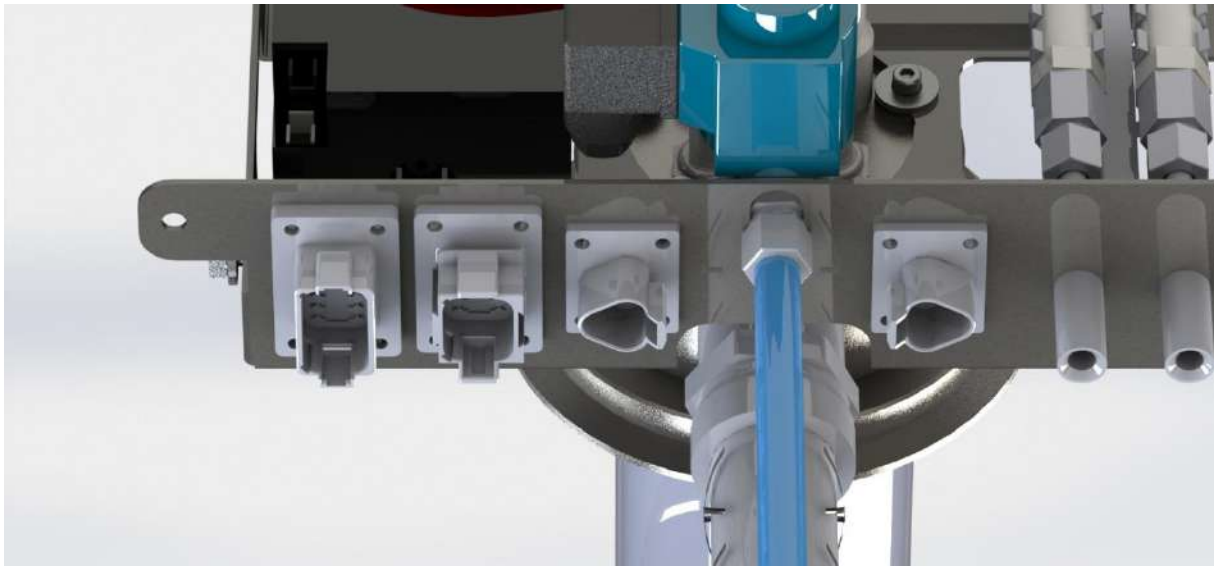
5.5.2.1. Connectors

There are 4 cable connectors on the burner head.

From left to right:

- 12 pole connector (T1)
- 6 pole connector (T2)
- 3 pole connector (T3)
- 3 pole connector (T4)





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Connector T1 (Sensors)	
7. *NOT USED*	***6.*** *NOT USED*
8. Flame sensor (+)	**5.** Flame sensor (-)
9. Fuel Pressure (+)	**4.** Fuel Pressure (-)
10. Back Pressure (+)	**3.** Back Pressure (-)
11. (from Connector T4, Pin 3)	**2.** (from Connector T4, pin 2)
12. (from Connector T3, Pin 3)	**1.** (from Connector T3, Pin 2)

Connector T2 (24V Components)	
4. Ignition PE (Grounding)	**3.** Fuel valve PE (Grounding)
5. Fuel valve (+)	**2.** Fuel valve (-)
6. Ignition transformer (+)	**1.** Ignition transformer (-)

Connector T3 (Thermocouple Upstream of filters)	
1. *NOT USED*	**2.** TC1 (-) wire to Connector T1 – Pin 1
	3. TC1 (+) wire to Connector T1 – Pin 12

Connector T4 (Thermocouple Downstream of filters)	
2. TC2 (-) wire to Connector T1 - Pin 2	***1.*** *NOT USED*
3. TC2 (+) wire to Connector T1 - Pin 11	

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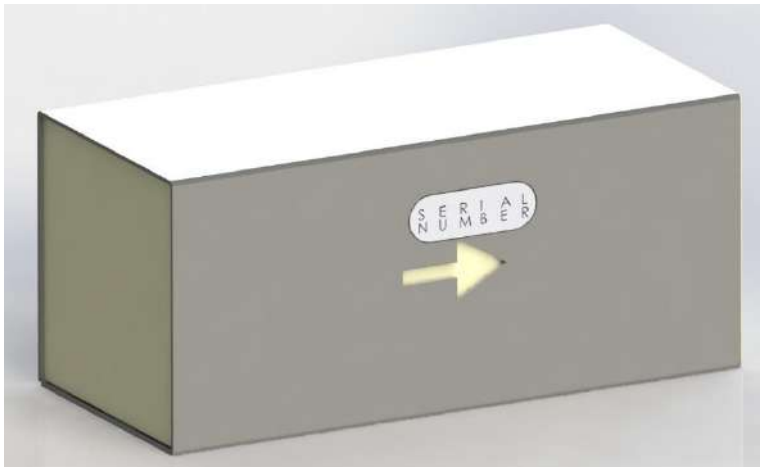
5.6. Soot Filter Elements

The soot filter elements are ceramic monoliths of the full flow type. To protect against mechanical damage, the monoliths are packed in a stainless steel housing with a layer of heat resistant resilient material between the ceramic and the can.



The resilient material maintains its elastic properties up to temperatures of 750°C

Do not overheat

Each filter element is numbered to facilitate relocation after servicing and follow the performance through its operational life.

An arrow indicating the flow direction is marked on the housing of each element, and should be marked with each removal and insertion of the element.

Always respect the flow direction

Although the filter elements are protected against mechanical load, the inlet and outlet faces are sensitive to damage.

Fragile inlet and outlet surfaces – Do not drop

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6. TECHNICAL DATA

6.1. Basic Design Parameters

Power supply		230 and 400V 50Hz

6.1.1. Environmental Conditions

Ambient temperature range	°C	0-50
Humidity	%	80

6.1.2. Fuel Requirements

Quality		ISO 8217:2010 DMA
Fuel temperature	°C	10-60
Viscosity	cSt	1,2-5
Sulphur content (by weight)	%	0,1
Minimum supply pressure at pump inlet	bar	-0,4 (vacuum)
Maximum supply pressure at pump inlet	bar	2
Maximum fuel flow	litre/h	25
Fuel filter upstream pump	µ	50

6.1.3. Combustion Air Data

Maximum ambient air temperature	°C	50
Maximum air flow @293K, 1013mbar	m^3/h	160
Maximum differential pressure over the blower	mbar	200
Burner head connection	BSP	1½"

6.1.4. Burner Data

Power	kW	80-100
Nozzle	gal/h	1,35gal/h 45°S
Fuel pressure	bar	8-11
Fuel flow	l/h	16-22
Maximum backpressure	mbar	150

6.1.5. Power Consumption

Blower (maximum @ 400V)	W	1300
Control unit incl. e-motor, ignition, valves (@230V)	W	200
Frequency	Hz	50

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6.2. Filter Element Specification

Material code	F180	-
Material	100% Re-SiC	-
Cell code	90	-
Cell density	12,75	$1/cm^2$
Cell dimensions	2,0 x 2,0	mm
Wall thickness	0,8	mm
Pitch	2,8	mm
Pore size	$20 – 30 \times 10^{-3}$	mm
Porosity	~45	%
Permeability at 20°C	$0,70 \times 10^{-12}$	$1/m^2$
Pressure loss (1)	0,42	kPa
Filtration efficiency (2)	>95	%
Filtration efficiency (3)	>98	%
Mass density SiC	3,2	kg/dm^3
Mass density filter	1,8	kg/dm^3
Monolith weight (volume weight)	0,92	kg/dm^3
Specific filtration area	0,51	m^2/dm^3

(1) Wall velocity 2 cm/s at 20°C
(2) Clean filter - PM10
(3) 10% loaded filter

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6.3. Basic System Requirements & Recommendations

Compulsory! Continuous power supply to the system when the engine runs
The power supply of the system must be protected by an external fuse/breaker

6.3.1. Fuel quality

- The fuel burner is designed to operate on DMA fuel according to ISO 8217:2010
- The fuel must be filtered and separated from any water present in the fuel tank

6.3.2. Engine lube oil quality

Lube oil consumption is of highest importance for both service interval and filter operational life time.

Depending on the engine size and type, the Emigreen® Alfa-Alfa soot filter system is dimensioned for a maximum lube oil consumption of

- 0,3% of the fuel consumption or
- 0,6 g/kWh

The use of low SAPS lube oil shows best results for filter service interval.

Strongly recommended lube oil quality

E6, E9 according ACEA 2010

Lube oil quality applicable with DPF

C1, C2, C3 and C4 according ACEA 2010

Lube oil quality NOT suitable with DPF

E4, E7 according ACEA 2010

In case the engine needs to operate with run-in lube oil, the filter elements must be removed

The filter elements may be replaced when the engine runs on normal lube oil

6.3.3. Engine operation

Engine operation and engine condition affect the service interval significantly.

Extended low load engine operation in combination with low exhaust gas temperatures implies a more frequent cleaning program.

6.3.4. Poisonous substances

Engine lubrication oil and fuel may contain substances poisonous to the catalytic coating of the soot filter elements

The list of known poisons together with the maximum permissible concentration is provided on 4.4 List of Poisonous Substances.

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6.4. List of Poisonous Substances

Element	Symbol	Maximum Concentration mg/kg	Hazard Category
Aluminium	Al	0.5	
Antimony	Sb	0.5	
Arsenic	As	0.2	
Boron	B	0.5	
Bromine	Br	1.0	
Cadmium	Cd	0.5	
Calcium	Ca	5.0	
Chlorine	Cl	5.0	
Chromium	Cr	0.5	
Cobalt	Co	0.5	
Copper	Cu	0.5	
Fluorine	F	0.5	
Iron	Fe	0.5	
Lead	Pb	0.5	
Lithium	Li	0.5	
Magnesium	Mg	5.0	
Manganese	Mn	0.5	
Mercury	Hg	0.5	
Molybdenum	Mo	0.5	
Nickel	Ni	0.5	
Phosphorus	P	25.0	
Potassium	K	1.0	
Selenium	Se	0.5	
Silicon	Si	0.5	
Sodium	Na	5.0	
Sulphur	S	15,000	
Tin	Sn	0.5	
Vanadium	V	15,000	
Zinc	Zn	0.5	

Harmful

Lightly Harmful

Strongly Harmful

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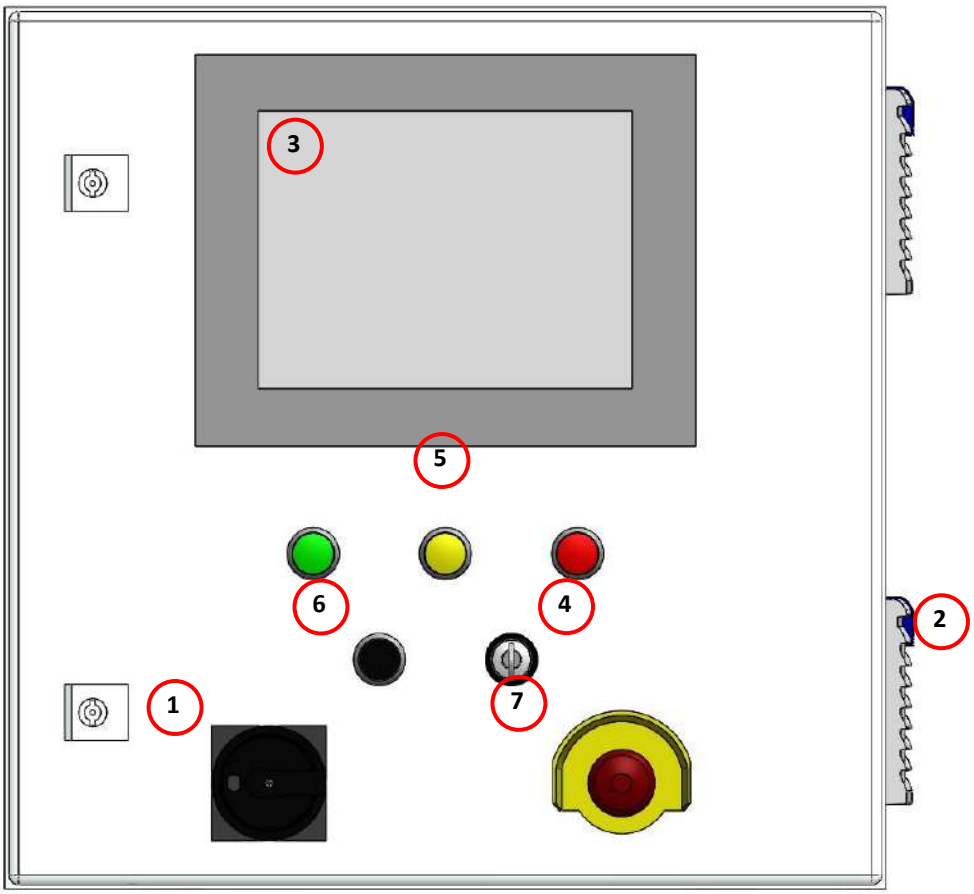
7. CONTROL SYSTEM

7.1. Control Cabinet Outside



Position	Description	Code
1	400V Power Supply Main Switch (ON – OFF)	1S1
2	Cabinet Cooling Fan	4G3
3	Control Screen (HMI)	2U5
4	Key switch; System OFF/AUTO	3S0
5	Status Indicator Lights: Operational Warning Alarm	 3L1 3L2 3L3
6	Reset Button	3S4
7	Emergency Stop	1S6

DO NOT switch off the 400V power supply while the engine runs!

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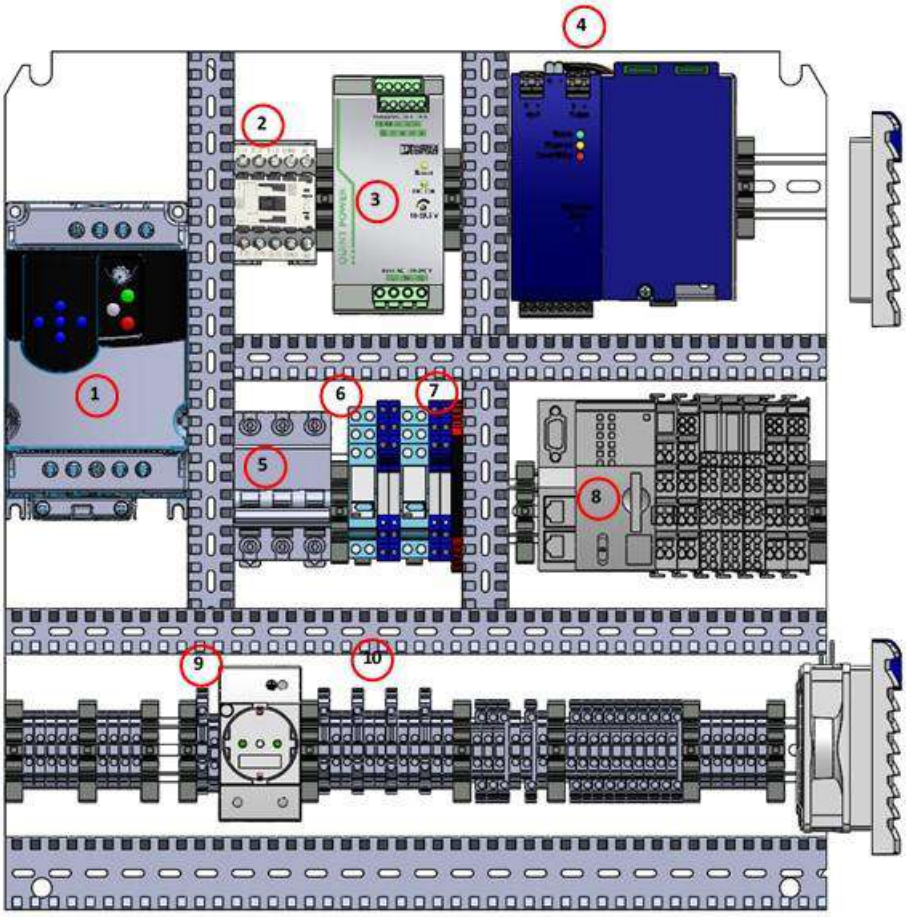
7.2. Control Cabinet Inside



1	Frequency Drive	1FQD1
2	3 Phase Power Relay	1K1
3	Power Supply 3x400V ~ 24VDC	2PWR1
4	UPS 24VDC (Contains Battery)	2UPS3
5	Main Breaker 3x400V	1F1
6	Component Relays: Ignition Coil Burner Valve Head Valve Fuel Pump Fuel Pump Motor Warning Alarm	 4K3 4K4 4K5 4K6 4K8 4K9
7	Signal Converters: Engine Load Signal (0-10V > 4-20mA) Flame Sensor Signal (Lin. R > 4-20)	 3PR1 3PR2
8	PLC	2PLC7
9	230VAC Socket	1SC1
10	Power Fuses Components: Ignition Coil (6.3A) Burner Valve Head (1A) Valve Fuel Pump (1A) Fuel Pump Motor (6.3A)	 4F4 4F5 4F6 4F7

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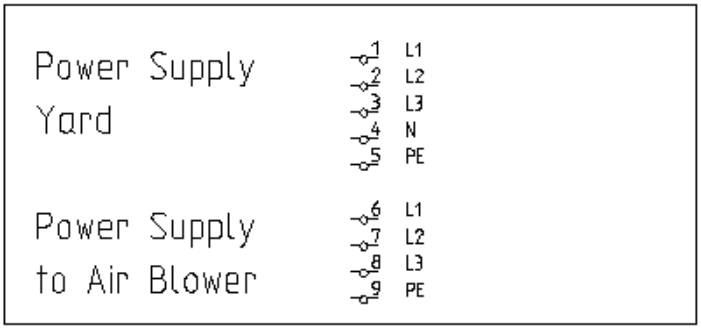
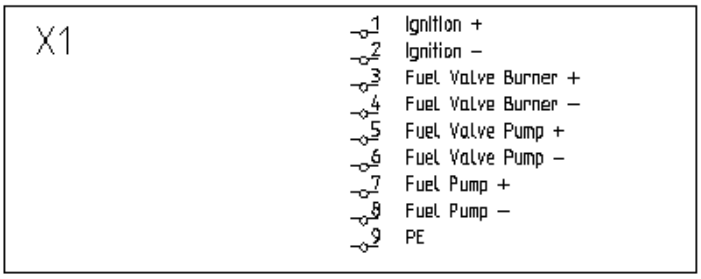
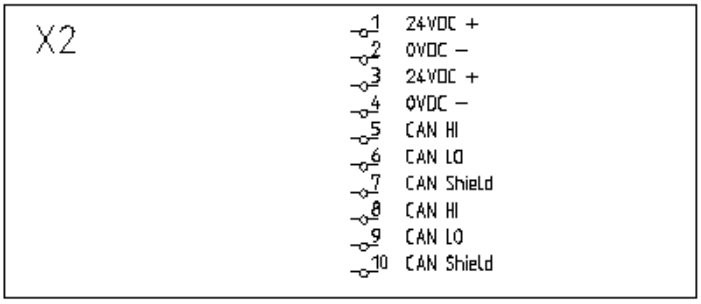
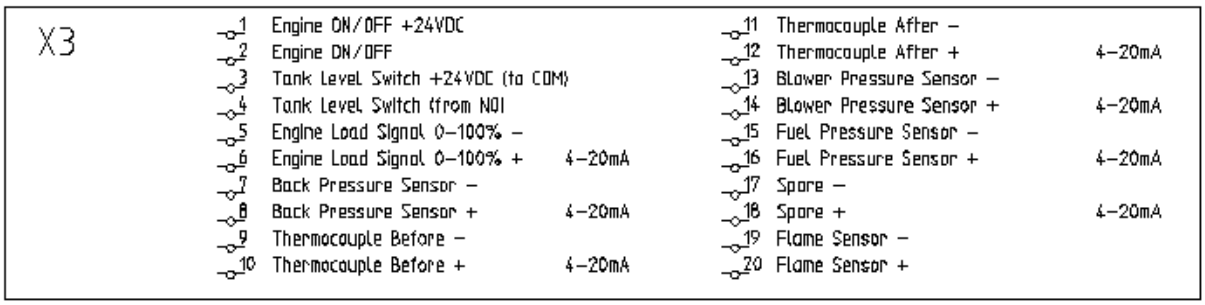
7.3. Terminal Connections

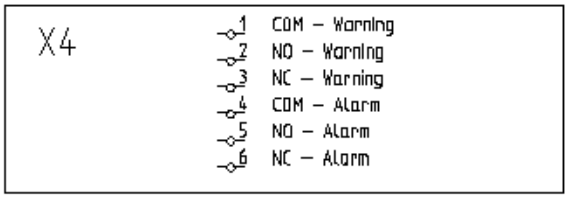
Terminal groups are indicated on the inside of the control cabinet.











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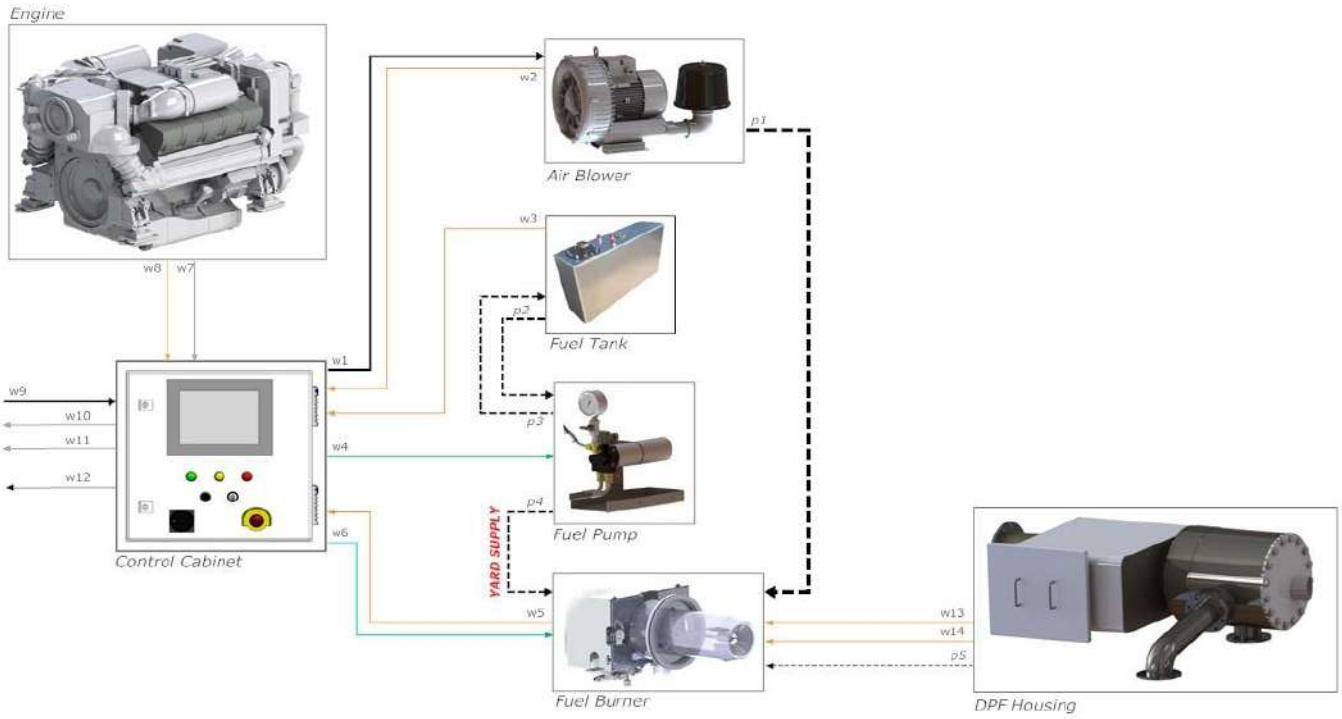
7.4. Cabling overview DPF system



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7.5. HMI Communication

Direct Human Machine Interface (HMI) is facilitated by the touch screen located on the door of the control cabinet.

The control panel is configured to boot automatically into the Home Screen.

7.5.1. Control System

Control of the system is managed by a PLC located in the control cabinet. The PLC is programmed to:

- Compute the data received from the sensors
- Activate the components required to operate the fuel burner system
- Indicate and store system related data, alarms and warnings and
- Ensure safe and reliable operation under all circumstances

DO NOT power the system if the control screen is disconnected

7.5.2. Fuel Burner System Activation

Fuel burner operation is triggered by:

- Backpressure signal (backpressure limit reached; pre-set value)
- Timer (time to next regeneration elapsed; pre-set value)

7.5.3. Preconditions for Fuel Burner Start

- Power supply, 400V, available
- Key switch in **AUTO** position
- Engine runs
- No Warnings or Failures indicated on the screen

7.5.4. System Checks

- Fuel available
- Air blower running
- Flame quality and stability

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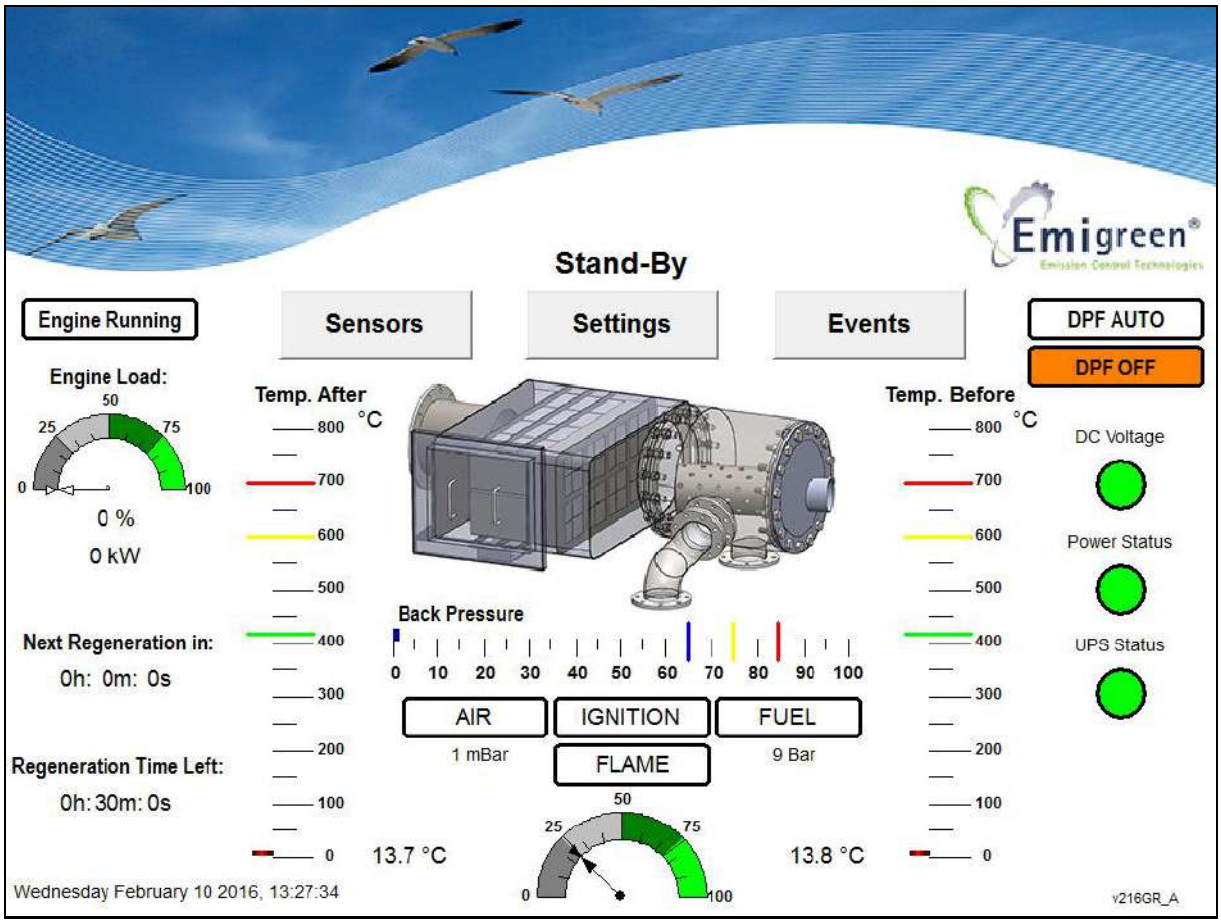
7.6. Control Screens

The communication between the operator and the system is arranged through the HMI screen.

As default, as soon as the system is active, the Home screen appears showing the diagram of the system.



From this screen the operator may select one of the following screens:

- Sensors
- Settings
- Events

The function and information offered by each screen are explained in the following chapters.

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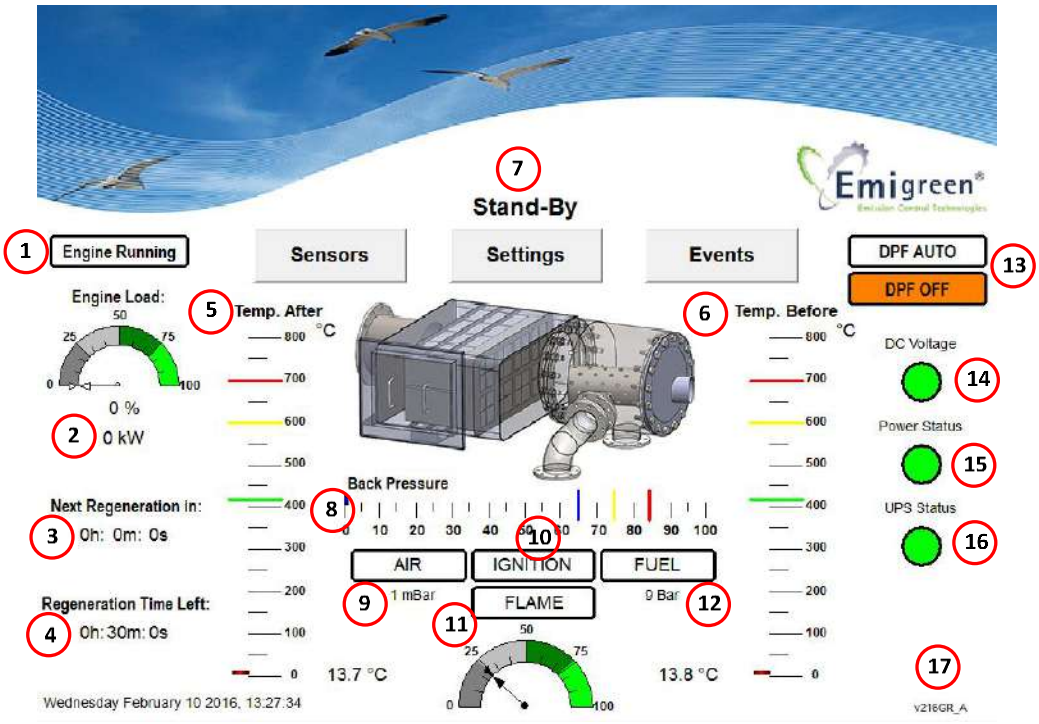
7.6.1. Home Screen

The Home Screen appears by default and displays an overview of the system.



1. Engine On lights green when the engine is operating
2. Indicates the engine load in % of rated power and kW
3. Count down indicator: shows the remaining time until the next burn cycle (timer trigger)
4. Count down indicator: shows regeneration time that is remaining
5. Displays the temperature **after** the filter elements:
   a. Green bar: Regeneration Temperature
   b. Yellow bar: Warning Temperature
   c. Red bar: Alarm Temperature
6. Displays the temperature **before** the filter elements:
   a. Green bar: Regeneration Temperature
   b. Yellow bar: Warning Temperature
   c. Red bar: Alarm Temperature
7. System status indicator
8. Displays the backpressure measured before the filter elements:
   a. Blue bar: Regeneration trigger pressure
   b. Yellow bar: Warning pressure
   c. Red bar: Alarm pressure
9. Lights green when the blower is running, with pressure displayed below
10. Lights green when the ignition is firing. (only during burner start-up)
11. Lights green when the flame is detected, quality of signal indicated on scale
12. Lights green when fuel nozzle is pressurised, pressure indicated below
13. Lights green when system is active (regeneration possible)
14. Indicated DC voltage in range
15. Indicates power consumption nominal
16. Indicates UPS status
17. Software version number

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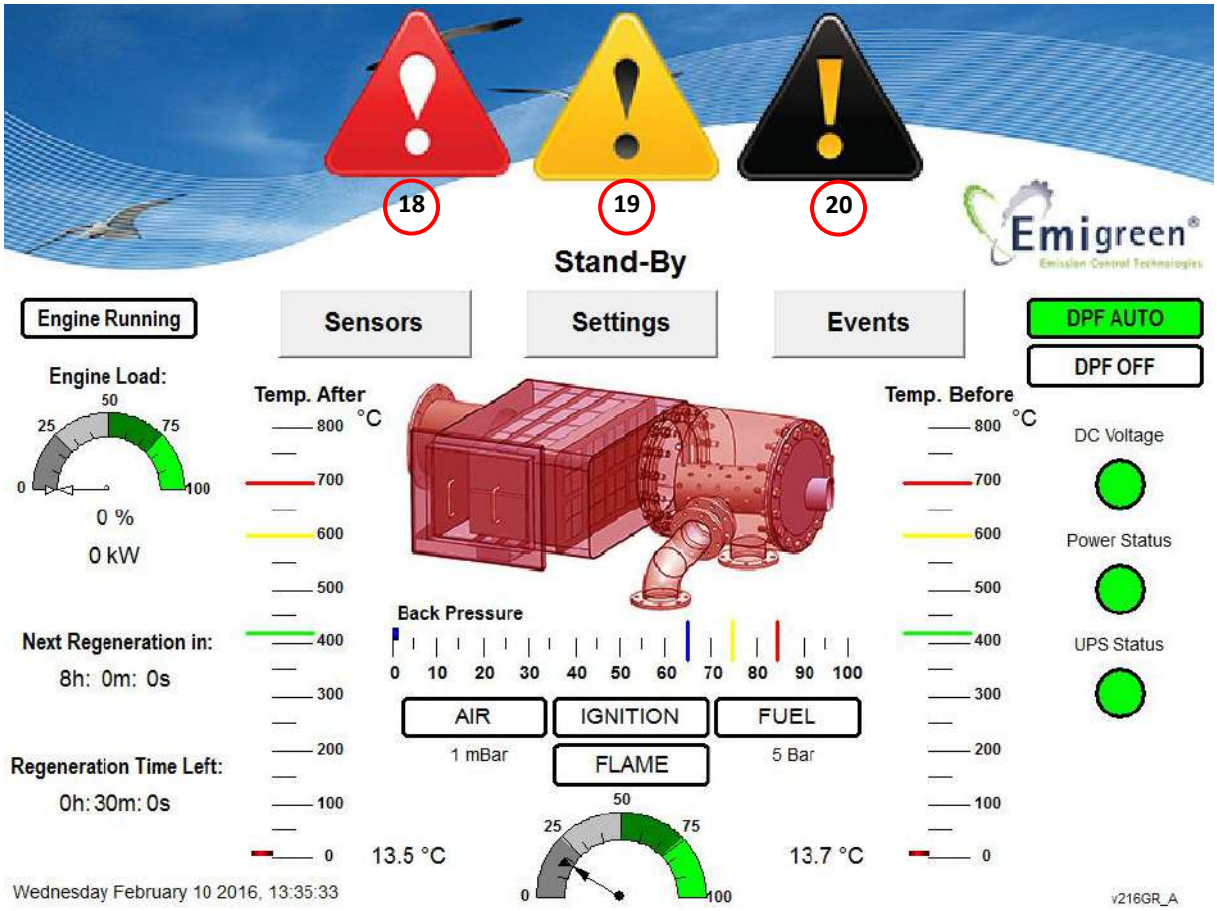

18. Alarm indicator
19. Warning indicator
20. Failure indicator

ALARM, WARNING and FAILURE indicators are displayed on every page
Pressing the indicator will short cut to the event page

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7.6.2. Status Indicator

The Status Indicator provides information on the current activity.

The Status Indicator may read:

- **Standby** The system is ready for operation
- **Purging** Continuous air supply to keep the burner head components clean and cool
- **Cooling** Air supply to ensure head components are cooled down after burn cycle completion
- **Sequence** Burner start-up procedure and safety checks
- **Heating** Burner supplies energy to bring the reactor temperature to filter regeneration temp
- **Regenerating** Burner supplies energy and the filter is regenerating

Status	Engine	Air Supply	Fuel Supply	Fuel Burner
Standby	Off	Off	Off	Off
Purging	On	On	Off	Off
Start-up	On	On	Start-up	Start-up
Heating	On	On	On	On
Regenerating	On	On	On	On
Cooling	Off	On	Off	Off

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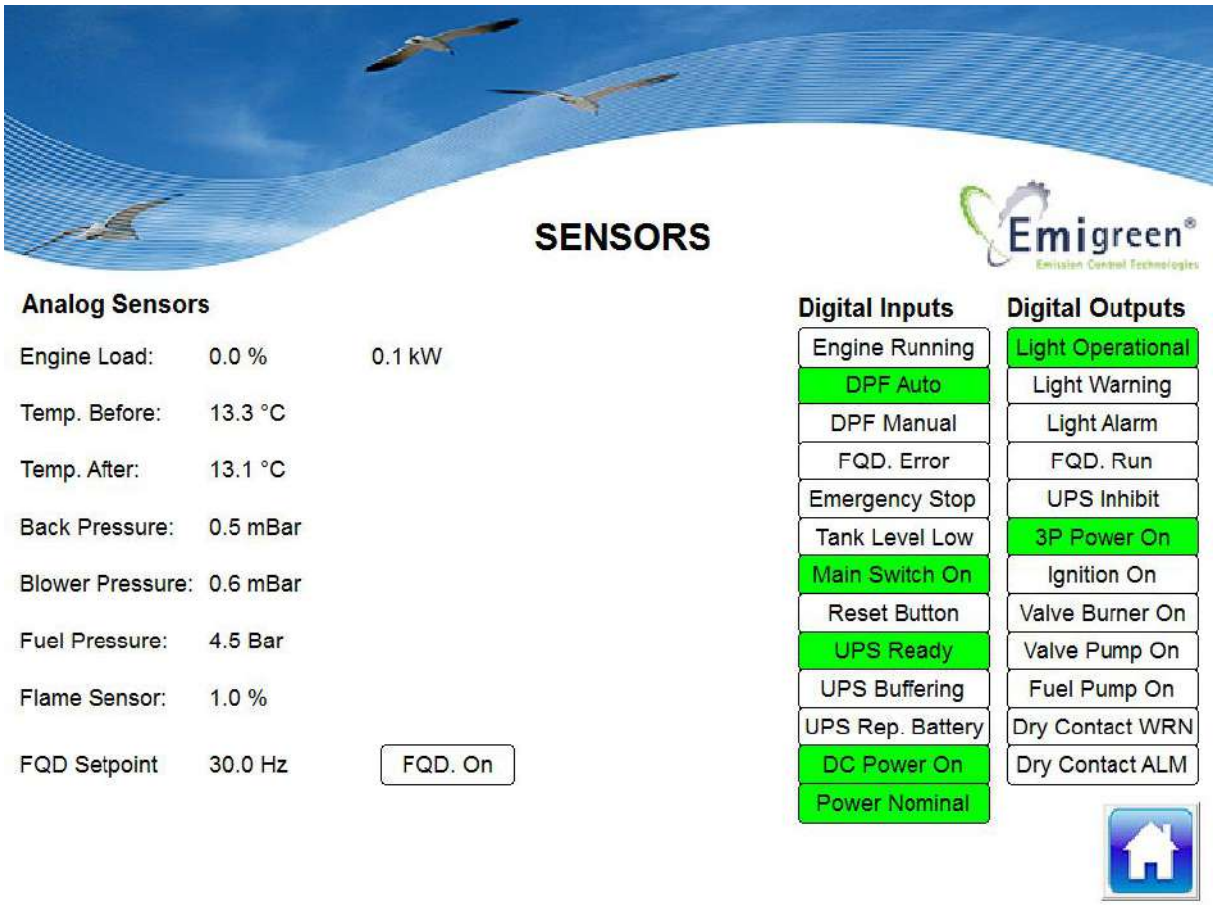
7.6.3. Signal Screen

Displays collected or computed data (digital or analogue) offered by the system's sensors.



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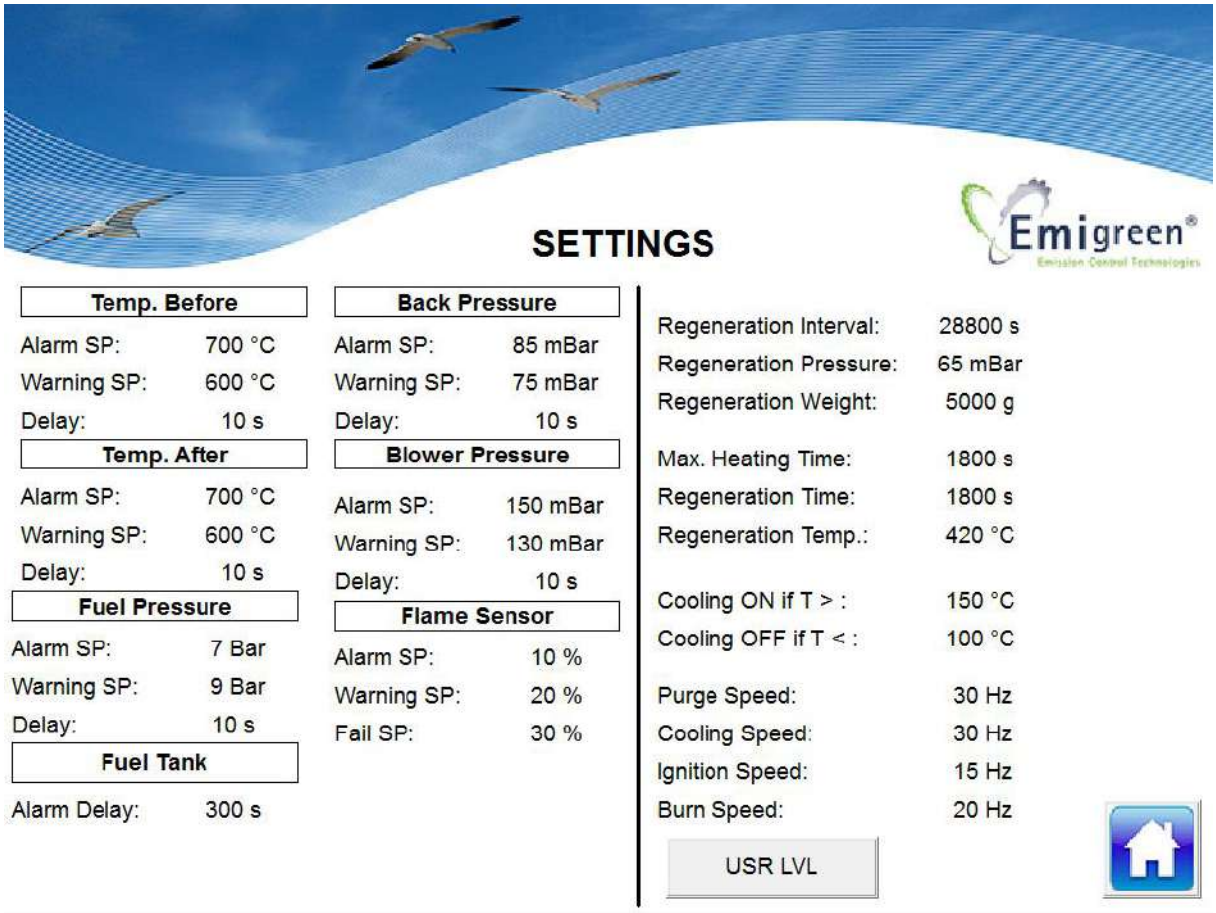
7.6.4. Settings Screen

This screen displays the current settings of the burner control system.



The default values are defined and set during Factory Acceptance Tests (FAT) and system commissioning.

To change a setting requires a higher access level
USER LVL offers access to higher user level (password required)

Regeneration interval	The period between subsequent timer triggered regenerations
Regeneration pressure	The backpressure value to trigger regeneration
Regeneration weight	The weight of collected soot to trigger regeneration
Maximum heating time	The maximum timespan allowed to reach regeneration temperature
Regeneration time	The time one regeneration takes
Regeneration temperature	Indicates the filter temperature at with regeneration occurs
Cooling ON temperature	Indicates the temperature above which cooling is activated
Cooling OFF temperature	Indicates the temperature at which cooling air supply stops
Purge Speed	The Frequency drive set point for purging
Cooling Speed	The Frequency drive set point for cooling
Ignition Speed	The Frequency drive set point while ignition is firing
Burn Speed	The Frequency drive set point while burner is on

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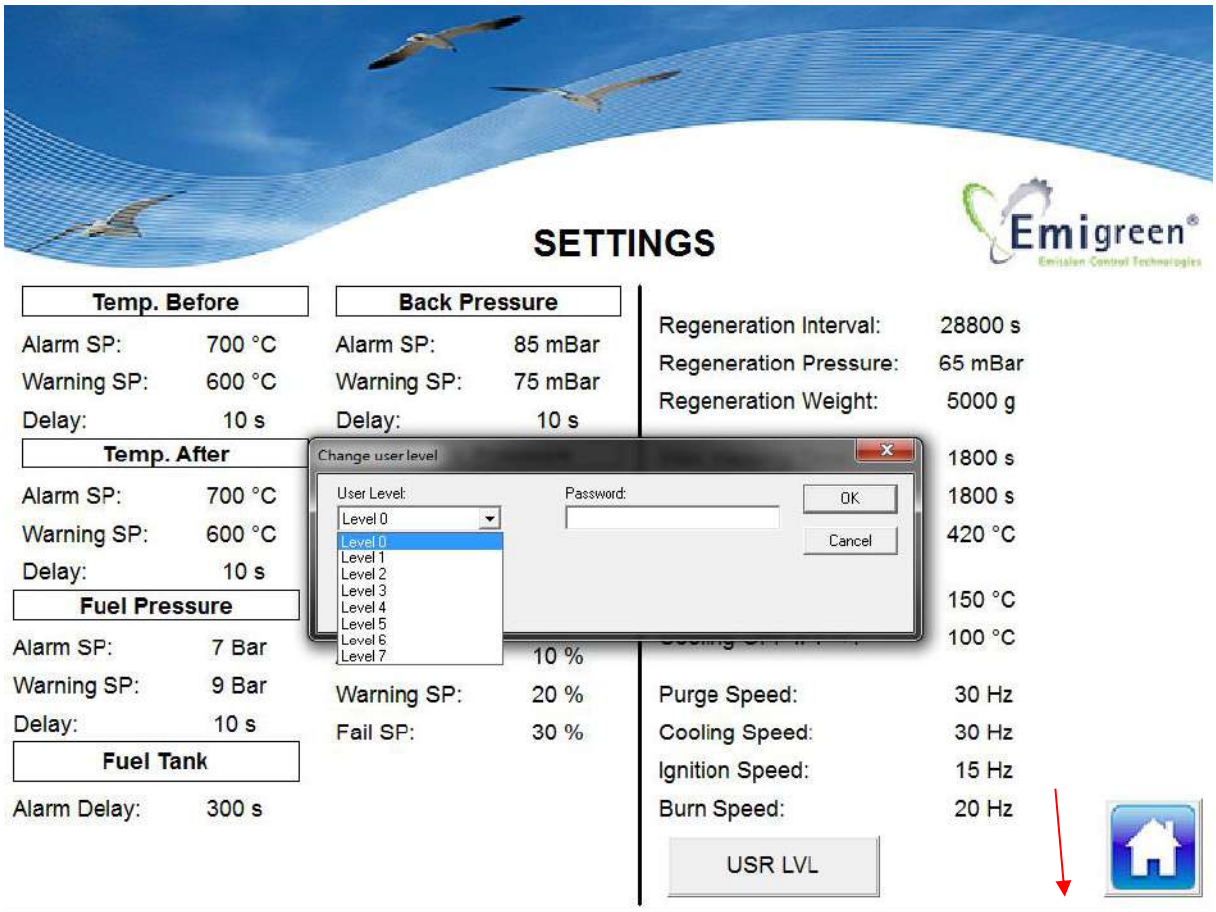
The passwords for logging into higher user levels are listed below:

Level	Password	Function
0	a	Disable higher level functions
1	Name ship	Change parameters on settings page
2	See Appendix A	Enable Manual Operation *(Only for qualified operator)*
7	ON REQUEST	Full access *(only after consulting Emigreen®)*



To fill in the password the on screen keyboard needs to be called. This can be done by pressing on the bottom of the page (indicated by the red arrow): the task bar will come up. The right most icon on the taskbar will show the option to enable / disable the input panel.

Always return to user level 0 for safe operation

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7.6.5. Events Screen

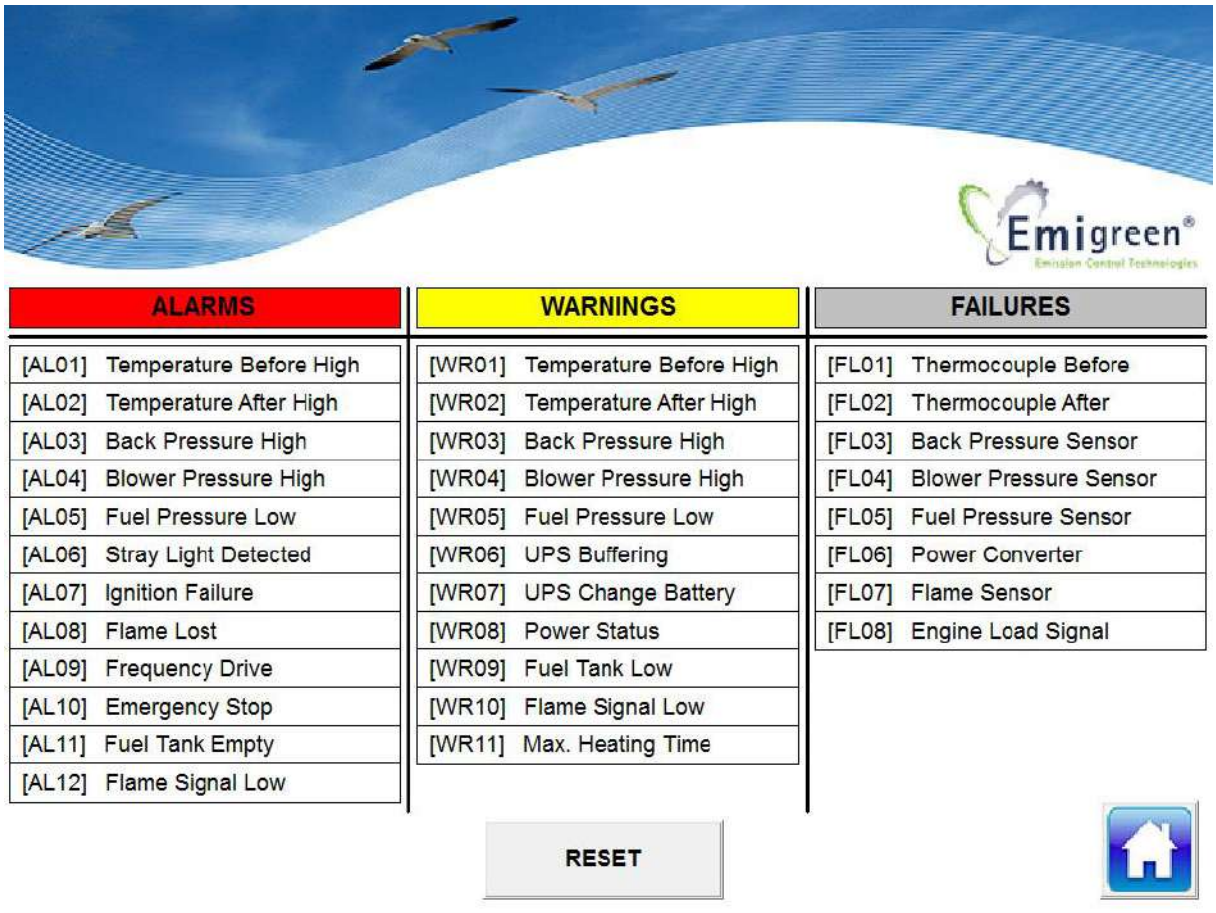
This screen displays an:

- **Alarm** or **Failure**, coded ALxx / FLxx, line coloured red / grey or
- **Warning**, coded WRxx, line coloured yellow

Each line indicates the date and time at which the Event occurred.

To use the **Reset** function, the Event needs to be confirmed by the **Accept** button.

As soon as the cause of the *Event* is resolved, the line with relevant information will be white again. The exception is: **AL06, AL07, AL08**. These alarms need to be reset by the operator with the software reset button or the hardware reset button on the cabinet door.



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7.7. Alarms

Symbol:

Definition: An **Alarm** indicates an *Event* which requires **immediate attention**!

Occurrence An Alarm is generated when the value transmitted by a sensor is beyond the defined range for safe operation.

List of Alarms

Code	Signal	Possible Cause
AL01	Temperature Before High	Burner on while engine off Insufficient exhaust gas flow Incorrect alarm set point
AL02	Temperature After High	Burner on while engine off Insufficient exhaust gas flow Incorrect alarm set point
AL03	Back Pressure High	Clogged filter elements Incorrect alarm set point
AL04	Blower Pressure High	No-return valve stuck Air supply piping blocked Incorrect alarm set point
AL05	Fuel Pressure Low	Fuel Pump Broken Fuel Pump Motor Broken Fuel Pump Valve Broken Fuel Piping Blockage Incorrect alarm set point
AL06	Stray light	Damaged flame sensor Burner head not gas tight installed Flame sensor detects light, incorrect installed
AL07	Ignition failure	Ignition transformer failure Damaged ignition leads Damaged ignition electrodes Incorrect air supply settings
AL08	Flame loss	Damaged or fouled flame sensor Loss of fuel supply Loss of air supply Loss of power supply
AL09	Frequency Drive	3 Phase Power not supplied to frequency drive Frequency drive overcurrent/voltage Reset frequency drive inside cabinet
AL10	Emergency Stop	Emergency stop pressed
AL11	Fuel Tank Empty	Level switch triggered and delay for alarm passed Level switch broken / incorrect wiring
AL12	Flame Signal Low	Fouled flame sensor Incorrect alarm set point

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7.8. Failures

Symbol:

Definition: A **Failure** indicates malfunction of a system component which requires **immediate attention**!

Occurrence Assessment of the integrity of the signals transmitted by the sensors is an essential part of the required conditions for the system to start.

Damage of a sensor or wiring, will generate a Failure.

List of Failures

The list below indicates the involved sensors and location. Refer also to Chapter “Sensors and Sensor Location”.

Code	Signal	Sensor location
FL01	Thermocouple Before	Filter Housing
FL02	Thermocouple After	Filter Housing
FL03	Back pressure sensor	Burner head
FL04	Blower pressure sensor	Blower Unit
FL05	Fuel pressure sensor	Burner head
FL06	Power Converter	Inside Control cabinet (1PWR1)
FL07	Flame Sensor	Burner head
FL08	Engine Load Signal	MTU Controller Cabinet

Flame Sensor Failure and Engine Load Signal Failure are only detected when sensor values are out of bounds
A broken sensor will give a zero read-out on the panel

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7.9. Warnings

Symbol:

Definition: A Warning indicates an incident which does not necessarily affect the function of the system but needs to be analysed and if necessary be attended and rectified within reasonable time.

Occurrence A control signal exceeds a set value. Non-critical system failure.

Some warnings are reset automatically

List of Warnings

Code	Signal	Possible Cause
WR01	Temperature Before High	Burner on while engine off Insufficient exhaust gas flow Incorrect warning set point
WR02	Temperature After High	Burner on while engine off Insufficient exhaust gas flow Incorrect warning set point
WR03	Back Pressure High	Clogged filter elements Incorrect warning set point
WR04	Blower Pressure High	No-return valve stuck Air supply piping blocked Incorrect warning set point
WR05	Fuel Pressure Low	Fuel Pump Broken Fuel Pump Motor Broken Fuel Pump Valve Broken Fuel Piping Blockage Incorrect warning set point
WR06	UPS Buffering	Main Power Failure: UPS is activated
WR07	UPS Change Battery	Battery UPS low / broken
WR08	Power Status	Current drawn by the system too high, faulty components
WR09	Fuel Tank Low	Level switch triggered. Alarm counter started
WR10	Flame sensor signal low	Flame sensor sight glass fouled Incorrect warning set point
WR11	Maximum Heating Time	Burner could not reach regeneration temperature within pre-set time Incorrect warning set point

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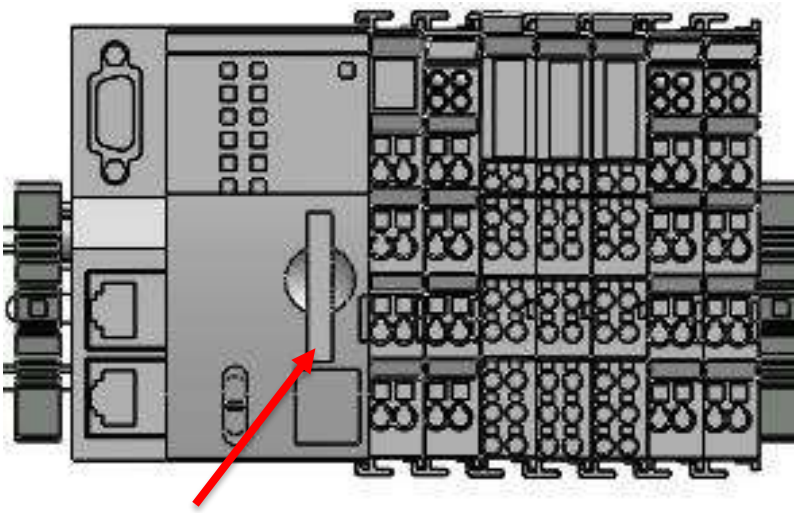
8. LOG FILES

8.1. Data logs

The controller logs all events and sensor values while the engine is running. The data is written to an SD-Card located inside the PLC.

To extract the data the cover can be opened (indicated by the red arrow) and by slightly pushing the card, the card can be extracted.



SD-Card - DATALOGS

Data on the SD-Card is divided into 2 csv files:

NAME_LOGS	Contains all sensor values
NAME_EVENTS	Contains events that the controller registered

Data on the SD-Card can be removed after copying to another medium
This will prevent filling the card to maximum capacity

Emigreen® provides data log analysis service
It is advised to submit data regularly, at least every 1000 engine hours
Logs can be sent to: logs@Emigreen.eu

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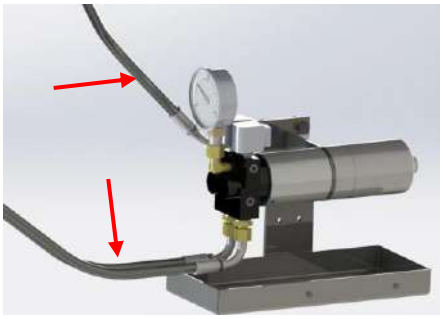
9. ROUTINE INSPECTION

9.1. Daily

9.1.1. Fuel supply

Inspect visually the fuel supply on leaks. Particularly pay attention to the:

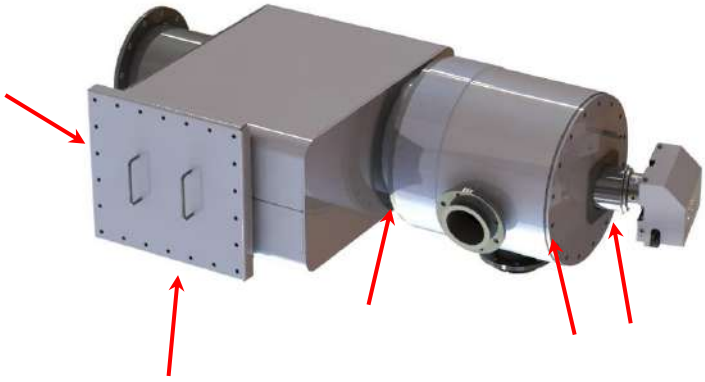
- Connections
- Flexible hoses
- Supply line filter(s)



9.1.2. DPF housing/exhaust gas silencer

Inspect visually the silencer/DPF housing on exhaust gas leaks. Particularly pay attention to the:

- Fuel burner head connection to the silencer
- The access hatches to the soot filters and the acoustic modules
- Flange connections between silencer chambers



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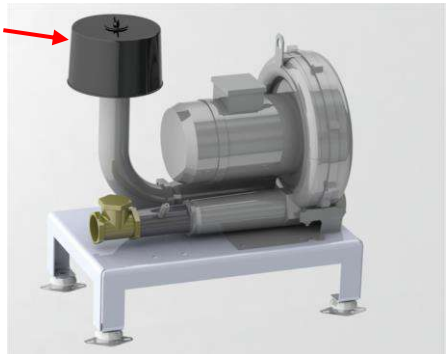
9.2. Every 1 month

9.2.1. Air supply unit

Inspect the blower air intake filter

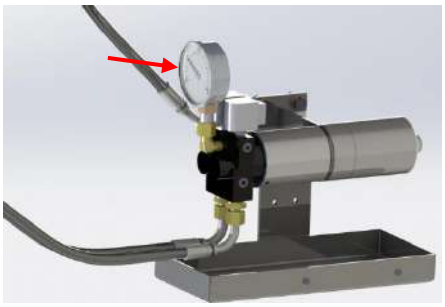


9.2.2. Fuel supply

Check the fuel supply pressure

Fuel burner is in operation

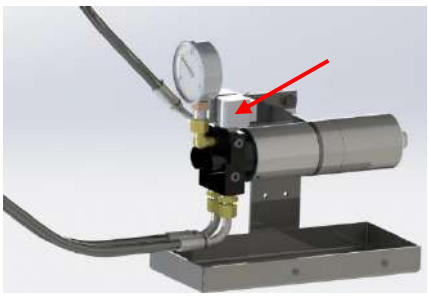
Compare reading of pressure gauge at the supply pump, the displayed value on the control cabinet of the fuel pressure at the burner head and value set at commissioning or last service.



Check the integrity of the fuel cut-off valves

Fuel burner is out of operation.

The pressure gauge at the supply pump should indicate a remaining pressure. In case of no pressure, proceed with fuel cut-off valve maintenance.



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9.2.3. Flame sensor

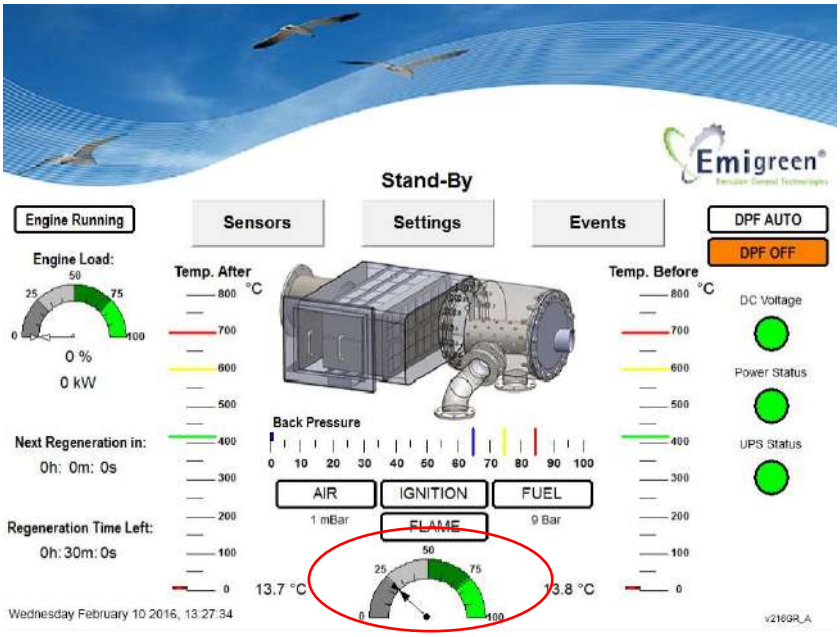
Check the quality of the flame sensor signal

Fuel burner is in operation

On the HOME screen the flame sensor signal quality is located at the bottom of the screen.

Flame sensor __ % is indicated with a virtual gauge.

Reading must be higher than 50%. If lower, clean/renew the light sensor and sight glass.



9.3. Every 3 months

9.3.1. Control cabinet

- Ensure the cooling fan of the control cabinet operates correctly (Can be done by adjusting the temperature setting on the thermostat inside of the cabinet)
- Inspect the cooling air inlet filter of the control cabinet
- Inspect the power supply terminals

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9.4. Every 12 months

9.4.1. Control cabinet

- Inspect the power supply terminals
- Ensure that the terminals and bus bars are free of corrosion
- Ensure proper functioning of the emergency stop
- Renew the cooling air inlet filters of the cabinet
- Download the data from the data logger

9.4.2. Burner head

Remove the burner head

- Inspect the connection flange on damage
- Inspect the V-clamp profile, thread and nut on damage. Renew if necessary
- Renew the flame sensor
- Renew the fuel nozzle
- Renew the ignition electrodes
- Inspect and if necessary, renew the ignition leads
- Clean the sight glass
- Clean the retention plate
- Check proper functioning of the fuel cut-off valve. Renew if necessary

9.4.3. Fuel pump

- Remove and clean/renew the fuel filter

9.4.4. Air supply

- Clean/renew the air intake filter
- Ensure that the non-return valve functions properly
- Inspect the anti-vibration mounts of the air supply skid

9.4.5. Emission measurements

- Measure and register O_2, CO and/or CO_2 content and temperature in the burner exhaust gas
- Perform soot emission measurement

9.4.6. Soot filter element

- Inspect the filter elements on mechanical damage
- Inspect the filter outlet surface (clean side) on damages

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10.COMPONENT INSPECTION

10.1. Burner Head

Safety Instructions

- **Ensure that the engine cannot start**
- **Switch off the power supply to the burner and secure it from being switched on un-intentionally**
- **Ensure that the system has cooled-off**

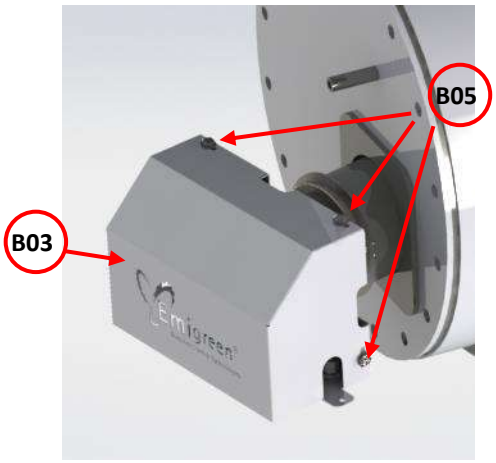
Access to:

- Ignition transformer
- Spark leads
- Spark plugs
- Flame sensor
- Fuel cut-off valve

To gain access to these components requires removal of the burner head cover

10.1.1. Burner head cover removal

To remove the burner head cover, (**B03)**, remove the four screws, (**B05)**, spanner size 8



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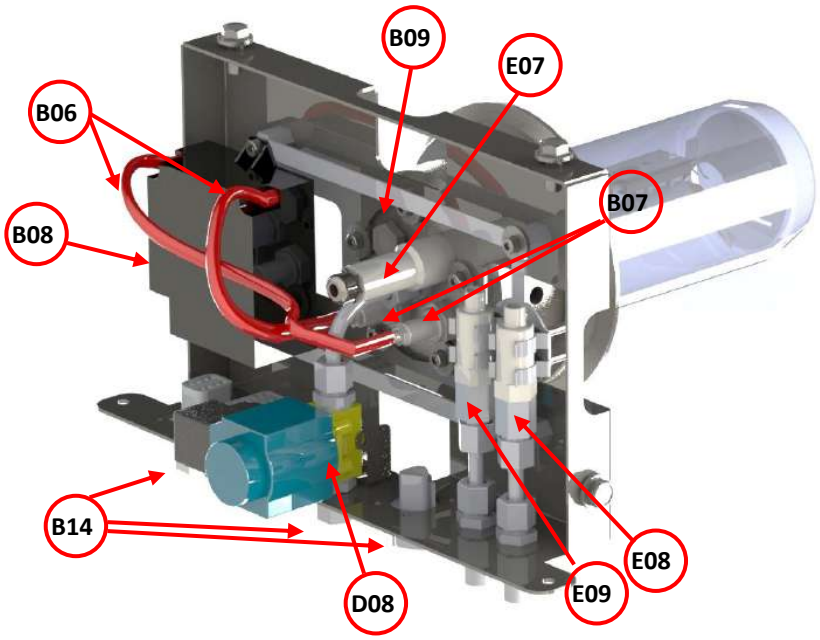


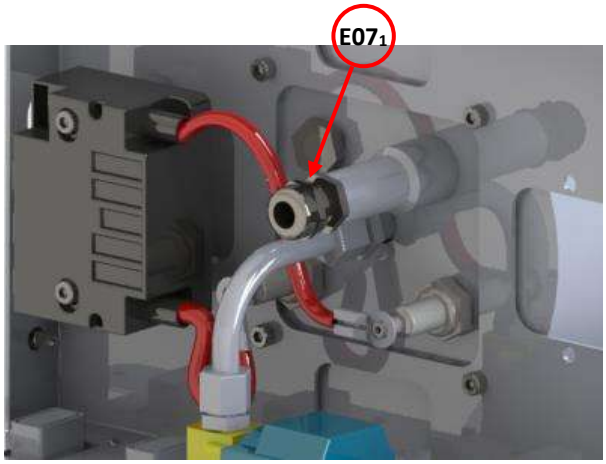
Position	Description
B06	Ignition wires (external)
B07	Spark plug
B08	Ignition transformer
B09	Sight glass
C06	Air supply flexible
D07	Fuel supply flexible
D08	Fuel cut-off valve
E07	Flame sensor
E08	Fuel pressure sensor
E09	Back pressure sensor
B14	Wiring connectors

10.1.2. Flame Sensor

Release the sensor wires from the cable plug

1. Release gland (**E07₁**)
2. Pull the sensor cell out of the housing

Reassemble in reverse sequence



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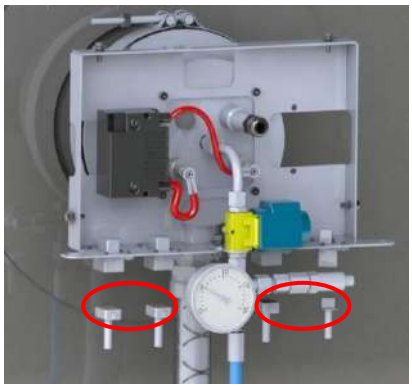
10.1.3. Burner head removal

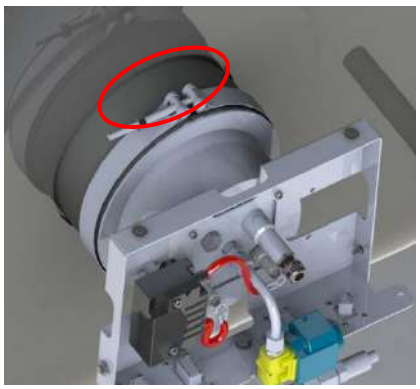
To remove the burner head:

1. Disconnect cable plugs (4x)

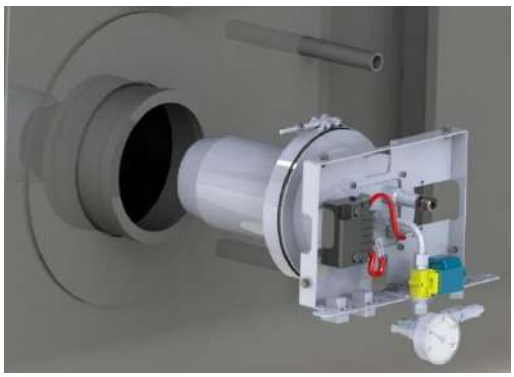


2. Disconnect air and fuel supply

3. Release V-clamp nut



Pull the burner head assembly out of the housing/silencer



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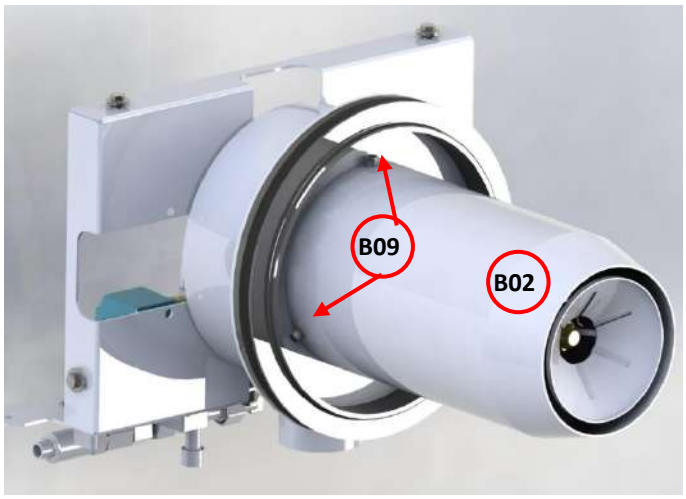
10.1.4. Access to:

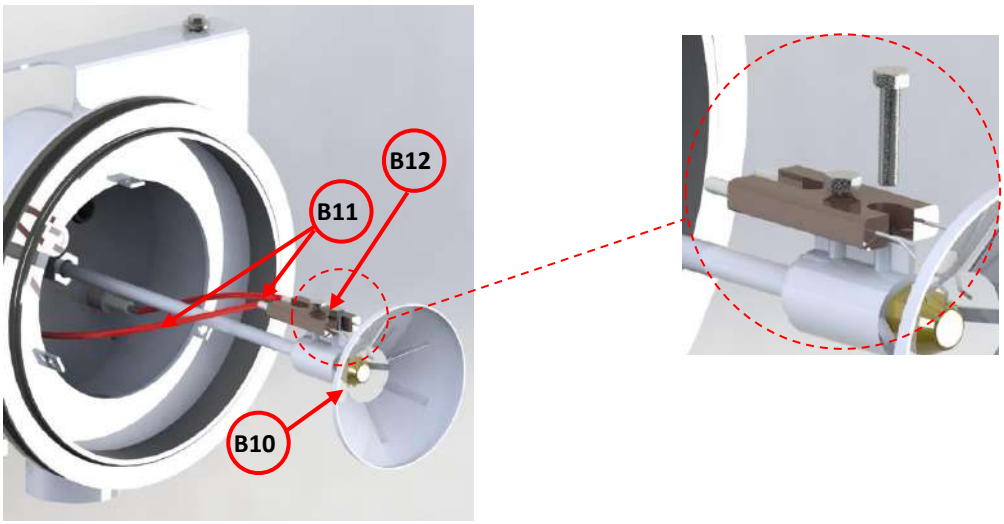
- Spark leads (internal)
- Ignition electrodes
- Fuel nozzle

To gain access to these components, requires removal of the burner tube (**B02**)
To remove the burner tube remove the (3) screws (**B09**)



To remove the retention plate (**B10**):

- Remove the ignition wires (**B11**)
- Remove screw (**B12**)



- Pull the retention plate and ignition electrode assembly away from the nozzle holder

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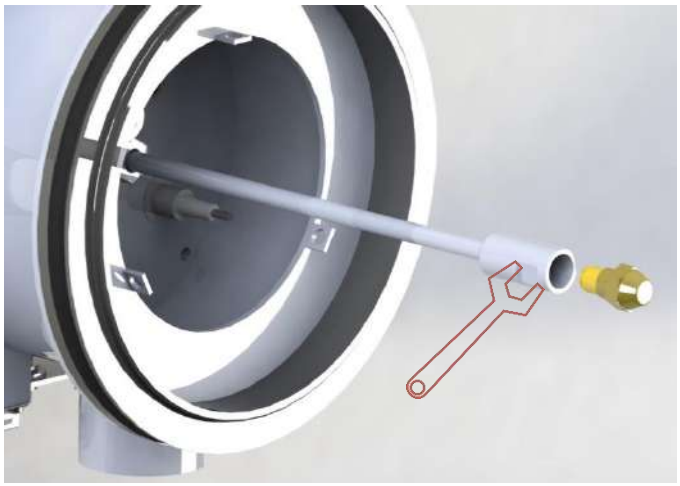
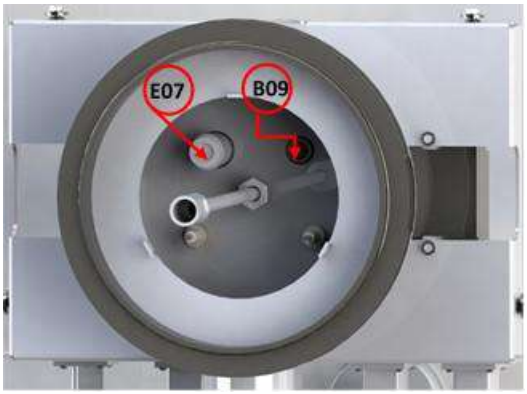
To remove the ignition electrodes remove the screw (**B13**)

To remove the fuel nozzle hold the nozzle holder with a spanner and use another spanner to unscrew the nozzle



10.1.5. Before reassembly

- Clean the sight glass (**B09**)
- Clean the flame sensor glass (**E07**)
- Clean the burner head, burner tube and retention plate



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10.1.6. Reassembly

10.1.6.1. Nozzle installation

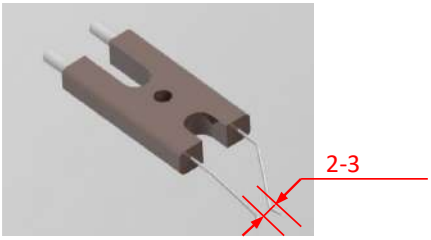
Always use a new nozzle

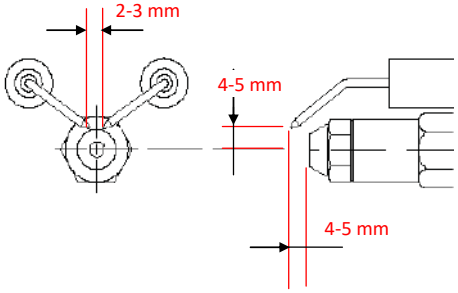
Attention! Handle the nozzle with care

The lightest dent or scratch will affect the burner performance

- Install the nozzle hand tight
- Fasten to **maximum torque 25 Nm,** or **further turn ⅛**

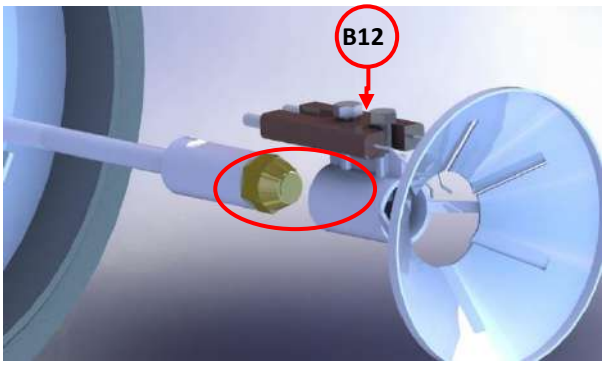
10.1.6.2. Ignition electrodes gap





10.1.6.3. Reassembly of the burner head internals

- Install the ignition electrodes on the retention plate
- Shift the retention plate/ignition electrode assembly over the nozzle holder
- Ensure that the flat part of the nozzle holder is parallel to the ignition electrode



- Secure the retention plate assembly with screw (**B12**)
- Install the ignition cables
- Install the burner tube and secure with the (3) screws

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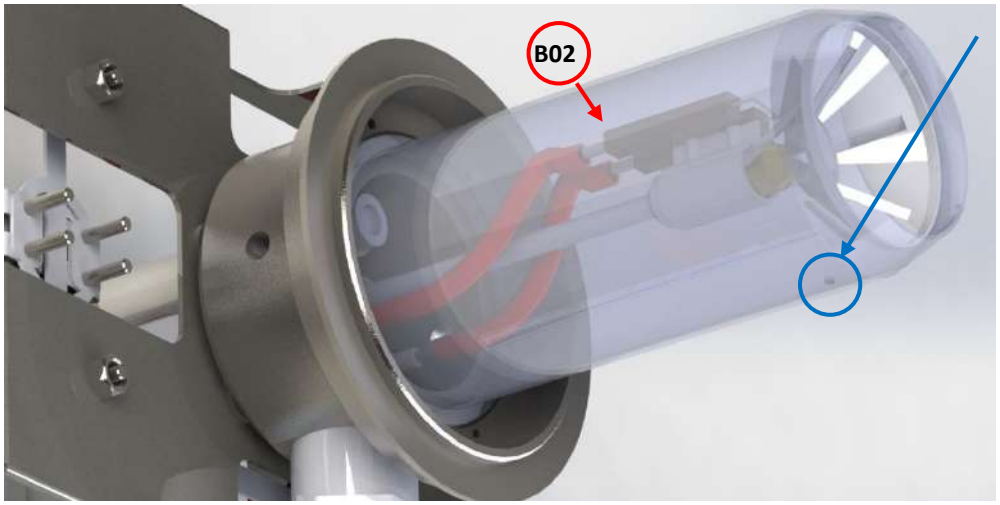
- There is a **small hole** in the burner tube (**B02**) to release fuel from nozzle drip
  This **hole** must be facing downwards. See image underneath



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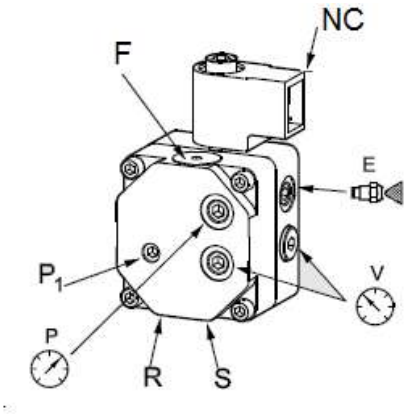
10.2. Fuel Pump



Position	Description	Connection
F	Cartridge filter	
P_1	Pressure regulator stage 1	
NC	Solenoid valve	
R	Return line	G ¼
S	Suction line	G ¼
P_1	Pressure gauge connection	G ⅛
V	Vacuum meter connection	G ⅛

10.2.1. Fuel Pump Filter Replacement

1. Remove filter plug (**F**)
2. Pull out the filter cartridge. If necessary, use a screwdriver to carefully twist the cartridge from the plug
3. Press the new filter cartridge on the plug
4. Reassemble and tighten slightly

10.2.2. Solenoid Valve Replacement

Renew the solenoid valves every 6 years

- (**NC)** on the fuel pump and
- (**B08**) on the burner head

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10.2.3. Nozzle Pressure Setting

To adjust the nozzle pressure use a 4mm Hex key

To increase the pressure turn clockwise, to reduce the pressure anti-clockwise

(**P1**) adjusts the pressure of the fuel pump feed line

Fuel pressure at the burner head, displayed on the controller cabinet is leading!

10.2.4. Nozzle Cut-off Test

After burner shut down the pressure reading at the pressure gauge should stabilise at 6 bar or higher and hold for at least 2 minutes

Rapid decrease in pressure indicates

- **Worn cut-off valve or,**
- **Fuel supply line leak**

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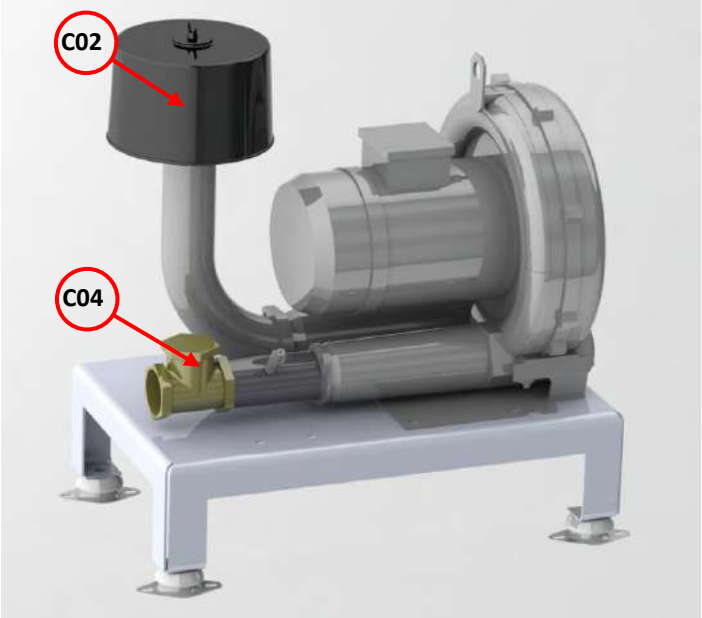
10.3. Air Supply

Maintenance of the air supply system mainly concentrates on:

- Cleaning/exchanging of the air supply filter at the blower and
- Cleaning of the non-return valve on the supply line of the blower



Position	Description
C02	Air intake filter cover
C04	Non-return valve

10.3.1. Air Intake Filter Replacement

To access the air intake filter, remove cover (**C02**)

Replace cover after cleaning/exchange

10.3.2. Non-return valve cleaning

Remove the flexible pipe downstream the valve

Inspect and clean the valve

Ensure the valve can open and close freely

Reconnect the flexible pipe

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10.4. Filter cleaning

10.4.1. Introduction

Diesel soot mainly consists of carbon particles, lube oil solid residue, ash remainders and metal wear and tear particles held together by unburned hydrocarbons. The adhesive property of unburned hydrocarbons prevents easy removal of the collected matter.

Regenerated filters are in general dry, free of sticky residue and allow easier cleaning. It is therefore recommended to clean the filters short after a regeneration cycle.

10.4.2. Filter regeneration

Filter regeneration is defined to be the process during which the collected soot and the soluble organic fraction is combusted. During this process heat is released, which is observed through a higher temperature downstream the filter in comparison to upstream.

The temperature difference depends on the quantity of the collected combustible matter and the combustion rate. During continuous or almost continuous regeneration conditions, the temperature difference will be low, 10-50°C, whilst higher levels may be expected, >100°C, during forced regeneration of a well loaded filter.

In case filter service is planned and the filter is not regenerated, a regeneration cycle may be forced according the following procedure.

10.4.3. Forced regeneration procedure

1. Load the engine such that the maximum backpressure limit is not exceeded
2. Run the engine until the exhaust gas temperature downstream the filter is stable
3. Slightly increase the load such as backpressure will trigger regeneration cycle (burner start)
4. Wait until the downstream temperature reaches 420-450°C
5. Reduce the engine load to minimum or run the engine on idle
6. Allow the regeneration (burn) cycle to complete

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10.4.4. Safety

Before commencing work:

Ensure that the engine cannot start
Ensure that filter housing has cooled down

10.4.5. Personal protection

- Dust tight goggles and face mask
- Protective boots/shoes
- PVC/rubber gloves
- Protective clothing

10.4.6. Environment

Respect local environmental regulations and hazardous waste laws

In some countries the ash in a DPF may be classified as hazardous waste because in tests high levels of zinc, a hazardous substance, have been found.

Some countries require that you properly manage a hazardous waste. It is illegal to throw hazardous waste away in ordinary trash, or to dispose of hazardous waste by burying, blowing it into the air, or placing it into water or down the sewage system.

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10.4.7. Shop Cleaning

This procedure includes:

- Removal
- Cleaning
- Rearrangement of the filter elements

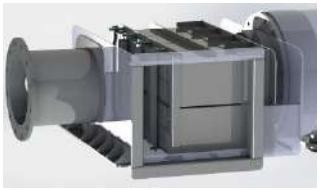
10.4.7.1. Required equipment

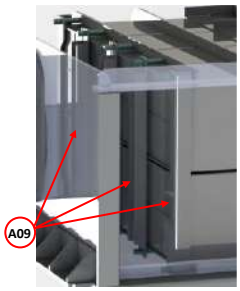
- Spanner 17, 19
- HEPA Vacuum cleaner
- Vacuum cleaner extension hose
- Scales
- Pressurised air gun

10.4.7.2. Procedure

1. Open the filter access hatch (**A03**)
   (Ensure the housing has cooled down, do not work on a hot exhaust system)

2. Release and remove the filter retention bars (**A09**)





3. Ensure that the number of each filter element is visible

   If the number is not visible, number the element with indelible marker or similar

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4. Use the matrix below to document the serial number and location of each filter element

Empty sheets are added at the end of this document

Access Hatch Side	1 ……..	2 ……..	3 ……..	4 ……..
	5 ……..	6 ……..	7 ……..	8 ……..

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5. Weigh each filter element and log

Empty sheets are added at the end of this document

10.4.7.3. Filter Log

Engine ..... Date.....

Hours of operation……

Filter serial No	Matrix Location	Weight	
		Before cleaning	After cleaning

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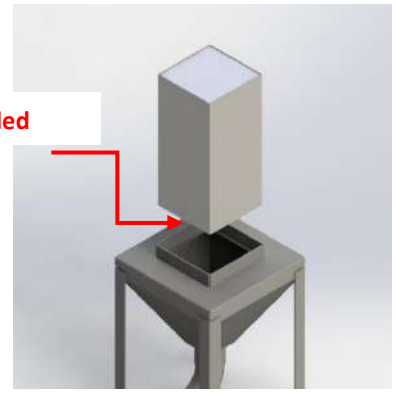
6. Insert a 1.5mm rod into a channel of the fouled side
    - 300-350mm; filter almost clean
7. Connect the HEPA vacuum cleaner hose to the cleaning table

   (In case there is no cleaning bench available, place filter element on side on a flat surface and follow the same procedure)

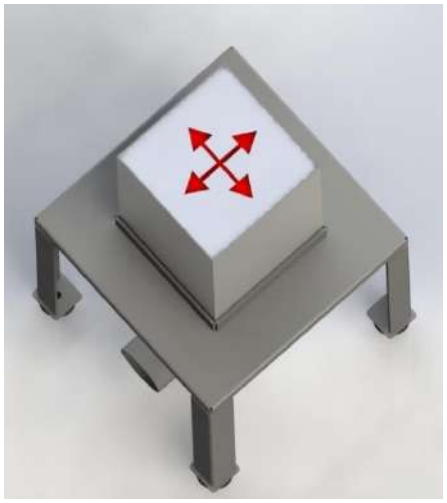
8. Start the vacuum cleaner
9. Place the filter on the cleaning bench, **fouled side facing downwards**



10. Blow pressurised air through the filter

    Blow direction alternating from horizontal to vertical

    Air pressure 5-6 bar



11. Turn the filter upside down, clean the side facing downwards

    Blow direction alternating from horizontal to vertical

12. Repeat step 10 through to 12
13. Weigh each filter and register the weight in the “Filter Log”
14. Clean filters are installed on a new location as indicated below

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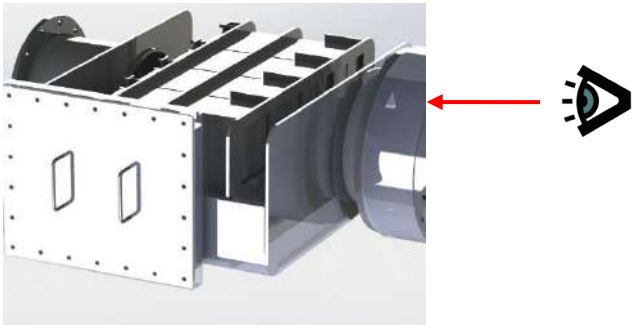
10.4.7.4. Filter Position Log

Matrix viewed from the inlet side of the filters (foul side)



Original position

Access Hatch Side	1 ……..	2 ……..	3 ……..	4 ……..
	5 ……..	6 ……..	7 ……..	8 ……..

New position (1st shop cleaning)

Access Hatch Side	8 ……..	7 ……..	6 ……..	5 ……..
	4 ……..	3 ……..	2 ……..	1 ……..

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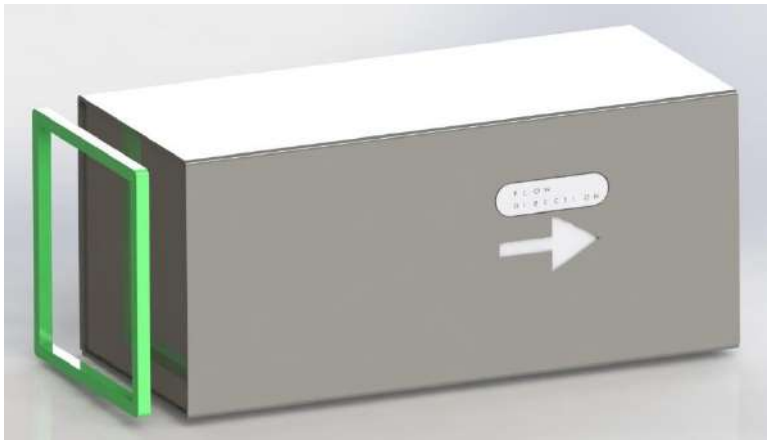
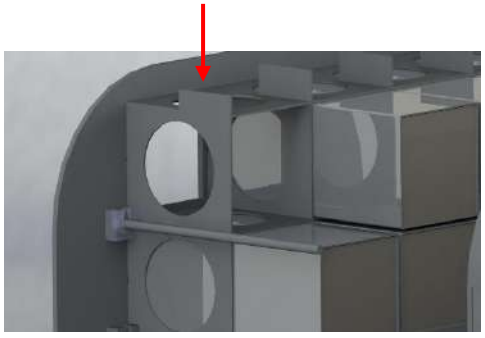
10.4.7.5. Filter installation

To install the filters follow the steps below

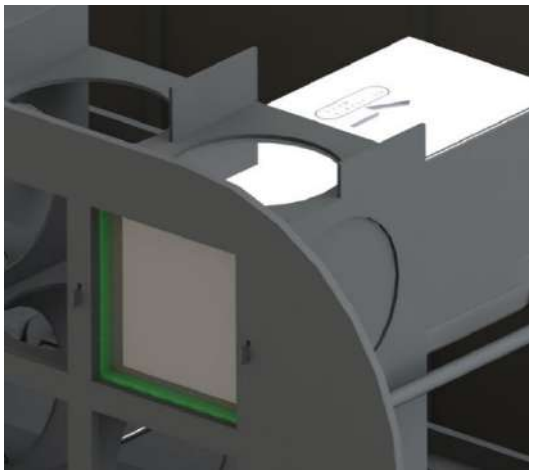
Step 1. Attach a new seal in the frame formed at the inlet side of the filter (Note the flow direction)



Step 2. Start to install the elements horizontally from low to high
Carefully insert the filter element into the pocket



Step 3. Push against the end plate/baffle



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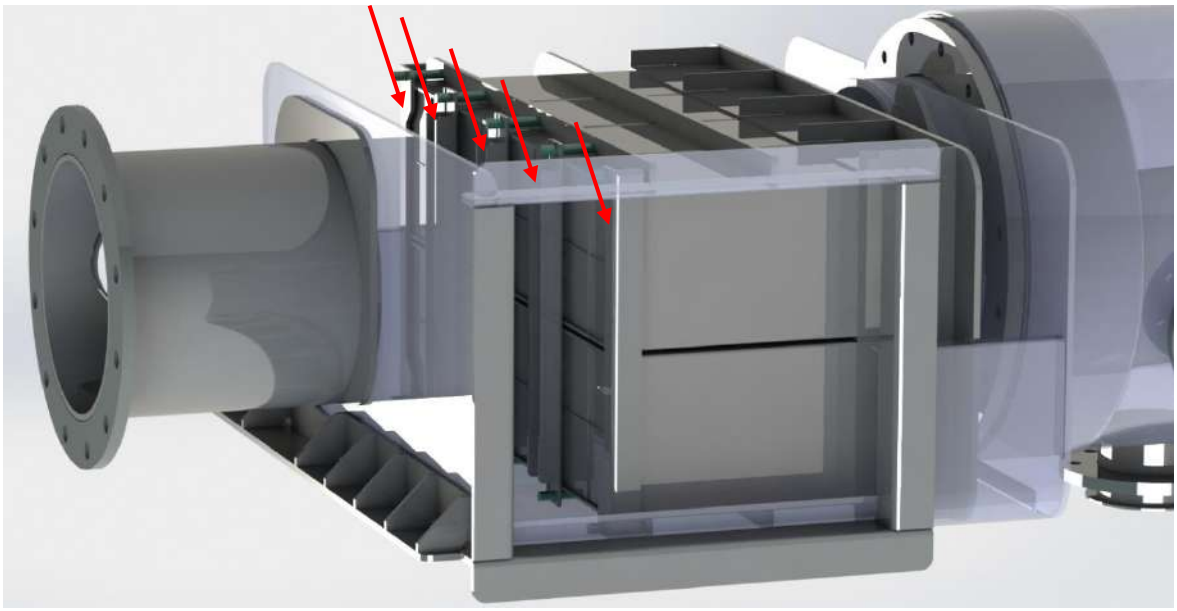
Step 4. After a row of pockets is filled, install the vertical retainer bar



Step 5. Treat the nut end of the stud with anti-seizing compound

Fasten the nuts at 5 Nm
Make sure filter elements can't move

Step 6. Close and secure the access hatch, (**A03**), to the filters

Step 7. Start the engine and inspect the access hatch gaskets on leaks

Step 8. Log the backpressure and engine load (if possible at several engine loads)

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Filter Log

Engine ..... Date.....

Hours of operation……

Filter serial No.	Matrix Location	Weight	
		Before cleaning	After cleaning

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Filter Position Log

Engine #..... Hours of operation.....

Date.....

Matrix viewed from the outlet side of the filters (clean side)

Original position

Access Hatch Side				

New position

Access Hatch Side				

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Backpressure Log

Engine #.....

Date.....

Hours of operation.....

Engineer.....

Engine Load	Pressure upstream	Remarks

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