

# SeaClean



## SeaClean System Description

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## GENERAL

This document is intended only as a general guide to the operation and routine maintenance of the SeaClean Diesel Particulate Filter System.

## SAFETY

**HIGH VOLTAGE:** The SeaClean control panel and exhaust heater may be supplied with up to 480VAC and are capable of delivering high amperage current. **Contact with terminals or components within the controller enclosure or heater terminal enclosure may cause severe injury or death.**

Multiple sources of power may supply the controller. Before opening the controller enclosure, ensure that it has been isolated from all electrical power sources. Follow all Lockout/Tagout procedures before working on SeaClean systems.

**HIGH TEMPERATURE:** SeaClean components including all parts of the heater and filter body operate at temperatures that may exceed 450°C (850°F). Contact with any exposed metal surface of the exhaust system may cause severe burns. Allow all parts of the exhaust system to cool before removing insulation blankets or attempting any service operation.



## **PURPOSE**

All diesel engines produce nanoparticles of soot as a product of combustion. A 99kW generator installed on a yacht before 2012 is allowed to produce over 700 grams (1.5 pounds) of particulates (soot) per day. Depending on which way the wind is blowing, many of those nanoparticles will imbed themselves in the microscopic pores present in even the highest quality hull finish. The results are permanent staining and damage from attempts to clean soot stains around the generator exhaust.

The SeaClean Diesel Particulate Filter System captures up to 95 percent of the soot and other particulates in the exhaust flow that would otherwise be discharged into the atmosphere. Soot particles plus unburned fuel and lubricating oil are trapped by the filter where it is reduced to carbon dioxide and water vapor. Inorganic particulates originating in lubricating oil additives and produced through normal engine wear are retained in the filter and removed by periodic mechanical cleaning.

Reduction of trapped soot and unburned hydrocarbons on the filter medium is called regeneration. Unlike other particulate filters which depend on high generator loads to create exhaust temperatures high enough to initiate regeneration, the SeaClean Diesel Particulate Filter System uses excess generator capacity to electrically heat the exhaust gas before it enters the filter housing. Exhaust is delivered to the filter at the correct temperature to initiate regeneration and thereby eliminate soot and the hydrocarbons associated with diesel smells and oil slicks.

## **DESCRIPTION**

The SeaClean Diesel Particulate Filter System is comprised of three major components in addition to the custom designed and fabricated piping that conducts exhaust gases between the engine and the outlet of the spray ring or mixing chamber:

Filter

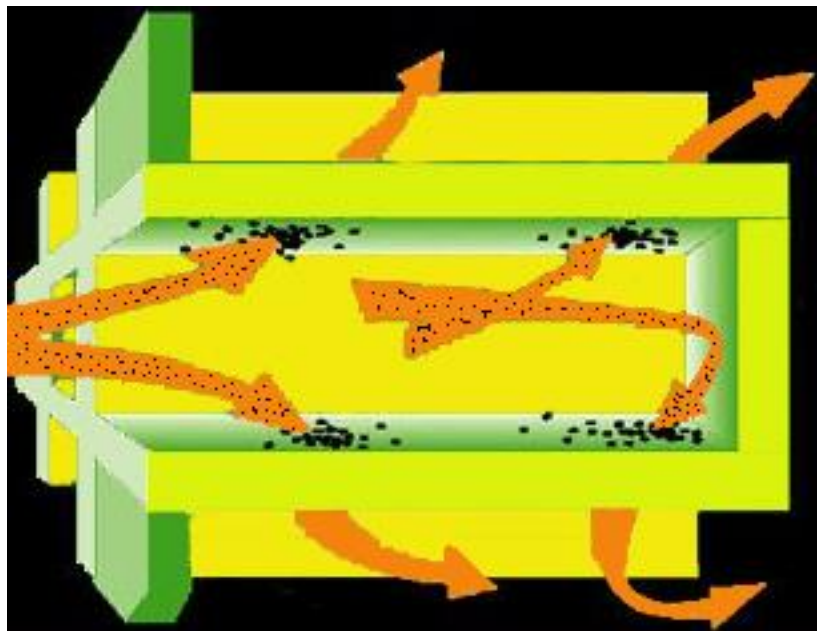
Heater

Controller

## **FILTER:**

The particulate filter itself is made of porous ceramic material with a coating of both precious and base metals that act as catalysts to promote oxidation of hydrocarbons, soot, and other aromatic molecules transported in the exhaust.

Because the outlet end of every other “cell” is blocked, all exhaust gas is forced to flow through the permeable walls of the filter. Each adjacent cell is blocked at the inlet end of the filter so prevents clean gases from returning to the inlet side. Soot particles are too large to pass through the walls and are trapped on the catalyst coated surface where oxidation takes place. Burning off trapped particulates is called regeneration and in the SeaClean system, is a continuous process across the normal operating load range of the generator.



*Exhaust flow through DPF filter element*

Dirty exhaust enters the filter from the left in this illustration. Soot and other particulates are trapped on the surface of the walls. Clean exhaust passes through the filter wall and is discharged on the right side.

## HEATERS:



The heater is made up of multiple tubular resistance elements encased in high temperature resistant nickel alloy sheathing. The elements are welded to a steel flange, the outside of which provides for electrical connections. The ends of the elements are sealed by a proprietary process capable of withstanding continuous temperatures over 1000°C or 2000°F. Normal operating temperature is well below this level ensuring a long working life for the heater.

The heater is fitted with a thermocouple which measures the surface temperature of the element sheathing. The temperature signal is used as a safety input to the temperature controller. Should exhaust flow decrease for any reason while the heater is energized, this safety feature will interrupt electrical power to the elements on reaching the limit setpoint to prevent damage to the heater or filter. An alarm display is provided on the temperature controller to indicate an over temperature shutdown.

The elements are wired for 3-phase  $\Delta$ . The loss of one or more elements from normal use will reduce the total available heating capacity but will not render the heater unserviceable. In normal operation, the total wattage required to maintain filter regeneration can be supplied by less than the total number of elements installed. It is probable that the unlikely loss of one or two elements would even be noticed.



#### **CONTROLLER:**

The SeaClean controller manages the operation of the system and provides monitoring and display of exhaust gas temperature and backpressure. The system controller contains a Temperature Controller, a Power Controller, and a Data logger.

Electrical power from the main switchboard is delivered to the Power Controller through a pair of high speed SCR fuses. These specialized fuses protect the Power Controller in the event of a short circuit or other fault and act much faster than the normal circuit protection provided by a supply breaker or ordinary fuse.

The Temperature Controller monitors and displays the temperature of the exhaust gas entering the filter body. It is a multifunction device that can display system parameters including exhaust gas temperature, temperature setpoint, exhaust backpressure, or a combination of parameters selected by the engineer. Power delivered to the heater may also be controlled manually should the engineer require higher or lower generator loading than the programmed parameters. This allows the SeaClean to be used as a load bank when conditions require additional loading. In this case sheath temperature becomes the limiting factor for how much power may be consumed by the SeaClean system. If additional loading above the standard heater rating is required, larger capacity or even multiple heaters may be fitted to enhance the load bank capability of the SeaClean system.

The Power Controller modulates the amount of electrical energy delivered to the heater elements. The Controller uses high speed silicon controlled rectifier (SCR) devices to switch power on or off in proportion to the exhaust temperature entering the filter. The SCR is a switch that only opens or closes during the "zero crossing" point of the alternating current wave form. Zero crossing means that no power is flowing at the moment the switch operates, this feature eliminates the electrical "noise," "spikes," and harmonics that are created by traditional power control devices such as soft start units and VFDs.



Power to the heater is modulated smoothly by the power controller in response to exhaust gas temperature changes. The rate of heater power increase and decrease is proportional to the rate of exhaust temperature change. As the vessel's electrical power consumption increases, the exhaust gas temperature also increases.

Since the Diesel Particulate Filter (DPF) performs best at high exhaust temperatures, high generator loads will normally supply exhaust hot enough that little or no electrical power is delivered to the heaters. The net result of this relationship is that when the vessel requires maximum generator output, it is available. When vessel electrical requirements are low, so is the exhaust temperature and "excess power" is delivered to the heater in order to increase exhaust temperature entering the particulate filter so as to assure effective soot removal in addition to improving engine operation.

Unlike other electrically regenerated systems which switch large heater loads on **and** off to initiate filter regeneration, the SeaClean system smoothly varies the flow of power to the heater elements when and as required. There are no abrupt changes in generator power output and no chance of electrical overload. By not rapidly switching heavy electrical loads on and off, the generator drive engine is allowed to smoothly increase or decrease power output without the familiar surge accompanied by flickering lights and a puff of black smoke. The SeaClean system does not "rob" the vessel of electrical power that is required elsewhere.

A built in data logger records temperature and back pressure continuously while the system is in operation. Data stored in the logger's non-volatile memory is used to evaluate system performance, confirm warranty conditions and help determine filter cleaning intervals. Performance data is readily available to the engineer.



## MAINTENANCE

The SeaClean Diesel Particulate Filter System is manufactured with the highest quality materials and components and assembled with great care and attention to detail. The result is a robust and dependable system that requires no more than the normal care and attention provided any other component of engine room machinery.

Filter service life, defined as the length of time before backpressure rises to and remains at its maximum allowable limit, depends on the condition of the diesel engine on which it is installed. An engine in good operating condition, fueled with Ultra Low Sulfur Diesel, and lubricated with low-ash oil will assure the longest running time before filter cleaning is required.

All diesels exhaust inorganic material along with the soot and hydrocarbons that are consumed during normal filter operation. These inorganics originate in the lube oil additive package, atmospheric contaminants (dust) and metal that wears off the cylinder walls and piston rings. Because this material cannot be oxidized in the regeneration process, it is trapped in the filter substrate and eventually restricts exhaust flow to the point where filter cleaning is required.

Running hours before cleaning is necessary may be anywhere from 1,000 hours up to nearly 5,000 hours. Each engine and vessel create conditions that differ from any other installation of the same filter and generator so only actual operational experience will provide useful guidance for your vessel.

The SeaClean system assures near constant filter regeneration so the longest possible service life will be obtained on a generator which operates most of the time at or above about 30 percent load. Each system is fitted with heater and filter matched to the size of generator and "normal loading" as specified at the time of ordering. Unless additional wattage is specified for loadbank operation, the engineer must not expect satisfactory performance if the generator is operated at extremely low loads for extended periods.

If extended low loading leads to earlier than expected increase in backpressure due to inadequate regeneration, a period of high loading will in most cases reverse the condition. This type of operation is not recommended and should be avoided. If this type of problem occurs frequently the system may be retrofitted with larger capacity heaters which not only increase exhaust temperature but also increase generator load to a reasonable level.





Regularly inspect all exhaust flanges and joints for signs of leakage. Do not allow any exhaust leak to go unrepaired as the joint will be damaged to the point where new gaskets may not prevent leakage.

Ensure that water flow to the mixing bowl or spray ring is adequate to maintain proper exhaust temperature entering the downstream components. In normal operation the filter will raise exhaust temperature above that shown on the monitor. This is a function of the amount of soot and unburned hydrocarbons being removed from the exhaust and older or dirtier generators will produce a hotter filter outlet. Observe downstream piping temperatures while the generator is in operation. A sudden rise in temperature above normal may indicate a problem with the engine itself.

When backpressure rises to an unacceptable level and remains high, the filter may be removed and inspected. The inlet face will be black and sooty. It should not be wet with oil as this indicates a potentially serious engine problem that allows excessive quantities of lubricating oil to reach the exhaust. The outlet face of the filter should be clean and dry in appearance. Reversing a dry filter end for end may temporarily restore satisfactory operation by using engine exhaust flow to blow out ash and inorganic deposits.

If the filter cannot be cleaned and no spare is available, replace the filter body with the supplied "spool piece" to quickly restore normal generator operation. Secure electrical power to the SeaClean control system unless the load bank mode of operation is desired. Ensure that a thermal protective blanket is fitted to the spool piece for personnel safety and fire protection.

Contact DeAngelo Marine Exhaust for information on the nearest DPF filter cleaning facility or for instructions on shipping the dirty filter to DeAngelo for service.