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MARINE ENGINEERING SERVICES AND SALES

What are diesel emissions and how can I clean up the discharge?

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Diesel engines convert the chemical energy contained in the fuel into mechanical power. Diesel fuel is injected under pressure into the engine cylinder, where it mixes with air and where the combustion occurs.

Carbon monoxide (CO), hydrocarbons (HC), and aldehydes are generated in the exhaust as the result of incomplete combustion of fuel. A significant proportion of exhaust hydrocarbons is also derived from the engine lube oil. Carbon monoxide can accumulate in the ambient atmosphere and cause headaches, dizziness and lethargy. Under the same conditions, hydrocarbons and aldehydes cause eye irritation and choking sensations. Hydrocarbons and aldehydes are major contributors to the characteristic diesel smell. Hydrocarbons also have a negative environmental effect, being an important component of smog.

Nitrogen oxides (NO_x) are generated from nitrogen and oxygen under the high pressure and temperature conditions in the engine cylinder. NO_x consist mostly of nitric oxide (NO) and a small fraction of nitrogen dioxide (NO₂). Nitrogen dioxide is very toxic. NO_x emissions are also a serious environmental concern because of their role in the smog formation. Sulfur dioxide (SO₂) is generated from the sulfur present in diesel fuel. The concentration of SO₂ in the exhaust gas depends on the sulfur content of the fuel. Low sulfur fuels of less than 0.05 percent sulfur are being introduced for most diesel engine applications.

Sulfur dioxide is a colourless toxic gas with a characteristic, irritating odour. Oxidation of sulfur dioxide produces sulfur trioxide, which is the precursor of sulfuric acid, which, in turn, is responsible for the sulfate particulate matter emissions. Sulfur oxides have a profound impact on environment, as they are the major causes of acid rains.

Diesel particulate matter (DPM), is a complex aggregate of solid and liquid material. Its origin is carbonaceous particles generated in the engine cylinder during combustion. The primary carbon particles form larger agglomerates and combine with several other, both organic and inorganic, components of diesel exhaust. Generally, DPM is divided into three basic fractions:

Solids - dry carbon particles, commonly known as soot.

SOF - heavy hydrocarbons adsorbed and condensed on the carbon particles, called Soluble Organic Fraction.

SO4 - sulfate fraction, hydrated sulfuric acid.

The actual composition of DPM will depend on the particular engine and its load and speed conditions. 'Wet' particulates can contain up to 60 percent of the hydrocarbon fraction (SOF), while 'dry' particulates are comprised mostly of dry carbon. The amount of sulfates is directly related to the sulfur contents of the diesel fuel. Diesel particulates are very fine. The primary (nuclei) carbon particles have a diameter of 0.01 to 0.08 micron, while the agglomerated particles diameter is in the 0.08 to 1 micron range.

Polynuclear Aromatic Hydrocarbons (PAH) are hydrocarbons containing two or more benzene rings. Many compounds in this class are known human carcinogens. PAHs in the exhaust gas are split between gas and particulate phase. The most harmful compounds of four and five rings are present in the organic fraction of DPM (SOF). There are of course a number of other by-product gases, however these categories mentioned are the main points of concern.

So from what we now know about the gases, we can start to treat and clean. Firstly, clean, high grade, low sulphur fuel is essential. Next, an engine that is running under load, with the air fuel ratio that is at its optimum. Most engines begin to operate efficiently over 65 percent, optimum efficiency for the machine is normally between 85 to 90 percent. At 85 percent with the charge air pressure to almost the maximum boost, we could then consider that we have the most suitable environment in the cylinder for the combustion reaction.

Problem number one;

Generators are usually rated to supply sufficient power for a vessel on the maximum demand required. Sufficient loading is not always available. Under-loading of the engine will cause a high wear rate due to incomplete fuel combustion, loss of lubrication and slobber, resulting in cylinder bore glazing and fouling of exhaust ports and valves, along with insurmountable amounts of exhaust pollution. Proper and controlled loading is therefore essential. It increases diesel engine life by up to four times and improves the efficiency by ensuring that the engine has sufficient loading at all times. It proves the rated power, proves system operation, and controls integrity and communications of your power system.

The solution is to incorporate an electrical auto load shedding load bank in the vessel's electrical system. Load banks are compact units that are coupled to the output of your power generation system such as diesel generators. Load banks are dummy loads, designed to simulate the plant load and prove the design, performance and capacity of the system, without interruption to the normal running of your vessel. In basics, programme a determined minimum load for the engine to be running at constantly into the logic control of the load bank.

When the vessel's load is low, the load bank maintains a minimum running load of, for instance, 65 percent with a maximum of 85 percent, then starts to switch off resistors as the vessel demand increases again. As we have determined at this range, apart from

many other added mechanical and cost saving benefits, our engines boost pressure is up and combustion is at its most efficient level.

We have up until this point done the maximum possible to give as clean as is possible, emissions. Now it is up to the exhaust system. Without hesitation a catalytic converter is required as an important factor in this story. The idea behind a catalytic converter is to try and eliminate the carbon monoxide, nitrous oxides and un-burnt hydrocarbons by reacting with palladium and platinum along with other precious elements, constructed in a honeycomb grid fashion. Chemists can create different compositions of catalysers to achieve different results.

Most non-active catalysers start to 'light off' at approximately 200 degrees Centigrade and efficient regeneration and 'burn off' is at approximately 350 degrees Centigrade. Because we have our engine running under load, the exhaust temperature is right within the peak performance range of most catalytic systems.

The reduction of contaminants through this unit is incredible, if they are working correctly. Low loads and oil kill catalysers! Because the hydrocarbon discharge is controlled, the ppm of the DPM (soot) is automatically reduced. Diesel smells as well as other contaminants are dealt with by now and our gas is now, hot and 65 percent minimum cleaner than about 0.16 seconds ago, if we consider the particle speed of gas for an average 160 kW generators. So at this point we have a hot, semi-clean gas. At this point the gases are cooled: The engines raw water discharge is then directed into a water injection spray ring or spray head, this condenses the gas and slows it down dramatically. Passing the cooled, slow gas through non-corrosive grp components.

The water in the system dramatically cuts the exhaust noise and serves as a system of silencing as well as 'scrubbing' the gases by saturating the majority carbon particulates left in the gas. Incorporating an exhaust water separation system is the tertiary stage of silencing and cleaning our exhaust discharge and gives us unique opportunities.

Firstly by separating the water and discharging the gas above the water line, we avoid to hear that horrible, whoosh, splash, gurgle, sound that is so abundant in most ports at around 1800 every evening when there is insufficient shore power for the galley and generators are on line.

Secondly and to complete the final stage of the system we would incorporate an exhaust water filtration unit. The discharge water from the exhaust passes through a pumped filtration system; the principle of the system uses filters that were introduced in to the oil industry some years ago in an effort to reduce oil contaminants being discharged into the sea. Whilst relatively new to the pleasure yacht industry, there are vessels using the systems with pleasing results.

In summation, we have learned a little more in a simple manner. The right component applied in the right manner, saves money and most importantly saves our environment.