

Marine Engine Seals Take the Heat

Developments in elastomer engine seals are enabling marine engine manufacturers to maintain engine efficiency and performance in the face of increasingly demanding emissions standards. Here we look at how manufacturers can maintain seal life as engine's burn hotter.

Over the next few years the marine engine market will see the introduction of stringent emission legislation designed to systematically drive down emissions of nitrogen oxides (NOx), sulphur oxides (SOx), CO₂ and particulate matter from ships.

In meeting these regulations, engine manufacturers have developed Exhaust Gas Recirculation (EGR) and Selective Catalytic Reactors (SCR) technologies; and made changes to the fuel chemistry such as reformulation of diesels to reduce soot levels for EGR, and the addition of lubrication agents to lower viscosity, low sulphur diesels (LSD) to reduce engine wear.

The consequence of these developments has been that engines now burn hotter than before. To overcome this Extended Life Coolants are used, containing a cocktail of chemicals that are predisposed to attack many commonly used engine sealing materials. Add higher acidity-prone biofuels and new engine technologies such as Dual Fuel: diesel and LNG, to the mix and it's not difficult to see why more and more is being expected of engine seals.

Critical sealing applications are those closest to the combustion chamber where they can expect to see higher temperatures and potentially exposure to fuels and coolants. Typical engine seal failure modes in these areas include the seal taking on a permanent compression set such that it's profile is permanently flattened, a phenomenon exacerbated by vibration and pulsing compression of the seal. Seal embrittlement caused by exposure to high temperatures over long periods. Seal swelling and extrusion brought about by exposure to chemicals present in engine coolants and fuels.

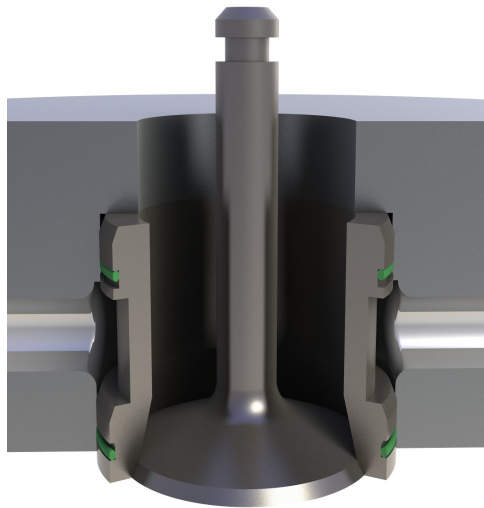


Each engine and fuel chemistry development changes the heating and cooling scenario experienced by the engine seals. Recent elastomer developments have focused on broadening their chemical and temperature resistance.

Lead-containing, fluoroelastomer (FKMs) are commonly used in engine sealing for their chemical resistance to oil and hydraulic fluids and high temperature resistance up to 200°C (392°F).

Traditionally these FKMs performed badly when exposed to high temperature water-based coolants, with excessive swelling and seal degradation. Where there is a risk of exposure, a high temperature water / steam resistant, peroxide-cured FKM is now the elastomer of choice. For applications such as pre-chambers and exhaust systems where the seal will experience sustained exposure to high temperatures, a perfluoroelastomer (FFKM) is often preferred over FKM due to its exceptional chemical and temperature resistance, and ultimately longer in-service life.

A recent exhaust valve sealing problem experienced by an engine manufacturer provides a good illustration of the challenges of engine sealing. Exhaust valve seats require an o-ring seal when they are installed into the head. The seals can expect to see temperatures in the region of 180°C. Although it should be noted that as metal-to-metal seals can experience differing rates of thermal expansion this needs to be considered when sizing the seal recess. At the opposite of the temperature scale cryogenic methods of freezing the insert and seal assembly prior to installation can risk making the seal brittle which then fractures during installation.



Engine exhaust valve showing o-rings and coolant channels

Care should be taken during seal fitting to avoid damaging the o-ring due to misalignment when pressing exhaust valve seals into the head. The seal should be a precise fit, over stretching or forcing the o-ring to fit will reduce the seal life significantly.

This particular problem sealing problem in this case was spotted during routine maintenance and inspection of fluoroelastomer (FKM) exhaust valve-seat o-ring seals showed some seal degradation raising concern about the risk of failure in service. Visual analysis of the seal showed the parts to be in good condition, with little or no evidence of compression set. However, small sections of both rings showed evidence of cracking. This suggested a 'hot spot' or localised over-heating arising from poor coolant channel design leaving the seal exposed to very high temperatures due to low heat transfer and heat soak.

Thermo gravimetric analysis (TGA) was used to confirm the diagnosis. Analysis of the cracked region showed that the material had substantially lower polymer content. The polymer loss for the cracked region would indicate significant damage to the polymer in this region of the seal, most likely due to exposure to localised elevated temperatures.



Example of thermal embrittlement of seal

Although it was observed that the seals did not leak during service, and hence may still have been suitable for continued use in this application; the engine manufacturer wished to reduce the risk of in-service seal failure. Two solutions presented themselves: improve the design of the cooling system to avoid the occurrence of hot-spots, however this was not financially feasible, and so the second solution was chosen - replace the FKM with a FFKM elastomer offering better performance in this application. As expected the FFKM elastomer has provided trouble-free service.

Engine manufacturers are relying on elastomer seals to deliver higher chemical and temperature resistance as engine technology and fuel chemistries evolve to meet emissions standards. In critical sealing applications where improvements in the design of the cooling system to avoid hot-spots are not possible, manufacturers can be assured there will be an elastomer materials that can cope with the conditions.

For more information on developments in diesel engine seals contact Precision Polymer Engineering (PPE) on +44 (0)1254 295400, email info@prepol.com and PPE web site www.prepol.com.