Tech topic

O-ring elastomeric seals

What to consider for O-rings in a jet engine oil system

Key insight

The O-ring reaches equilibrium after

1,000

hours of engine operation on a single lubricant.

Background

Lubricant formulators ensure that the balance between low and high swelling is maintained and that oil additives have minimal effects on elastomer embrittlement. The significant formulation variation permissible within typical elastomer specifications makes this more difficult.

Size, shape and standards

O-ring elastomeric seals are used to seal joints between components. Manufactured to internationally specified size with a toroidal shape, circular outside diameter and circular cross section.

Formulated as a blend of fluorinated hydrocarbon polymer with a filler, antioxidant and curing agents.

Industry standard for materials is a low-compression set fluorocarbon elastomer.

These formulations should be used where maximum sustained temperature is below 180°C and maximum transient temperature does not exceed 200°C. For higher-temperature applications, the fluorinated hydrocarbon can be substituted with a perfluorinated hydrocarbon polymer, which offers superior thermal stability.

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Manufacturing

During manufacture, the O-ring is molded at an elevated temperature and subjected to a curing cycle appropriate to the dimensions and the formulation of the seal. The properties of the finished seal are checked for compliance with the relevant specification (e.g., SAE, AMS standards). Such specifications do not rigorously control the compatibility of different supplies of O-rings with lubricants.

Sealing and swelling

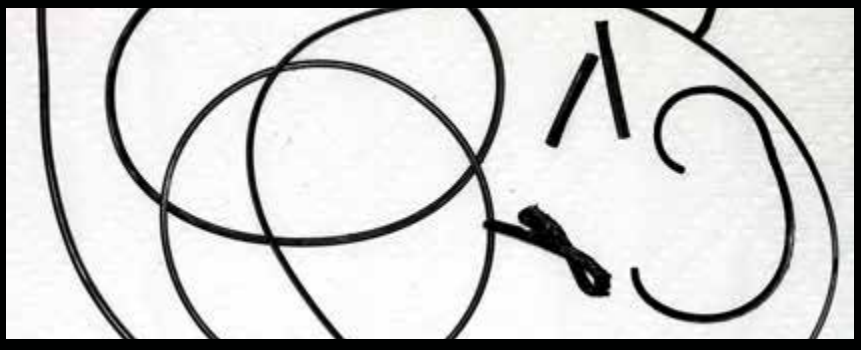
In the engine, the O-ring is fitted into a groove — typically a "V" or rectangle in cross section. When the mating component is installed, the O-ring is compressed between the components, resulting in the exertion of an opposite sealing force by the elastomer. This compression, coupled with engine temperature cycles, causes the O-ring to develop a permanent set, which increases with engine running time and reduces the sealing force exponentially. The effect of this is balanced by the volume changes of the O-ring brought about by the thermal expansion of the seal and by the swelling action of the lubricant.

Reaching equilibrium

The O-ring reaches equilibrium between compression set and the lubricant swelling action after about 1,000 hours of operation on a single lubricant. Lubricant swelling is influenced by the lubricant base stock and the degree of degradation of the lubricant in proximity to the seal. The elastomer acts as a molecular sieve, allowing lower-molecular-weight materials to be absorbed preferentially into the elastomer. The swelling action is higher in a rectangular groove than in a "V" groove seal due to the greater surface area of the O-ring exposed to the lubricant.

Results

The elastomer loses mechanical strength and can be extruded from the seal groove if the lubricant swelling action becomes excessive. This reduces sealing efficiency. Lubricants can cause premature surface embrittlement of the O-ring resulting from a chemical reaction involving the lubricant additives causing additional polymer cross-linking. This causes cracks at the surface, and ultimately leaking paths across the O-ring.



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