“O”-Ring Elastomeric Seals

ExxonMobil
Aviation Lubricants

Introduction

The task of the lubricant formulator is to ensure that the balance between low and high swelling is maintained and that oil additives are selected to have minimal effects upon elastomer embrittlement. This task is made much more difficult by the significant formulation variation permissible within typical elastomer specifications.

Size, Shape and Standards

In the jet engine oil system, “O”-ring elastomeric seals are used to seal joints between components. The “O”-ring is manufactured to an internationally specified size with a toroidal shape having a circular outside diameter and a circular cross section.

- The current industry standard for the “O”-ring seal material is a low compression set fluorocarbon elastomer.
- This is formulated as a blend of a fluorinated hydrocarbon polymer with a filler, antioxidant and curing agents.
- Such a formulation should be used where the maximum sustained temperature is below 180°C and the maximum transient temperature does not exceed 200°C. For higher temperature applications, the fluorinated hydrocarbon can be substituted by a perfluorinated hydrocarbon polymer which offers superior thermal stability.

During manufacture, the “O”-ring is molded at an elevated temperature and is then subjected to a curing cycle appropriate to the dimensions and the formulation of the seal. The properties of the finished seal are then 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 which is typically either a “V” or a 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 thermal expansion of the seal and by the swelling action of the lubricant.

Reaching Equilibrium

The “O”-ring reaches an equilibrium between compression set and the lubricant swelling action after about 1000 hours of engine operation on a single lubricant. This factor has importance when an oil change takes place. The impact of it is discussed in the Tech Topic on the subject of Oil Changes.

The swelling action by the lubricant is influenced by the lubricant base stock and by the degree of degradation of the lubricant in proximity to the seal. In that respect, 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.

The elastomer loses mechanical strength and can be extruded from the seal groove if the lubricant swelling action becomes excessive. This results in a reduction in sealing efficiency.

Lubricants can cause premature surface embrittlement of the “O”-ring. This results from a chemical reaction involving the lubricant additives causing additional polymer cross linking. The effect is to cause cracks at the surface and ultimately leaking paths across the “O”-ring.