

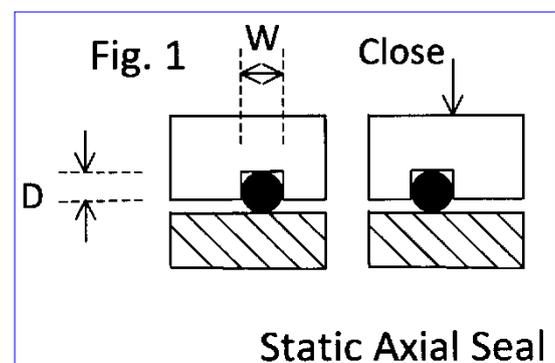
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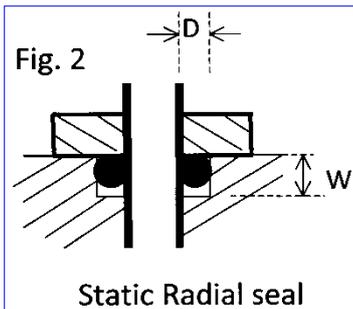
O rings and their use

This document was written by Mike Wheelwright and was originally published by Worthing and District SME in their newsletter in the Winter of 2011.

Before I started building engines my contact with practical engineering was limited and although I knew that there were things called O-rings, quite what they did escaped me. After looking at a few 3½" G locomotive designs in the 1970's I was none the wiser as the technology was too new for Curley and Martin Evans, and in any case, O-rings were not part of steam locomotive practice. I do remember a report in ME about a locomotive which the builder had been quoted as saying "was assembled around O-rings": it all sounded a bit strange to me. My Derby 4F employed soft graphited packings for the pistons and glands and the next engine was my Don Young Design "Glen" with gunmetal cylinders for which Viton O-rings were specified for the pistons and piston rod glands. I was a bit nervous as I had not heard of this on any other model but my confidence in Don was such that I did exactly what he said and successfully completed and ran the engine. At this stage I fancied myself as a latter-day CME and started to design my own locomotives and as No. 3 was to be a big'un it had CI cylinders and piston rings but I continued with soft packings for glands. This engine really accumulated mileage so glands needed regular attention, either tightening or repacking, which I found quite fiddly even though cylinders and valves were on the outside, so when I came to design the Cloughton thoughts turned to what was to be done with two cylinders and valves between the frames and two on the outside partially obstructed by the Edwardian style platework. By then the Glen had been running for several years and despite not giving a moment's thought to the piston rod glands there was still not the slightest whiff of steam, that was it, all change to O-rings.

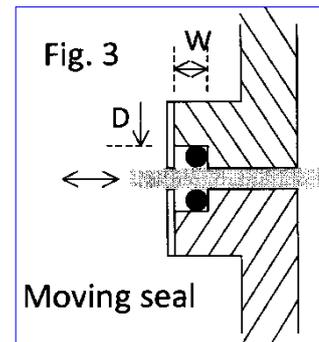
On the whole I find that very few Miniature Locomotive Engineers are acquainted with the characteristics of O-rings so given how cheap they are and easy to use perhaps it is time to say something about them. First what are they used for? They are used as seals both in static and sliding fits. Static fit is where two surfaces are joined semi-permanently, i.e. the only movement is on making or breaking the joint, and they are used for face seals and axial seals. Face seals are like Fig 1 where two flanges are brought together, I have a steam manifold like this which is pressed down on a flange rather than being a threaded fitting since there is not enough room to unscrew it with the spectacle plate in the way. The seal is easy to make with an O-ring that is compressed into the recess. With time and temperature, it sets deformed, although it does not leak until the joint is undone when a new ring is required.





Axial seals are like Fig 2 where a tube is inserted into a hole and passes through an O-ring, the outer diameter of the ring is pushed in by the housing recess so that its inside diameter grips the tube. The steam connection through the frames between the back of the outside cylinders and bolting face of the inside block of my Claughton is sealed this way: a simple push fit.

Sliding fits are easy to visualise, typically a piston rod gland as in Fig 3. The cylinder cover has a recess to accommodate a ring sized to fit the piston rod and the ring is retained captive by a simple plate that bolts on and has a clearance hole for the rod. For this use care has to be taken to polish the part of the rod that passes through the ring so that the ring does not wear out, this is very important as unlike a soft packing that can be picked out and renewed, replacement of a ring means dismantling the connection to the crosshead to slip the new ring on.



O-rings come in many sizes, but for our purposes the nominal 1/16" cross section is what we need, and this is the section generally stocked by model suppliers. The exception is the 1mm section rings for use with gauge glasses, but in general their use is limited to this purpose. The 1/16" ring is actually 0.070" +/-0.003" and the recommended fits are as follow:

Static axial (face) seal: Groove width 0.084 – 0.089" x depth 0.050 – 0.054", the force of closing the surfaces compresses the ring which then expands into the width.

Static radial seal: Groove width 0.093 – 0.098" x depth 0.050 – 0.052", the squash between outer and inner diameters compresses the ring

Reciprocating seal: Groove width 0.093 – 0.098" x depth 0.055 – 0.057" the squash between outer and inner diameters compresses the ring.

As an example, consider a gland for a 1/4" piston rod where the rear face of the cylinder cover has a circular recess of 0.362" diameter (0.250" + twice 0.056") sunk in 0.095" into which a nominal 3/8" x 1/4" O-ring is pushed. The ring is trapped in the groove by a thin plate attached to the rear of the cover by 8BA bolts with a clearance hole for the rod. Now you may well have a 23/64" drill to make the recess for the ring but ideally it needs to be flat bottomed with slightly rounded corners, and I doubt you have a D-bit of this size. The tolerances mentioned are for high pressure industrial use and we modellers can work with a bit of latitude. I just make them 3/8" dia. x 3/32" deep using a D-bit with the corner slightly stoned off and have had no problems over several years.

Finally, the matter of material. Model suppliers use different materials for their O-rings, one offers rings in Nitrile, Silicon and Viton but the common ring found in multi-size boxes at the DIY store is Nitrile. Our rings have to live with mineral oil and steam, this latter is at 324°F when it leaves the boiler at 80psi and may increase temperature in a good superheater, but it is quite a bit cooler by the time it gets in the cylinder.

Nitrile falls down on temperature as it is limited to 250°F max, but Viton at 400°F and Silicon at 450°F will certainly survive. Silicon has a poorer wear characteristic and less short-term resilience so it looks like Viton is what we need. This has always been my choice and so far, they have not needed

replacement other than when dismantling a static seal. According to the specification Viton is also whisky resistant so it will be OK if you accidentally drop one into a nightcap, but I stress that I have not yet completed this test so don't blame me if it goes wrong.

I mentioned that the Glen was built according to the DYD drawing with Viton O-rings on the pistons. As far as I can see they are not recommended as piston rings, even with smooth gunmetal cylinders, BUT my engine has been running for years and it still cannot be rolled along without opening the drain cocks, so there! In fact I am sufficiently convinced to have put them into the 5"G Whitworth I am building. Another seal that has bugged me is the regulator gland, always seems to be dripping and difficult to repack. The problem lies in the recess which is usually $\frac{3}{8}$ " dia to allow for the insertion of the neck ring but the $\frac{3}{16}$ " regulator spindle takes a $\frac{5}{16}$ " OD ring. I looked up metric O-rings and found a 10mm x 5 mm ring (2.5mm section) and I have standardised on 5mm dia. rod with a 10mm recess which has so far held under steam and hydraulic test. So there, dig deep and for a bit of small change you can run rings round your sealing problems.