Permeation of O-Rings

INTRODUCTION
A number of o-ring materials are available for high vacuum seals. The most commonly used is black Viton®, although brown Viton is also quite common. The color of black Viton is attributed to a carbon filler, while iron oxide produces the color in brown Viton. A 2037 Kalrez® o-ring is specified frequently for chemical resistance in semiconductor applications, while 4079 Kalrez is used where temperatures exceed 200°C for extended periods.

Our standard procedure is to apply a small amount of Krytox vacuum grease o each o-ring before installation, but sometimes our customer request that they be used dry. There are differing opinions about the optimum finish for the o-ring to seal against. Typically they seat against a 32 RMS machined finish, or a smoother 22 RMS finish.

We were curious what effect these variables have on sealing performance. using a residual gas analyzer (RGA), technicians tested helium permeation of black Viton, brown Viton, and 2037 Kalrez without vacuum grease. we also compared a dry black Viton o-ring to one with a light coating of Krytox. lastly, we compared a dry black Viton o-ring using a 32 RMS machined finish seat to one with a 22 RMS finish.

TEST PROCEDURE
We attached a one inch ID angle valve with special machined ventilation slots in the body to our fifteen liter test vacuum chamber. The chamber is fitted with a turbo pump and an RGA. After installing each 121 size o-ring under clean room conditions and closing the valve, the valve was sealed in a polyethylene bag. The pump was run until the pressure reached 10-8 torr. Then the bag was filled with helium and the data log on the RGA was started. Atomic mass units 4 (helium) and 16 (not shown on graphs) were switched on. Atomic mass unit 16 (not shown on graphs) was left on to confirm that its partial pressure remained constant. all tests were preformed at ambient temperature. In the case of the o-ring seat surface finish test, the valve was removed and machined to produce a 32 RMS machine finish on the seat. (The standard surface finish for a Nor-Cal valve seat is 22 RMS.)
CONCLUSIONS
Repeated tests should be performed to confirm our initial findings. However, it appears that there is no appreciable difference in the permeation rates (increase in helium partial pressure) for brown or black Viton.

There appears to be no significant reduction in permeation from applying vacuum grease, although there are advantages in terms of repeated sealing performance and ease of o-ring installation.

Comparing Kalrez to Viton, Kalrez begins to permeate more quickly and reaches a partial pressure nearly a decade greater than Viton. The initial rapid rise could lead a vacuum technician operating a leak detector to mistakenly conclude that this was caused by a vacuum leak. In terms of sealing performance, Kalrez appears to be inferior to Viton where chemistries and high temperature are not a factor.

We found no degradation of sealing performance by increasing the machine produced roughness of the valve seat from 22 to 32 RMS. we do not, however, recommend surface finishes courser than 32 RMS or non-circular machine patterns.

FOR MORE INFORMATION
Complete O-Ring Test Data is available for your review, please download the full document and graphs.

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