May 1971 Brief 71-10098

NASA TECH BRIEF

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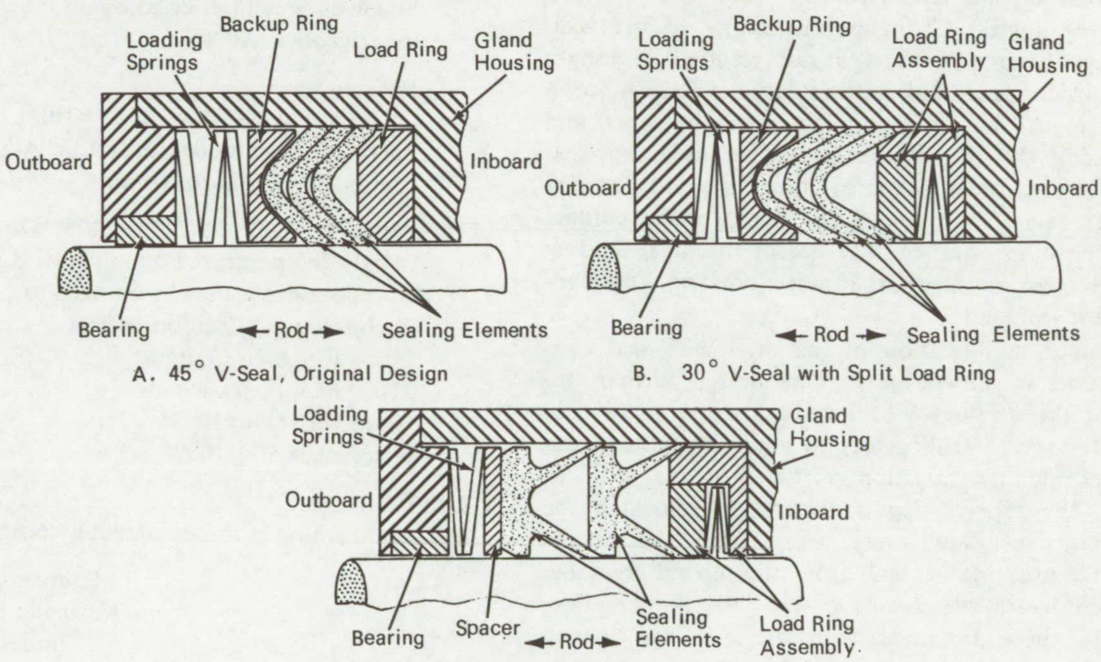
High-Temperature, Long-Life Polyimide Seals for Hydraulic Actuator Rods

Two new types of polyimide seals have been developed for an hydraulic actuator rod in the low pressure second stage of a two-stage configuration. The first stage is subjected to full hydraulic system pressure of 20.7 to 28 MN/m^2 (3000 to 4000 psi), and leakage past this seal is returned to a reservoir. The second stage is subjected to a return pressure of about 0.69 to 1.38 MN/m^2 (100 to 200 psi). Each seal met test objectives of 2×10^7 cycles of operation at 534°K (500°F). The severity of this testing was equivalent to 3000 hours of operation in an advanced aircraft.



C. Tapered Leg V-Seal with Split Load Ring

Rod Seal Designs with Polyimide Sealing Elements

Present seals in the hydraulic systems of commercial, subsonic, jet aircraft operate satisfactorily for more than 1000 hours at temperatures in the range of 344° to 356°K (160 to 180°F); but seals in Mach 2 military fighters are limited to less than 1000 hours of operation at the higher temperature of 409°K (275°F). Previous laboratory work established that elastomeric rod seals are restricted to several hundred hours of service at 478°K (400°F), and that the best nonelastomeric seals are limited to less than 500 hours at 590°K (600°F) due to limitations in seal design and/or seal materials.

(continued overleaf)

The selection of unfilled polyimide plastics as seal material for a second-stage actuator rod was based on an evaluation of numerous materials, including plastics, soft metals, and hard metals. Characteristics evaluated were: compatibility with various high-temperature fluids at temperatures of up to 590°K (600°F); sliding friction; tensile modulus of elasticity; tensile yield strength; percent elongation; and hardness. An extensive analytical and experimental study was made to find the most promising combination of seal designs and materials. Those selected for endurance tests included the polyimide V-seal, the cobalt-molybdenum lip seal, and a tool steel-silver reed seal. Of the seals evaluated, the polyimide V-seal demonstrated the best potential for meeting the requirements.

Two modifications of the original V-seal design were evolved (see fig.). The original $\pi/4$ rad (45°) V-seal design configuration is shown in A.

Design B is a reconfigured V-seal with $\pi/6$ rad (30°) leg angles. Changing the angles of the sealing legs from $\pi/4$ to $\pi/6$ rad resulted in longer legs, which permitted greater leg deflections for a given load, thus reducing the sealing stress and increasing the life of the seal. The initial application of the axial load by the outboard loading springs causes the inner load ring to make contact with the outer seal leg. The use of this dual loading arrangement resulted in a more uniform and controllable seal load.

Another modification of the original V-seal configuration is shown in C. This design further improved the original V-seal designs by incorporating linearly tapered sealing legs to minimize the bending stresses at the transition surfaces of the seal. In effect, the tapered leg configuration relocated the maximum bending stress away from the notch-sensitive area of the seal, thus minimizing cracking. This configuration also gave seal deflections equivalent to those obtained with the $\pi/6$ rad V-seal, but with an approximate 35% lower seal circumferential loading. This resulted in lower contact stresses at the seal contact surface between the polyimide element and the actuator rod.

Both the $\pi/6$ rad V-seal and tapered leg V-seal with split load ring assemblies successfully completed the 2×10^7 cycle test at temperatures to 534°K (500°F), with a leakage rate of less than one drop per minute. Test fluid was a chlorinated phenyl methyl silicone at a pressure of 0.69 to 1.035 MN/m^2 (100 to 150 psig). The actuator cycling rate was maintained at 5 cps with a total piston-rod stroke length of 0.51 ±0.051 cm (0.20 ±0.02 in.).

Notes:

1. This seal could be directly applied to flight and engine control actuators for high-performance aircraft. It may also have potential application as a low pressure, high temperature rotary shaft seal for other types of equipment.
2. The following documentation may be obtained from:

   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

   References:
   NASA-TM-X-52888 (N70-40903), High-Temperature Polyimide Hydraulic Actuator Rod Seals for Advanced Aircraft

   NASA-CR-72563 (N70-10905), Development of High-Temperature Polyimide Rod Seals
3. Technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B71-10098

Patent status:

No patent action is contemplated by NASA.

Source: John Lee of
Fairchild Hiller Corp.
under contract to
Lewis Research Center, and
William R. Loomis and Robert L. Johnson
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(LEW-11212)