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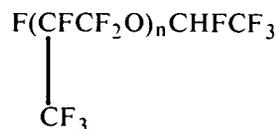
## Liquid Cryogenic Lubricant

Fluorinated polyethers have been shown to be suitable and effective lubricants for rolling-element bearings in cryogenic systems. Their lubrication effectiveness is comparable to that of super-refined mineral oil lubricants operating at room temperature.

There has always been a need for reliable bearings for short term use in cryogenic systems. Now the need exists for bearings that can operate for long periods of time. These systems include high-speed rocket turbopumps which run several minutes, as well as cooling-system pumps with moderate speeds and loads which run several hundred hours. Present cryogenic systems are lubricated by the transfer of a dry lubricant film from the ball-retainer (cage) pockets to the balls and subsequently to the races of the bearing during operation. This "dry transfer-film" method of lubrication provides only boundary lubrication. Wear, therefore, occurs on the rolling elements as well as on the races of the bearing. This wear leads to early failure and relatively short bearing life. In addition, wear in the ball pockets of the retainer can be excessive, leading to premature retainer failure and thus catastrophic failure of the bearing.

A study and test program were conducted using a different approach to the problem of lubrication in cryogenic systems. The new concept involved the use of liquid lubricants. To be an effective lubricant in a cryogenic system, a fluid must be a liquid in the cryogenic temperature range, capable of operating at the maximum system temperature without evaporating; it must be chemically inert, not susceptible to water absorption, and must have good heat-transfer properties; additionally, such a fluid must be able to form a fluid film in the high-pressure region of a rolling-element contact.

The test lubricants evaluated in this effort were a family of fluorinated polyethers having the following general formula:



Four fluids, each having a different viscosity, were evaluated in two phases: first, to compare the lubricating characteristics of fluorinated polyether fluids at outer-race temperatures of 160° to 410°R (89° to 227°K) with those of a mineral oil at room temperature; and second, to determine the effect of fluid viscosity, maximum Hertz stress, and contact angle on the system temperature. Lubrication effectiveness was analyzed with respect to wear and the deformation of the ball running track and compared with the effectiveness of a super-refined mineral oil at room temperature.

Rolling contact under these conditions results in an alteration of the rolling-element surfaces. This effect is usually indicated in three basic forms: (1) elastic deformation; (2) plastic deformation; and (3) wear. Deformation and wear were essentially the same for the specimens run in fluorinated polyethers at cryogenic temperatures as for those specimens run (under the same working viscosity) in super-refined mineral oil at room temperature or slightly higher. These results indicate that the fluorinated polyethers as lubricants in the range of 160° to 410°R (89° to 227°K) are comparable to mineral oil lubricants at moderate temperature, i.e., 560° to 760°R (311° to 478°K), and also verify the fact that the fluorinated

(continued overleaf)

polyether lubricants can form elastohydrodynamic films at the cryogenic temperatures tested. They show that the fluorinated polyethers could be used in many cryogenic applications, providing longer life and higher reliability.

**Notes:**

1. These lubricants could prove valuable in gas liquification plants and frozen food processing industries.
2. The following documentation may be obtained from:

Clearinghouse for Federal Scientific  
and Technical Information  
Springfield, Virginia 22151  
Single document price \$3.00  
(or microfiche \$0.65)

**Reference:**

NASA-TN-D-5566(N70-11365), Rolling-  
Element Lubrication with Fluorinated  
Polyether at Cryogenic Temperatures  
(160° to 410°R).

3. Technical questions may be directed to:

Technology Utilization Officer  
Lewis Research Center  
21000 Brookpark Road  
Cleveland, Ohio 44135  
Reference: B70-10347

**Patent status:**

No patent action is contemplated by NASA.

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