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AEROSPACE INFORMATION REPORT

AIR 810

DEGRADATION LIMITS OF MIL-H-5606 HYDRAULIC FLUID

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Revised

1. GENERAL:

It is the purpose of this information report to discuss the causes and effects and recommend toleration limits for the degradation of MIL-H-5606 Hydraulic Fluid. The degradation of the fluid stems from two basic causes, the usage of the fluid in a hydraulic system and the presence of contaminants in the fluid. There are two basic effects on the fluid characteristics and other minor effects which are largely associated with the usage and functional operation of the fluid in a hydraulic system, but may also be caused by contamination. The presence of contaminants in the system can arise from contaminating materials which are already in the fluid when it is introduced into the system or added to the system as a result of servicing operations or as a result of wear or breakdown effects on the materials of system construction.

2. FLUID CHARACTERISTIC CHANGES:

The effects considered under this category are, in general, representative of chemical or physical changes which have taken place in the fluid, resulting in degradation of the basic characteristics. These effects can also be caused by the presence of certain contaminants which are usually fluid in nature.

2.1 Viscosity: Specification MIL-H-5606 requires that new fluids have a minimum viscosity at 130°F of 10.0 centistokes (c.s.). Since the fluid contains certain long chain polymeric additives (viscosity index improvers), operation of the system with its pumps, valves, and other components has a shearing effect on these additives. Some of the shearing effects are a relaxation or a lack of newtonian characteristics in the additives. Other shearing effects result in a permanent breakdown of the chain structure of the additives. The shearing effect is evinced by a reduction in fluid viscosity, which will tend to approach a value of 5 c.s. at 130°F. This is still somewhat in excess of the viscosity of the base stock of the fluid which is about 2.5 c.s. Examination of the effects of reduced viscosity indicate two conditions to be of major consequence.

First, in general, a reduced viscosity in a fluid will result in a degradation of the hydrodynamic lubricity of that fluid. In most hydraulic systems the pump is the component most susceptible to the effects of lowered lubricity. However, pump life tests indicate that the reduction in lubricative effect is not sufficient to cause noticeably premature wear or failure. There is no doubt that the reduction of fluid viscosity is due largely to the shearing of the polymeric additives rather than a change in the base oil, which contributes the major lubricating qualities to the fluid. Therefore, based on evidence at hand, it is felt that a reduction in fluid viscosity to 5 c.s. at 130°F will not have excessive effects on fluid lubricity.

Second, reduced viscosity will result in greater internal leakage of system components. This will be more noticeable in pump efficiency and the internal leakage of slide type and similar valves. Servo valves, due to their low overlap, are the category of slide valves most subject to variation in internal leakage. However, the reduced viscosity will result in a decrease in line

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2.1 Viscosity: (continued)

losses, which will to some extent offset the loss of power due to increased internal leakage. Moreover, since the internal leakage of slide valves is generally at its highest value when the valve is in the neutral or null position, the reduction in usable power will be negligible. The increased neutral or null leakage will be noted in an increase in system heat rejection, which can readily be evaluated. The majority of systems can easily assimilate this greater heat rejection, as it will be at a much lower rate than under system operating conditions.

Therefore, it can be concluded that a reduction of viscosity of MIL-H-5606 fluid to a value of 5 c.s. at 130°F can be tolerated. To be conservative, it is recommended that a value of 6 c.s. at 130°F be used as a lower limit for fluid viscosity. At any fluid viscosity level above this limit there should be no need for fluid replacement, unless there is evidence of fluid contamination due to the introduction of solvents or similar materials into the system.

Attention should be paid to an increase of the fluid viscosity. This can be due to contamination of the fluid with higher viscosity liquids, however, it will, in general, be an indication of evaporation or oxidation. Therefore, a value of 12.5 c.s. at 130°F is recommended as an upper limit of usable fluid viscosity.

2.2 Neutralization Number: The neutralization number of a fluid, which is reported as "mgKOH/gm", can be roughly stated as an index of the acidity or presence of free hydrogen ions in a fluid. The specification limit for MIL-H-5606 fluid is 0.20 mg maximum. In many ways this is a much more reliable indication of fluid degradation than viscosity, since it, to some extent, indicates the presence of materials which will have a corrosive effect on the materials of system construction. An increase in the neutralization number can also be indicative of the presence of moisture in the fluid or that incipient gum-forming molecular species are present. If the fluid continues to be exposed to the oxidative environment, heavy gum-forming and resin precipitation may occur after the initial induction period.

Except as caused by contaminants in the system, fluid breakdown is generally caused by excessive temperature. Even though the bulk fluid temperature may have been maintained well below the level of inception of fluid breakdown, hot spots can result in fluid degradation. One, which is not generally recognized, is the fluid in the vicinity of pump bearings, where the local temperature can readily be 300°F to 400°F in excess of surrounding temperatures. Fortunately the volume of fluid so affected is very small and thus the overall effect on the neutralization number of the bulk of the fluid in the system is negligible.

In general, it can be stated that an increase in the neutralization number of system fluid to a level in excess of 0.40mgKOH/gm or twice the specification limit, is cause for fluid replacement.

2.3 Rubber Swell: A less important effect of fluid degradation is the swelling of rubber caused by the fluid. The specification test, which is rather difficult for the average user's laboratory to perform, requires the use of a standardized rubber as an indice of swelling effects. The compounded rubbers used in standard packing will swell a great deal less than the test rubber. Moreover, the rubber used in the packing of a system will be enclosed in grooves where it is not subjected to the soaking conditions that the packings are subjected to

2.3 Rubber Swell: (continued)

under qualification test and thus the swelling effect is greatly reduced. It is not recommended that rubber swell be used as an indication of fluid degradation or of a need for fluid replacement.

3. CONTAMINATION:

Fluid contamination can be defined as the presence in the fluid of material which is not a basic element of the fluid. In the strictest sense products of fluid degradation can be considered to be contaminants.

3.1 Particulate: Particulate contamination in a hydraulic system can be due to material in the fluid when it was added to the system, material in the system or components at the time of assembly, wear products of components, or materials entering the system during servicing operations. Since, in general, particulate contamination can be controlled by adequate filtration and careful servicing, except in unusual circumstances it is not a cause for fluid replacement.

3.2 Water: By Specification MIL-H-5606 fluid is permitted to contain 0.005% of water by weight. The specification method for water determination is distillation, however, it is considered that this method will not produce sufficiently accurate results for the determination of so small a percentage, therefore the Karl Fischer titration method (Federal Test Method No. 791-3253, "Water by Electrometric Titration with Karl Fischer Reagent") be used.

This water can be found combined with oil in three ways. First, it can occur as a solution where water is in molecular dispersion in the oil. Second, water can occur in a supersaturated condition where it is in nearly colloidal suspension in the oil, but has a tendency to settle out with time. Third, a condition can exist where a very large amount of water is present and it has settled out in pools held separate from fluid by the difference in surface tensions and densities of the fluids. This latter is generally referred to as "slug water".

There are two major effects on system performance and condition which are caused by the presence of water. First, freezing, which is intolerable, is generally an indication of slug water. Second, corrosion, which is a function of the materials of system construction and their protection, is undesirable and may or may not be intolerable, depending on the nature of the corrosion effects. It is felt that water in solution will have at most a minor tendency to cause corrosion. It is concluded that a moisture content of 0.010% by weight is tolerable. Any water concentration in excess of this amount can be taken as indicative of need for fluid removal and water separation. It is also felt that many hydraulic systems will be tolerant of much greater concentrations of water and only the presence of slug water need be cause for action. In this latter category are most aircraft.

3.3 Other Liquids: The presence of other liquids in a hydraulic system and the need for corrective action must be based on the nature and degree of contamination and the utilization for which the system is designed.