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STABILITY OF AIRCRAFT GREASES



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STABILITY OF AIRCRAFT GREASES

INTRODUCTION

During and immediately following World War II a considerable number of the complaints which were brought to the attention of aircraft manufacturers centered about the loss of lubricant from shielded, anti-friction bearings. These bearings were often so located in the aircraft frame as to be subjected to rather unfavorable operating environments, such as driving rain and high temperatures. However, many failures also occurred in comparatively well protected bearings operating, normally, under conditions of low load and slow oscillatory motion. The evidence indicated that the necessity for specifying greases which would perform under the various climatic conditions of the different theaters of war had resulted in the sacrifice of certain stability characteristics. Thus it was that when the emphasis changed from military to commercial applications, and long lubricant life became of major importance, the shortcomings of the products designed to meet the early AN specifications were revealed. The service data available to the Committee were, unfortunately, not as specific as was desired. Also, detailed information as to the type and frequency of servicing and lubricant history was generally lacking. In most of the bearings examined the initial cause of the failure was obscured by the excessively deteriorated condition of the bearing. In the overall picture, however, it was apparent that loss of lubricant was a serious factor. Whether this loss resulted from disintegration of the grease structure, from separation or evaporation of the oil component, or from mechanical removal by water, steam, or air, was generally a matter of conjecture. One aspect of the problem, i.e., the stability of the lubricant, was a characteristic subject to measurement and control and, therefore, became a part of the S-5C Committee investigation.

It was believed that the primary factors to be considered could be classified as thixotropic changes in consistency, oxidation, oil separation, and oil evaporation. Of these, the investigation of thixotropy was under investigation by an ASTM committee. Because of advancements made during the war years in the field of oxidation inhibitors for greases, and the development of the Norma Hoffman Test Procedure, the problem of oxidation appeared to be well in hand. The Committee, therefore, emphasized in its work the test methods concerned with oil separation and evaporation, not only at low to moderate temperatures but also under high-temperature conditions of short duration - as might be found in generator and cowl-flap bearings.

During the time that the Committee work has been carried on, rapid advancements have been made by the petroleum industry in grease manufacturing techniques. The overall quality of lubricating products recommended for aircraft today far surpasses that known during the war years. As a result of these improvements, the difficulties with unstable greases have largely been corrected and very few examples of bearing failures which could be attributed to this source have come to the Committee's attention during the last year. Specifically, the present-day requirements for evaporation and bleeding, coupled with healthy competition among the lubricant suppliers, have resulted in types of greases of vastly improved resistance to oxidation and separation.

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STABILITY OF AIRCRAFT GREASES

1. OBJECTIVE:

The objective of the work was to investigate methods for evaluating the stability of greases which would correlate with performance in commercial aircraft.

2. SUMMARY AND CONCLUSIONS:

The principal activities of the laboratory investigation on stability were directed along the lines of testing oil separation and evaporation at moderate and at high temperatures.

- 2.1 Oil Separation at Moderate Temperatures: A number of methods were screened. While the AN-G-25 method showed fair correlation with field data, a proposed centrifuge test procedure indicated better correlation and excellent repeatability; it was therefore chosen for further study. To extend the base line for evaluating correlation beyond the rather meager field data available, the Committee members individually reported separation in the samples of Committee greases retained by them for periods of a year or more. A considerable variation in the results reported indicated that the conditions of storage played an important part in influencing this characteristic. Comparison of the centrifuge test results with the consensus ratings assigned to the individually stored samples showed no improvement in correlation over that obtained with the AN-G-25 method. More recently a new test has been described by Smith, Amott, and McLennan in "The Institute Spokesman" (Vol XIV No. 4, July 1950). An exhaustive study of the applicability of this method to commercial aircraft greases has not been made but preliminary work shows it to have considerable promise. A more thorough study is recommended. Lacking evidence of a clear superiority of any of the methods investigated over that described in AN-G-25, the consensus of the Committee is that no change in the current practice should be recommended.
- 2.2 Evaporation: By modification of the ASTM Evaporation Cell Method, the Committee hoped to develop a combination bleeding and evaporation test for both moderate and high temperatures. The procedure consisted of using a packed SKF 204 bearing as the sample container and measuring both percent of separated oil and percent evaporated at various temperatures and combinations of temperatures. The reproducibility of the proposed test was found to be unsatisfactory and after further investigation the Committee recommended that ASTM D972-48T be reported as the most satisfactory evaporation test to come to its attention and, also, that the evaluation of oil separation be covered by separate test methods.
- 2.3 Separation at High Temperatures: The Committee believed that methods of comparing the resistance of greases to separation under short-time, high-temperature conditions should be investigated. An AN-G-25 type of cone and holder was employed and temperatures were controlled by using both a forced draft oven and an ASTM Evaporation Cell. The work showed that at temperatures approximating 300F and above very large differences existed in the greases under examination. These differences were so large, (ranging from 0.8 percent for the best to 89 percent for the worst) that the effects of time and temperature were somewhat overshadowed. These important

variables, however, would have to be carefully controlled in standardizing this or a similar test, and the Committee suggests that this standardization could profitably be the subject of further investigation. In its present rough form the procedure is adequate as a quick, practical, "go or no-go" test for high temperature stability.

3. DISCUSSION:

3.1 Grease Samples: The characteristics of the test greases under examination are shown in Table I.

3.2 Separation at Moderate Temperatures: The following factors were considered to be possible contributors to the degree of separation.

1. Composition, including both ingredients and method of manufacture
2. Chemical and/or physical changes in grease structure
3. Temperature and temperature fluctuation
4. Pressure
5. Relative area and condition of the grease surface
6. Vibration
7. Filtration

Any separation test proposed must, per se, be designed to evaluate the influence of changes in chemical and/or physical structure and in composition. A literature search showed that other workers in this field have established that pressures up to 3,000 psi have no effect on confined greases. On the other hand, if there exists an avenue of escape for the oil component then even low pressures, by exerting a filtration effect, will aid in separating the oil from the soap base. However, this filtration effect, whether brought about by pressure or by the capillarity of the filter medium, was deemed extraneous to the problem under study in that it introduced factors not normally found in conventional storage; and, for that reason, this factor was investigated only briefly. The effects of vibration were studied by two members of the Committee, using apparatus designed to simulate the repeated jarring shocks associated with railroad transit, and no noticeable effect on bleeding characteristics of the test greases was observed.

With regard to the other factors listed above, of the various methods studied in the primary investigation, one based on the use of a centrifuge appeared to offer the most promise. The effects of surface area, depth of sample, temperature, relative centrifugal force, and time were investigated. It was found that within the limits imposed by the equipment, the depth of the sample influenced the percent of bleeding markedly between the ranges of 1/2 inch to 2 inches, but above 2 inches had very little effect. Increases in surface area, in temperature, in force, and in time, all resulted in increased percentages of free oil. Finally a procedure which gave good repeatability and which was not too arduous from the standpoint of time and equipment requirements was adopted for further work. This method has been described in ASTM Special Technical Publication No. 48-5 (1948). The correlation with data on storage and service stability which had been supplied the Committee soon after its organization, was fair. However, in the intervening months, samples of all the greases had been distributed to the Committee members and had been stored under various conditions which, in the aggregate, were thought to represent a fair cross section of average conditions in the field. Each member was asked to examine the samples in his possession and to report on their history and the amount of free oil found in each container.