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CORROSION PREVENTIVE CHARACTERISTICS
OF
AIRCRAFT GREASES



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PREPARED BY

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INTRODUCTION

In aircraft operation there are bearings in control mechanisms, wheels, wing tabs, rudder posts, etc., which are exposed to water, either salt or fresh, under flight or landing conditions. This water contamination can occur because of rainstorms, flooded landing strips, washdowns, or ordinary surface condensation.

The aircraft industry recognizes that some greases provide better corrosion protection than other greases. In addition, there are a few greases which permit moderate corrosion in the presence of moisture.

Corrosion protection requirements are a minor item in aircraft grease specifications, because of the relatively limited number of applications where such characteristics are of primary importance.

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CORROSION PREVENTIVE CHARACTERISTICS
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1. OBJECTIVE: The objective of this work was to develop a relatively simple screening or bench test, or a combination of such tests, which would evaluate aircraft greases in respect to corrosion protection under the operating conditions described above.

2. SUMMARY AND CONCLUSIONS:

2.1 While the Salt Spray Test, the Emulsion Test, and the Condensation Test, give results which agree fairly well for any one grease, the Salt Spray Test is recommended for evaluating the corrosion protective characteristics of aircraft greases, since it gives quicker results and it is more convenient to use than the alternative methods.

2.2 The results of the Salt Spray Test correlate reasonably well with the limited service data available, but a definite correlation could not be obtained because of the lack of more specific service data.

2.3 Additional service performance information is essential to the development of a correlating laboratory test.

2.4 The development of a short time laboratory test which will predict service performance is complicated by the syneresis, evaporation, and changes in consistency, which occur during long time service.

3. DISCUSSION:

3.1 Grease Samples: The characteristics of the SAE S-50 Aircraft Lubricants Committee greases are shown in Table I.

These greases represented a wide variation in composition, and at the same time they were greases for which some service performance information was available. Further information concerning these greases may be found in A. S. T. M. Special Technical Publication No. 34, "Symposium on Functional Tests for Ball Bearing Greases".

3.2 Test Methods Used: Five test methods were selected for study. A detailed outline of each method is given in Appendices A-E, inclusive. A brief description of each follows:

3.2.1 Salt Spray Test: This test is essentially a modification of the procedure described in A. S. T. M. Tentative Method B 117¹. The test cabinet is cubical in shape and is constructed of redwood. The cabinet is provided with a drain at the lowest point, and no attempt is made to maintain a liquid level. A salt spray is introduced at top center in the conventional manner, and the temperature of the box is controlled thermostatically. Test specimens are suspended from a spider which rotates at 1 r.p.m.

Sandblasted SAE 1010 steel panels are used as test specimens. Scotch tape is used to cover the edges of the panel, and this tape also serves as a means of controlling the thickness and uniformity of the grease layer when applying the greases. The panel is covered with grease and a straight edge is run over the tape thereby removing the excess grease and giving a layer of uniform thickness.

The test is run for any desired number of hours, usually 100, in an atmosphere of high relative humidity at a temperature of $95 \pm 5^{\circ}\text{F}$.

- 3.2.2 Immersion Test: This test involves the immersion of test panels coated in a similar manner to that described above under the Salt Spray Test, in beakers half-filled with distilled water. The beakers and panels are exposed to the weather for arbitrary periods, usually 300 hours or more, after which the panels are cleaned, inspected, and visually rated. With this procedure a reference sample is included in each run.
- 3.2.3 Condensation Test: In the condensation test, the panels which have been coated with grease in the manner described for the previous two procedures, are cooled for two hours at 40°F . in a cold box and then quickly transferred to a humidity cabinet at 90°F . and high relative humidity. After a twenty-two hour exposure in the cabinet, the panels are moved to the cold box again, and the foregoing twenty-four hour cycle is repeated. After an arbitrary number of cycles, a minimum of seven, the panels are cleaned, inspected, and rated.
- 3.2.4 Emulsion Corrosion Test: In this test the panels are sandblasted and taped as previously described, but the materials applied to the surfaces are not the test greases as such but rather the water emulsions of the test greases as prepared in the Navy Absorption Test². After these emulsions have been applied, the test is conducted as for the Salt Spray Test.
- 3.2.5 Tidewater Immersion Test: In this test the panels are coated as described for the Salt Spray Test and clamped to an immersion board which is suspended at mean tide level in the ocean. They are subjected to the mechanical action of the water and sand and are alternately exposed to air and sunlight. Inspections are made every twenty-four hours. After seven days they are removed from the rack, cleaned, inspected, and rated. Further details on this test procedure are given in Appendix A.
- 3.3 Experimental Results: In the appended Table II are presented the results of tests by the five methods and for the eleven greases studied. With a few exceptions, all of the greases were tested by each of the five methods, and, except in one case, multiple test or test specimens, were obtained.

In the case of the Salt Spray Test, a considerable period of time elapsed between the first tests run and the later tests, and, accordingly, the repeatability shown may be poorer because of the use of freshly-made grease samples in the early tests and of aged grease samples in later tests.

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1. Tentative Method of Salt Spray (Fog) Testing (B-117-44 T), 1946
Book of Standards, Part 1-B, p. 773.
 2. AN-G-5 Specification, March 6, 1943.

Grease was removed from the test panels by washing the panels with solvent in all instances just before they were rated, and the rating was a visual estimate of the amount of the panel surface covered by rust. In many cases a considerable amount of personal judgment was involved in order to arrive at the ratings listed, and, accordingly, the numerical values shown carry a considerable error factor.

Photographs are appended of the Salt Spray Test panels just after the completion of the test, both before and after washing the grease from the panels. A photograph of the Tidewater Immersion panels after exposure but before cleaning is included in Appendix E. The appearance of the test panels after the test, but with the grease still present, is somewhat confusing. The reason is that the grease discoloration does not correlate with the appearance of the grease-free panel and hence may appear to be at variance with the rating. Although panel rusting is not as evident from the photographs as from a direct visual observation, differences in the washed panels are evident in the photographs upon careful inspection.

- 3.4 Evaluation of Test Data: In most cases the different tests employed agree with each other in their rating of the committee greases. This is evident from the appended Table III in which it is indicated, as nearly as possible, whether the rating lies in the best, middle, or poorest one-third of all the values. All of the tests agree well in their ratings of greases M-1, M-2, and M-3; fairly well in the cases of L-1, L-2, L-4, and L-6; and less satisfactorily in the case of H-2, and L-5. In the case of H-1 and M-4, four of the five tests rate the greases similarly; the Tidewater Immersion Test gave results that were not in agreement with the data from the other four tests. The reason for the difference in the case of the M-4 grease appears to be that much of the grease was washed off the panel because of the vigorous agitation, and the small residue was not effective in preventing corrosion. No reason is evident for the discrepancy in the case of the other grease, H-1.

In order to state which test procedure, or combination of procedures, would predict most accurately the behavior of the greases, it would be necessary to know the service performance history of each grease in respect to its corrosion protective properties. Fully reliable information for the greases in this respect is not available. It is meagre and unreliable in most cases, and reasonably dependable only in the cases of M-2, M-3, and M-4.

Based upon all reported service performance, M-2, M-3, and M-4 appear to be acceptable in service. M-1 and L-5 are reported to have to have given some trouble in service because of corrosion.

In addition to the above information, various statements have been made to the effect that AN-G-3a-type greases in service have not provided satisfactory protection against corrosion; that AN-G-15-type greases in service have not performed satisfactorily in general; and that AN-G-25 greases have rendered acceptable service. Of the committee test greases it is believed that H-2 is of the AN-G-5-type, M-2 and M-4 of the AN-G-15-type, and L-2 of the AN-G-3a-type. It is evident that a great deal more information must be obtained upon the service performance of specific greases if there is to be any hope of establishing a solid basis for the correlation of bench tests with service performance.

Upon the basis of the foregoing evidence, it is possible to state that there is reasonably good correlation between the bench test data and service performance in the case of M-2, M-3, and M-4, particularly if the Tidewater Immersion Test is excluded. Beyond that the data are too incomplete to permit further valid correlation.

There are a number of complicating factors entering into an attempt of this sort to develop a reliable criterion for predicting service performance. For example, in the case of control bearings a relatively static condition exists which may also be complicated in some instances by windsweep or other factors favoring oil evaporation or ejection of grease from the bearings. As a consequence, greases such as L-2 have a favorable opportunity to harden in such bearings because of evaporation or separation of the oil. This complication does not necessarily appear in the case of the bench test, and hence a grease like L-2 might appear satisfactory in the bench test but poor in service. Likewise, the factor of thixotropy could complicate the predicting of service performance from the results of bench tests. It seems only reasonable to expect that the relative static conditions present in wheelbearings and the relative dynamic conditions present in wheelbearings may introduce complications in any attempt to correlate the results of a single test, or perhaps even a combination of tests, with actual service performance. This would appear to be a reasonable explanation for some of the discrepancies between bench tests and service performance found in the present work.

Consideration was also given to the possibility that corrosion of wheelbearings might be affected in some manner by the emulsified condition of the grease after water contamination. In an attempt to throw some light on this possibility, three sets of samples were prepared from greases H-1, M-1, M-2, and M-4 as follows:

- 3.4.1 Each grease to be emulsified as much as possible with approximately 40% of water and the resulting grease emulsion to be coated on the panels in the usual manner. The panels to be exposed for 24 hours in air and then put into the salt spray corrosion cabinet for the regular salt spray test of 100 hours.
- 3.4.2 Each grease to be emulsified as described under (1) above, and coated on the panels in the same manner. The panels to be exposed to the air until some rusting is visible.
- 3.4.3 Each original grease to be coated on the panels in the usual manner and the regular 100-hour salt spray corrosion test run made.

The panels coated with the greases prepared under (2) showed no rusting after 53 days exposure. The data for the other two sets of panels were as follows:

Sample No.	Appearance of Panel at End of Test	
	Emulsified Grease	Original Grease
H-1	Visible rust on 10% of surface area.	Visible rust on 10% of surface area.
M-1	Visible rust on 10% of surface area. Slight pitting.	Visible rust on 8% of surface area.
M-2	Brownish rust stain on 8% of surface area.	Brownish rust stain on 5% of surface area.
M-4	Visible rust on 15% of surface area. Heavy pitting with black deposits on larger part of panel surface.	Visible rust on 10% of surface area. Heavy pitting visible on this panel also.

It would appear that the emulsification of the water in the grease was not a particularly complicating or adverse factor.

One point not studied in this work, but worthy of consideration under the recently initiated Coordinating Research Council project upon aircraft greases, is the finishing of the panel surface. Sandblasting was used in the present work as a matter of convenience, but it is possible that a smooth buffed finish may lead to more significant results inasmuch as this finish might more closely simulate bearing surfaces. Limited evidence available in the present work did not suggest that salt water promoted corrosion to a greater extent than fresh water. It was used, however, upon the basis of being possibly more representative of service conditions.

Based upon the evidence, and keeping the factors of practicability and convenience in mind, it is believed that the two immersion tests are less satisfactory than the other three tests. Of the other three, the preference would appear to be, in order of convenience in testing, the Salt Spray Test, the Emulsion Test, and the Condensation Test. More service performance history on the greases would be required before a selection among these three procedures could be justified.

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TABLE I
SAE COMMITTEE S-5C COOPERATIVE TEST
GREASES

FINISHED GREASE						
S-5C Code No.	ASTM Worked Penetration	ASTM Dropping Pt. °F	Soap Type	Soap Content	Base Oil	
					Vis. at 100°F	V.I.
L-1	304	358	Li	15%	61 SSU	50
L-2	313 - 319	380 - 385				
L-3	312	400+				
L-4	273	371				
L-5	310	365				
L-6	345	300 min.	Li	21%	56 SSU	40
M-1	248	300	Na-Ca	19%	159 SSU	97
M-2	243	400+	Sr	22%	130 SSU	52
M-3	265	400+	Sr	22%	130 SSU	51
M-4	279	380	Li	8%	115 SSU	40
H-1	295 - 311	343 - 363	Na	14.6%	210 SSU	41
H-2	237	400+	Na	35%	414 SSU	55