AIRCRAFT CORROSION RESULTING FROM THE USE OF CALCIUM CHLORIDE ON AIRPORT RUNWAYS

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Technical Development Note No 33

March 1944

U S. DEPARTMENT OF COMMERCE

CIVIL AERONAUTICS ADMINISTRATION

WASHINGTON, D C

UNITED STATES DEPARTMENT OF COMMERCE

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SUMMARY

Calcium chloride when mixed with sand or cinders and applied to icy airport runways has been found effective in providing a "skid-proof" surface. This material is also used as a dust palliative. There is, however, considerable concern as to the possibility of serious corrosion resulting from continued splashing of calcium chloride on the structural components of the airplanes.

A search of the literature has yielded three reports covering laboratory tests in which steel, unprotected aluminum alloy, and aluminum-coated or "alclad" sheets were subjected to the corrosive effect of calcium chloride. In addition to the above, letters of inquiry were sent to a large number of airport managers to obtain information concerning actual experience in this connection.

Information involving actual operation of aircraft on runways conditioned with calcium chloride was meager and inconclusive The laboratory tests indicated that "alclad" aluminum alloy sheet was highly resistant to corrosion. Serious intercrystalline corrosion and embrittlement of the unprotected aluminum alloy sheet, however, were noted. The tests also indicated that when alloy steel was subjected to corrosion while stressed, its fatigue limit could be reduced to one-third of its normal value The effectiveness of corrosion inhibitors has not been conclusively established.

A careful review of all available information indicates that considerable quantities of calcium chloride can be thrown up into the wing as well as on the outside of the airplane and that it will be deposited on portions of the aircraft constructed of unprotected aluminum alloy as well as on steel components. It can be driven into seams and crevices, and highly concentrated solutions can result from the evaporation of the water Washing down of the airplanes will not completely remove this material from the seams or from the interior of the wings. Serious corrosion and embrittlement of the aircraft structures resulting from the use of calcium chloride on airport runways therefore appear possible. However, tests which closely simulate the conditions actually encountered in practice as well as field surveys must be conducted if a satisfactory solution of this problem is to be obtained

INTRODUCTION

The long use of calcium chloride on roadways as a stabilizing agent and dust palliative has lead to the use of this material on airport runways. For this purpose it is mixed with sand or cinders and is applied to ice-coated runways. When applied in this manner, the calcium chloride combines with the moisture in the air to form a solution which surrounds the individual sand or cinder grains. This solution melts the ice adjacent to the grains and later, upon freezing, imbeds them, thereby giving a magnified sandpaper texture to the icy surface. In some cases the calcium chloride solution melts all of the ice from the runway. Furthermore, the sand-calcium chloride mixture tends to prevent initial ice formation if it is applied during ice-forming conditions.

Although calcium chloride has proved effective as a runway surface conditioner it has been suspected that the melted brine may seriously corrode the skin and structure of the airplane when sprayed by the wheels and the propeller blast. A study of the available technical literature and of the reports of airport managers relative to the corrosive effects of calcium chloride on the metal parts of airplanes was therefore undertaken by the Technical Development Division of the Civil Aeronautics Administration.

ANALYSIS OF THE PROBLEM

When the melted calcium chloride brine is splashed up on the airplane, it not only contacts the outer skin but is splashed up into the wheel wells and thus comes in contact with the internal structure, which generally has no protective aluminum coating (not constructed of "alclad"). It is also driven into the seams The usual washing down of the airplane will not remove brine so deposited Furthermore, in spite of the fact that the concentration of calcium chloride when first deposited is extremely low, the subsequent evaporation of the water will result in an increasing degree of concentration until a highly concentrated solution is obtained Repeated splashings will result in the eventual accumulation of considerable amounts of such concentrations. Therefore, an investigation of the corrosive effect of variously concentrated solutions of calcium chloride on the metal parts of aircraft is required

APPROACH

As a first approach to the problem, a study of available literature concerning the corrosive effect of calcium chloride on aluminum and its alloys as well as on other metals used in aircraft construction was undertaken In addition, letters were sent to a large number of airport managers requesting information regarding their experience in this connection

TECHNICAL LITERATURE

An exhaustive search of the available technical literature dealing with the corrosive effect of calcium chloride on metals used in aircraft construction has yielded the following three reports

Reference

1 Rawdon, Henry S., "Corrosion Embrittlement of Duralumin II Accelerated Corrosion Tests and the Behavior of High Strength Aluminum Alloys of Different Compositions," NACA Technical Note No 283, 1928

2 Rawdon, Henry S , "Corrosion Embrittlement of Duralumin IV. The Use of Protective Coatings," NACA Technical Note No 285, 1928.

3 McAdams, Dunlap J , and Geil, Glenn W , "Influence of Cyclic Stress on Corrosion Pitting of Steels in Fresh Water, and Influence of Stress Corrosion on Fatigue Limit," National Bureau of Standards Journal of Research, January - June, 1940

SUMMARY OF REPORTS

The laboratory tests described in Reference 1 involved only the use of uncoated aluminum alloy (no "alclad") The tests were conducted on strips of uncoated duralumin sheet These resulted in considerable embrittlement of the sheet duralumin due to the corrosive effect of a normal and a one-fourth normal calcium chloride solution Subsequent microscopic examinations showed that the corrosive attack was in large measure of the intercrystalline type A prolonged period of exposure to the solution (approximately 40 days) was necessary to obtain any appreciable changes in tensile properties However, a period of 10 days was sufficient to reduce the elongation from 20 percent in 2 inches to 10 percent in 2 inches for a normal solution, while a period of 39 days was required to produce the same effect for a one-fourth normal solution In other instances, the elongation was further reduced to 3 percent in 2 inches during a period of 39 days using a one-fourth normal solution In brief, the most detrimental effect of the corrosion was reflected in the reduction of the ductility of the duralumin which materially reduces its fatigue resistance properties.

The laboratory tests described in Reference 2 involved both uncoated and "alclad" sheets. The results of those tests showed marked superiority of aluminum-coated duralumin sheet over the uncoated sheet A comparison made between the two showed little difference on the score of strength but a great superiority for the protected sheet on the score of ductility and freedom from brittleness. The "alclad" sheet showed practically no intercrystalline corrosion or loss in ductility. A one-fourth normal solution reduced the ductility of uncoated duralumin sheet from 20 to 10 percent in 39 days, while a normal solution had practically no effect on the sheet "alclad" speciman for a period of 40 days In all these tests a normal solution of calcium chloride produced a more deleterious effect on ductility than the one-fourth normal solution

The results of laboratory tests as set forth in Reference 3 showed that the fatigue limit of alloy steels was markedly reduced as a result of corrosion due to well water containing very small amounts of calcium chloride, particularly when the specimans were under constant stress when subjected to the corrosive effect of the well water. For example, one specimen was subjected to corrosion for 20 days while stressed to 13,000 pounds per square inch In this case the fatigue limit was reduced from 65,000 pounds per square inch to 21,000 pounds per square inch

DISCUSSION OF REPORTS

In connection with the high resistance of "alclad" sheet to corrosion, tests showed that where the protective aluminum coating was itself attacked by the solution, the duralumin core beneath was protected from corrosion because of the anodic character of the pure aluminum coating. The attack on the pure aluminum coating may be partially explained by the presence of calcium oxide found in commercial calcium chloride In the presence of moisture, calcium oxide becomes calcium hydroxide, a base, which attacks the pure metal aluminum and causes surface pitting

The results in Reference 3 are significant since it is shown that even a mild concentration of calcium chloride can seriously reduce the fatigue limit of alloy steels. In actual practice four pounds of calcium chloride per gallon of water (4.31 normal solution) are used to mix with the abrasive When this is applied to the icy runway and the ice melts, a dilute solution will result. When this is splashed on the airplane, subsequent evaporation of the water will result in increasing concentrations during which the concentration for maximum corrosion undoubtedly will be realized. It may be inferred, therefore, that the higher concentrations to which aircraft in actual runway operation can be subjected will have a serious effect upon the steel structural components.

DISCUSSION OF REPORTED CASES

Information received from the various airport managers indicated that the use of calcium chloride on airport runways, even as a dust palliative, had been extremely limited. Only one of the airport managers to whom inquiries were sent was able to furnish any information regarding its corrosive effect on aircraft in actual use.

Several years ago, before all-metal airplanes were in common use, calcium chloride was applied on the cinders of the Boston Municipal Airport. After its application, various airplane operators informed the manager of the airport of the corrosion that had taken place on the metallic parts of their airplanes The manager, claiming that the resulting corrosion was due to the use of calcium chloride, discontinued its use thereafter as a stabilizing agent on the airport runways. Calcium chloride was also used on various country roads in the states of Connecticut and Massachusetts, with the result that many of the automobiles using such roads had the centers of their mudguards seriously corroded Calcium chloride was added to the ballast water of the dirigible "Los Angeles" to prevent freezing Some of this water spilled on the metal structure of the ship and serious corrosion resulted.

USE OF INHIBITORS

There is some evidence indicating that the corrosive action of calcium chloride can be minimized, if not completely eliminated, by the use of an inhibitor Investigations conducted by the Aluminum Company of America and also by the Solvay

Process Company Laboratory have shown by laboratory tests that sodium dichromate is effective in suppressing the corrosive effects of calcium chloride on aluminum and its alloys. It is claimed as a result of these tests that the dichromate serves to reduce the natural alkalinity of the calcium chloride solution to approximately the neutral point. However, other tests conducted at the National Bureau of Standards with various antifreeze, calcium chloride solutions, both with and without an inhibitor, resulted in severe corrosion damage to the aluminum parts of the engine under test.

CONCLUSIONS

When icy runways are treated with calcium chloride, a solution of low concentration is first splashed onto the airplanes. As the water evaporates, however, the concentration increases until a highly concentrated solution remains, and the quantity increases with continued applications. This can be deposited in seams and crevices and inside the wings where it cannot be readily washed off. With the above in view, serious corrosion and embrittlement of the aircraft structure appear possible.

However, field surveys involving actual operations carefully correlated with laboratory tests which closely simulate actual conditions must be conducted if a complete solution to the subject problem is to be obtained