

Report 141

MICHIGAN
STATE HIGHWAY DEPARTMENT
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STUDY OF CORROSION INHIBITORS ADDED
TO DE-ICING CHEMICALS

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Research Laboratory
Testing and Research Division

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STUDY OF CORROSION INHIBITORS ADDED TO DE-ICING CHEMICALS

The Research Laboratory of the Michigan State Highway Department has recently completed a study of the corrosive effects of de-icing chemicals on automobile body steel and the feasibility of adding corrosion inhibitors to these chemicals in connection with ice control practices on the State trunk line system. Because of the current widespread interest in the subject, the present report is designed to present in condensed form the more important and significant results obtained to date.

Scope of the Tests

The testing program comprised three general phases: 1) laboratory study of the corrosiveness of salt solutions; 2) laboratory study of inhibitors; and 3) field tests of inhibitors.

Laboratory test procedures in general consisted in exposing mild steel plates to the corrosive action of calcium and sodium chloride brines of systematically varied strengths under different conditions of aeration, agitation, temperature, and inhibition concentration. The plates were then cleaned and weighed to determine corrosion loss.

Inhibitors under study included chromates and two phosphate-type products. Results of the laboratory evaluation of these two phosphate-type inhibitors are shown in the graphs of Figures 1 and 2.

In the field tests, mild steel plates were mounted on the underside of a group of police cars in each of two cities, one of which used a commercial inhibitor added to the salt used for winter maintenance, while the other used no inhibitor. The winter tests were supplemented with a similar, but shorter, test in the spring of the same year.

Summary of Findings

Significant facts brought out by the study were:

1) Corrosion is most severe in very weak salt solutions, reaching a maximum usually at concentrations somewhere between 0 and 2 percent, depending on the conditions of exposure; higher concentrations may be less corrosive than plain water.

2) Salt solutions found to be present on highways usually fall within this range of 0 to 2 percent concentration.

3) The quantity of inhibitor necessary to give satisfactory protection in these dilute chloride solutions cannot be supplied by adding inhibitor to salt in the ratio of 1 to 100 recommended by the manufacturers. Effective inhibition would require many times this amount, and the use of insufficient amounts of inhibitor actually increases corrosion in dilute salt solutions. (Figures 1 and 2).

4) Protective films cannot be built up by continuous exposure of the metal to solutions of low inhibitor concentration.

5) In none of the tests was there a significant difference in the corrosive effects of sodium chloride and calcium chloride solutions.

6) Anodic inhibitors, such as chromates and dichromates, cause pitting rather than overall corrosion. Although pitting corrosion takes place over a small area and does not cause a great loss in weight of a test panel, it constitutes an intensive attack on a small area and can produce deep holes in a relatively short time. This pitting was observed in 2 percent brines containing as much as 10 parts of sodium chromate per 100 parts of calcium chloride.

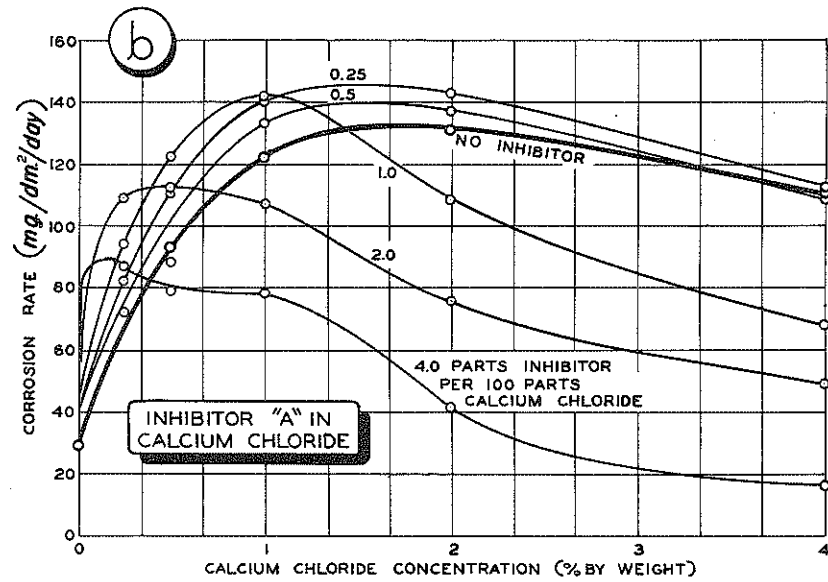
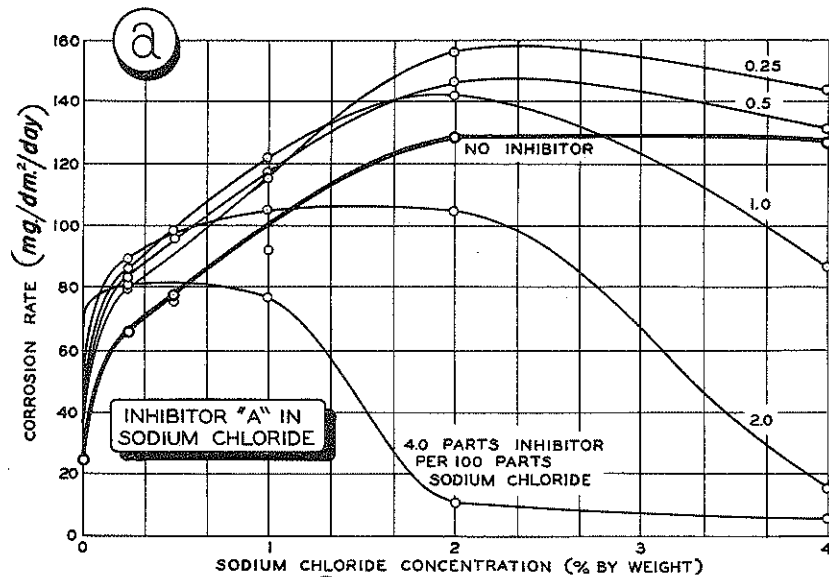
Another disadvantage in the use of chromates as inhibitors is their possible toxic effect on persons handling the chemicals and children and animals coming in contact with pools of the solution.

7) Field tests were not conclusive, due to the use of an insufficient number of test panels, difference in salt application rates and climatic conditions in the two cities, and other uncontrolled variables. Photomicrographs of pitted areas of panels from the spring tests indicate that appreciable corrosion takes place during that portion of the year when no salt is used, as well as in the winter.

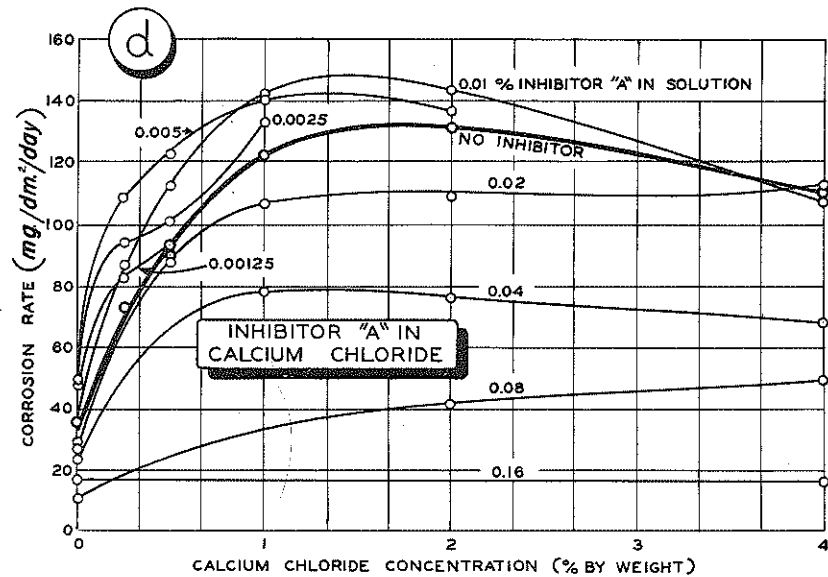
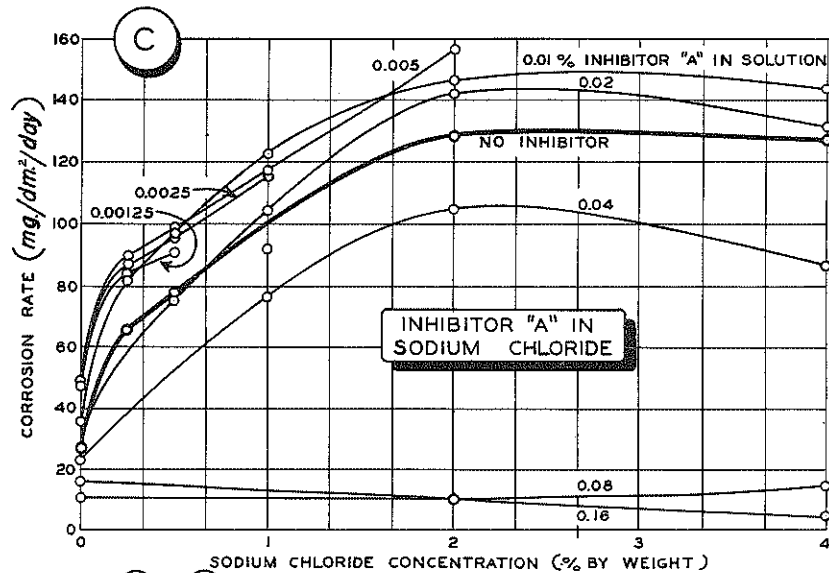
Conclusion

From the information obtained in this study, the costly addition of corrosion inhibitors to chlorides used for ice control is not considered feasible.

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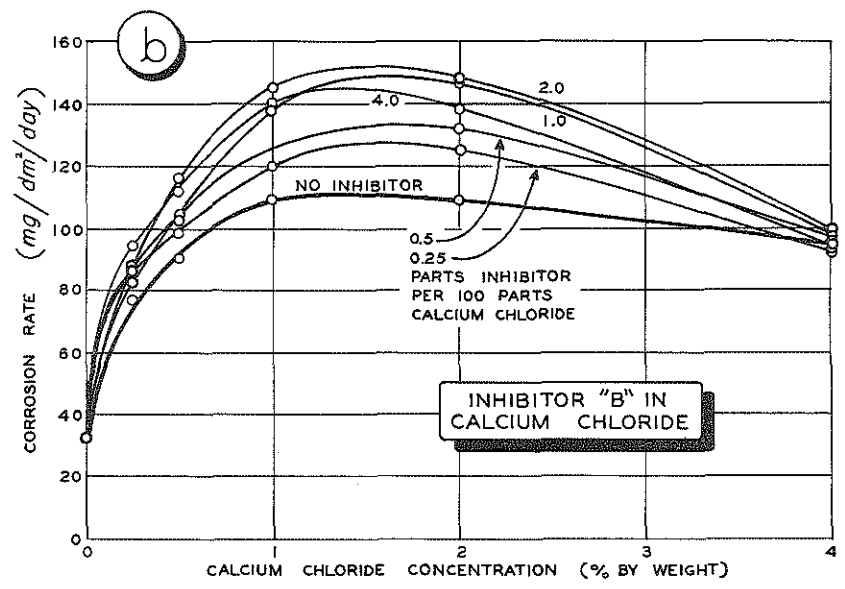
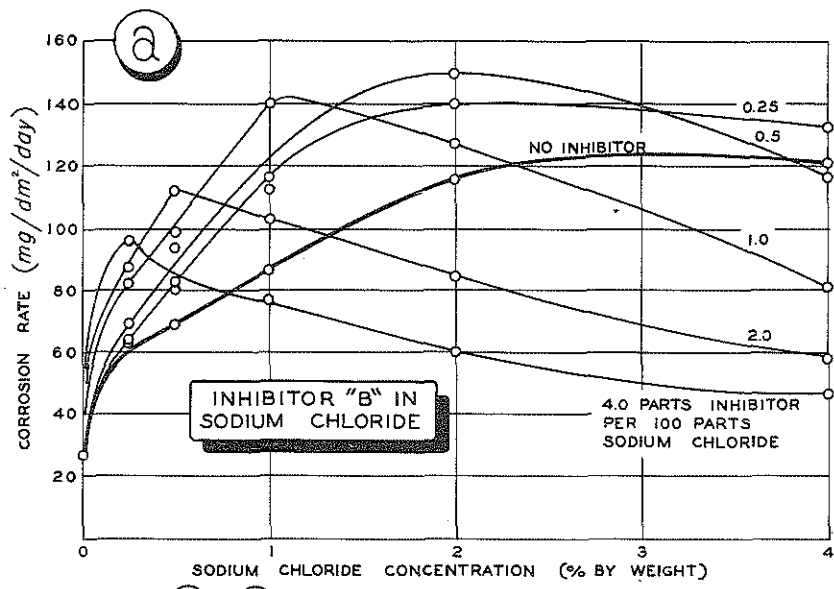
(a) & (b) CURVES CONNECTING POINTS WITH EQUAL RATIOS OF INHIBITOR TO SALT WEIGHT



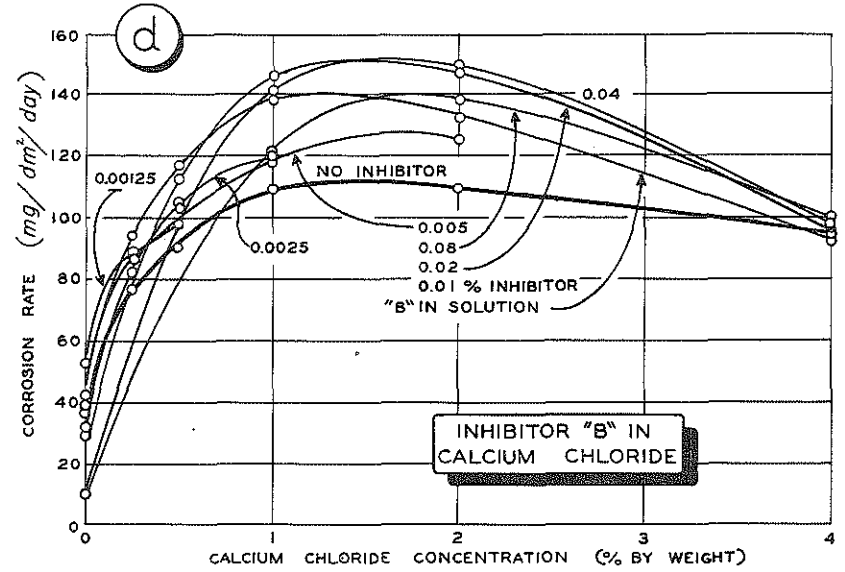
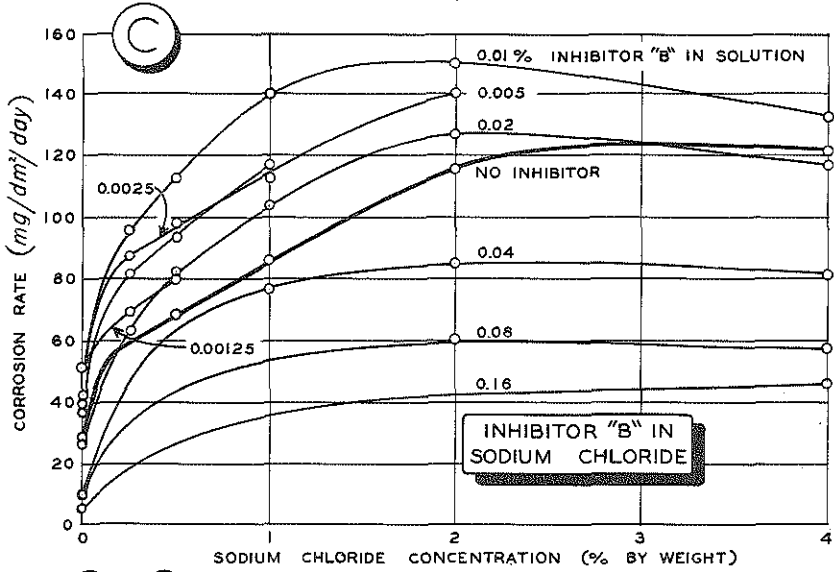
(c) & (d) SAME DATA, WITH CURVES CONNECTING POINTS WITH SAME CONCENTRATION OF INHIBITORS IN SOLUTION

(S.A.E. 1008 SHEET STEEL, ALTERNATE IMMERSION, 14 DAYS AT 80° ± 5° F)

EFFECT of INHIBITOR "A" on CORROSION RATE in DILUTE SODIUM and CALCIUM CHLORIDE SOLUTIONS



(a) & (b) CURVES CONNECTING POINTS WITH EQUAL RATIOS OF INHIBITOR WEIGHT TO SALT WEIGHT



(c) & (d) SAME DATA, WITH CURVES CONNECTING POINTS WITH SAME CONCENTRATION OF INHIBITORS IN SOLUTIONS (S.A.E. 1008 SHEET STEEL, ALTERNATE IMMERSION, 14 DAYS AT $80^{\circ} \pm 5^{\circ}$ F.)

EFFECT OF INHIBITOR "B" ON CORROSION RATE
 IN DILUTE SODIUM AND CALCIUM CHLORIDE SOLUTIONS