

A STUDY OF THE CORROSION
OF AUTOMOBILE SHEET STEEL

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This is to certify that the

thesis entitled

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A STUDY OF THE CORROSION OF AUTOMOBILE SHEET STEEL

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FOREWORD

In presenting this information, it is not the intention of the author to attempt to fix the responsibility for the corrosion of automobile bodies on either the manufacturers of motor vehicles, nor on the governmental agencies using chloride salts on streets and highways.

It is felt, however, that this problem can best be solved by the cooperative action of all the organizations connected with motor transportation. This information is presented, therefore, not as a solution to the problem, but as an initial step toward that goal. It is hoped that this work may, in a small way, contribute to the ultimate success of their efforts.

The author wishes to thank Dr. C. C. DeWitt, Dr. M. G. Larian, and Dr. R. W. Ludt of the Chemical Engineering Department for their helpful counsel and guidance. Sincere appreciation is expressed to Mr. E. A. Finney, Mr. C. C. Rhodes, Dr. Richard Thurm, and the other members of the Michigan State Highway Research Laboratory for the friendly assistance and cooperation which contributed so much to the completion of this work. Without their assistance, this project would not have been possible.

L. L. Peterson
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A STUDY OF THE CORROSION OF AUTOMOBILE SHEET STEEL

In recent years, the problem of automobile body corrosion has become increasingly troublesome to motorists. The extensive use of the automobile as a means of transportation has demanded that streets and highways be kept safely passable under all weather conditions. To this end, sodium chloride and calcium chloride have been applied as a means of ice control and dust palliation. The use of these chemicals has mounted in direct proportion to the increasing traffic on our highways and has brought the problem of corrosion sharply to the attention of the motorist. The opinion of a great majority of motorists seems to be that these chloride salts are the chief cause of this destruction (Figure 1).

Little published information is available on this specific phase of chloride salt corrosion, although some work on this problem has been reported in recent periodicals and press releases. These reports have apparently been based on opinion and visual field surveys, lacking (1)(2)(3)(16) in quantitative support. However, considerable data may be found on the corrosive properties of refrigerating brines and sea (5) (7) water. Speller gives an excellent bibliography on the general subject of corrosion.

This investigation concerns the feasibility of reducing the corrosion of automobile bodies by the addition of corrosion inhibitors to the chloride salts used on streets and highways. Since a thorough study of the complete problem of automobile body corrosion would require a very extensive investigation, the scope of this work has been limited to a laboratory study of the corrosiveness of sodium



Figure 1. Typical examples of the corrosion of automobile bodies.

and calcium chloride salts and of the effects of various corrosion inhibitors.

FACTORS AFFECTING CORROSION

Generally, corrosive action is similar to the action occurring in a galvanic cell. Just as the galvanic cell has positive and negative terminals, so a sheet of metal has positive and negative areas. There may be a great many of these oppositely charged areas on a single sheet of metal. These areas are caused by internal stresses, heterogeneity, ruptures in a protective coating, and many other factors. Corrosion takes place when metal dissolves at the positive area, or anode. The corrosion products are generally deposited on the negative area, or cathode. ⁽⁷⁾⁽⁸⁾ These corrosion products form a film over the negative region, isolating the metal and thus retarding corrosion. Excellent examples of the formation of very thin, dense and adherent films of corrosion products over the metal surfaces are afforded by stainless steel, chromium, and aluminum.

Corrosion continues when this film is mechanically or chemically broken. In the case of chromium, aluminum, or stainless steel, film destruction is very difficult. Other metals, such as iron and steel, form films of corrosion products which are easily removed or broken, thus allowing corrosion to continue. Many agents such as oxygen, abrasive action, or the presence of certain chemicals accelerate the breakdown of the film of corrosion products.

It is the function of corrosion inhibitors to form new or repair ⁽⁹⁾ the old films on the surface of the metal. Inhibitors are classified as anodic or cathodic depending on whether they form a film over the positive or negative areas of the metal. The isolation of the metal

from the corroding medium is essential if corrosion is to be prevented.

Consideration of the problem of automobile body corrosion indicates that the following factors are involved.

1. - A corrosive brine is formed as a result of the use of sodium and calcium chlorides on roads for dust palliation and ice control.
2. - Rain and other forms of precipitation, in the absence of chloride salts, cause corrosion.
3. - In industrial areas sulfur dioxide-laden rain and moisture contribute to active corrosion.
4. - In the case of rock salt, crystal growth by evaporation may mechanically loosen the protective paint coating. Calcium chloride leads to corrosion by holding moisture in cracks and crevices.
5. - Accumulation of water, with or without dissolved chloride salts, in hollow body members such as doors, door posts, and running boards likewise contributes to the corrosion picture.
6. - Abrasive action of sand and pebbles thrown against the body breaks paint coatings and films of corrosion products.
7. - Soil and other foreign matter, comprising the mud that exists underneath an automobile, materially affects the character of the corrosion.
8. - The changes in metal thickness and the stresses set up in the metal by deep-drawing operations contribute largely to localized corrosion failures.

The above factors will, directly or indirectly, affect either the actual dissolving of the automobile steel and the continual destruction of the protective film of corrosion products. In this paper, only the first of these factors will be considered.

SCOPE AND GENERAL PROCEDURE

The investigation was divided into two major parts. First, an examination of several inhibitors was undertaken. This was done to determine which inhibitors might be effective in reducing the corrosiveness of the chloride salts. The second part of the investigation consisted of a comparison of the corrosive effects of distilled water, sodium chloride, and calcium chloride. Its purpose was to learn whether or not the chloride salts were more corrosive than rain or ground water.

Throughout the investigation, the chloride concentrations are given in weight-per cent based on the weight of water in solution. The inhibitor (or inhibitor mixture) concentrations are in weight-per cent based on the weight of total chloride salts in solution. The various components of the inhibitor mixtures are given in parts by weight, with the entire mixture taken as 100 parts. In all cases, except the elimination study, triplicate samples were tested.

Inhibitor Study

In studying the effects of the various inhibitors, eleven series of tests were conducted. The test periods were two weeks initially, but were increased to four weeks later on. Room temperature (75° F.) was maintained throughout the inhibitor tests.

Series 1 was an elimination test of several inhibitors and inhibitor mixtures conducted on single samples. The inhibitors were used in concentrations of 0.5 per cent. The corrosive solution was a 5 per cent calcium chloride brine, saturated with oxygen by a continuous flow of air bubbles.

Series 2, 3, 6, 10, 11, and 12 were confined to a study of chromate inhibitors. Samples were continuously aerated throughout the test. In series 2 the effect of various organic additives on the inhibitive efficiency of sodium chromate in a 5 per cent calcium chloride brine was studied. Series 3 compared the inhibitive properties of sodium chromate and sodium dichromate at various concentrations in a 5 per cent rock salt (NaCl) brine. The effects of hydroquinone on sodium dichromate and of quinone and quinhydrone on sodium chromate in a 5 per cent calcium chloride brine were examined in series 10. In series 6 the optimum sodium chromate-hydroquinone ratio was determined by varying the proportions of each at a constant concentration of inhibitor mixture. This was done in a 5 per cent and a 20 per cent calcium chloride solution. An effort to ascertain the minimum effective inhibitor concentration was made in series 11, by using various concentrations of a fixed sodium chromate-hydroquinone mixture in a 5 per cent calcium chloride brine. Series 12 was identical to series 11, except that sodium chromate alone was used.

In series 4 the effect of road soil on inhibition efficiency was studied. A mud consisting of road soil passing a 30-mesh sieve and a saturated calcium chloride brine was made up to simulate a graveled road immediately after a chloride application. Weighed metal plates

were immersed in the mud for eight hours and exposed to the air for sixteen hours over a period of twenty-eight days. The plates were cleaned and weighed once each week according to the procedure described in Appendix B, and returned to the test. This was done at room temperature with brines containing varying amounts of sodium chromate as an inhibitor.

In series 7 several phosphate inhibitors were tested at a 1 per cent concentration in a 5 per cent calcium chloride brine and a 5 per cent rock salt (NaCl) brine. The metal plates were alternately immersed in the brine and exposed to the air. This test was repeated in series 8, except that the metal plates were continuously immersed in aerated brines. These two tests were performed in order to compare the continuous aeration and alternate immersion types of tests. In series 9 several other phosphate inhibitors were tested at 0.5 per cent concentrations in both a 5 per cent rock salt brine and a 5 per cent calcium chloride brine.

Study of the Corrosive Media

In this study, the influence of temperature, aeration, and agitation on the corrosive effects of distilled water, sodium chloride, and calcium chloride was investigated. Brines of various concentrations were used, ranging from distilled water to a saturated brine for both calcium chloride and rock salt.

Series 5, 14, and 15 were all continuously aerated tests. Series 5 and 15 were run at 75° F. and were identical, except that series 15 included rock salt solutions. Series 14 was the same as series 15, except that it was conducted at a temperature of 35° F.

Series 13 and 16 were conducted under conditions of limited access to air by placing the specimens in sealed jars. The brines were prepared with distilled water that had been freshly boiled. The two tests were the same, except that series 13 was conducted at 35° F., while series 14 was run at 75° F.

The detailed procedure for all of these tests may be found in pp. 75-79 of Appendix B. Series 1, 2, 3, 5, 6, 8, 9, 10, 11, 12, 14, and 15 were conducted according to cycle 1; series 7 according to cycle 2; and series 13 and 16 according to cycle 3. Series 4 was performed as previously stated. Data summaries and photographs are located in pp. 33-73 of Appendix A. All original data is included in pp. 85-109 of Appendix B.

DISCUSSION OF RESULTS

The chief factors affecting the results of all these tests seemed to be temperature and aeration. The temperature variations were within $\pm 5^\circ$ F. and did not appear to introduce any appreciable errors. The control of aeration, however, was not completely satisfactory.

(7)
According to Speller⁽⁷⁾ the supply of oxygen to the metal surface is influenced by the solubility of oxygen in the solution, the physical distribution of oxygen throughout the solution, and the rate of diffusion of oxygen across the liquid film at the metal-liquid interface. Since the degree of aeration affects all of these factors, and since oxygen is essential for ordinary cases of corrosion, it can easily be seen that aeration is a critical factor. In concentrated brines and in the presence of an effective inhibitor, i.e. at low rates of corrosion, no appreciable variations were noticed. However, in dilute brines, i.e. at high rates of corrosion considerable uncertainty was

observed. At these high corrosion rates, the supply of oxygen to the metal was apparently the controlling factor, rather than the nature of the solution itself.⁽¹⁰⁾

Although it is well recognized that pH and its proper control exert considerable influence on corrosion, it was deemed unnecessary to control pH in these tests. The reason for this decision was the apparent impracticability of controlling pH over miles of road surface under widely varied conditions. For this reason, it was decided that an inhibitor should be effective without any particular attempt at pH regulation.

The pH of some of the solutions was, however, checked with a Beckman pH meter at intervals throughout the tests, pp. 87-109, Appendix B. The only significant trend noticed was a general decrease in pH as corrosion progressed. The higher rates of corrosion also appeared to be accompanied by a larger pH drop for aerated solutions. The unaerated tests, however, sometimes exhibited an increase in pH.

All data presented represent the average results of three samples.

Chromate Inhibitors

The data of Table 1 and Figure 2 show that the corrosiveness of a 5 per cent sodium chloride brine was reduced considerably for a period of fourteen days by either sodium chromate or sodium dichromate. There appeared to be very little difference in the behavior of the two, although the chromate lost most of its effectiveness at low concentrations after about seven days.

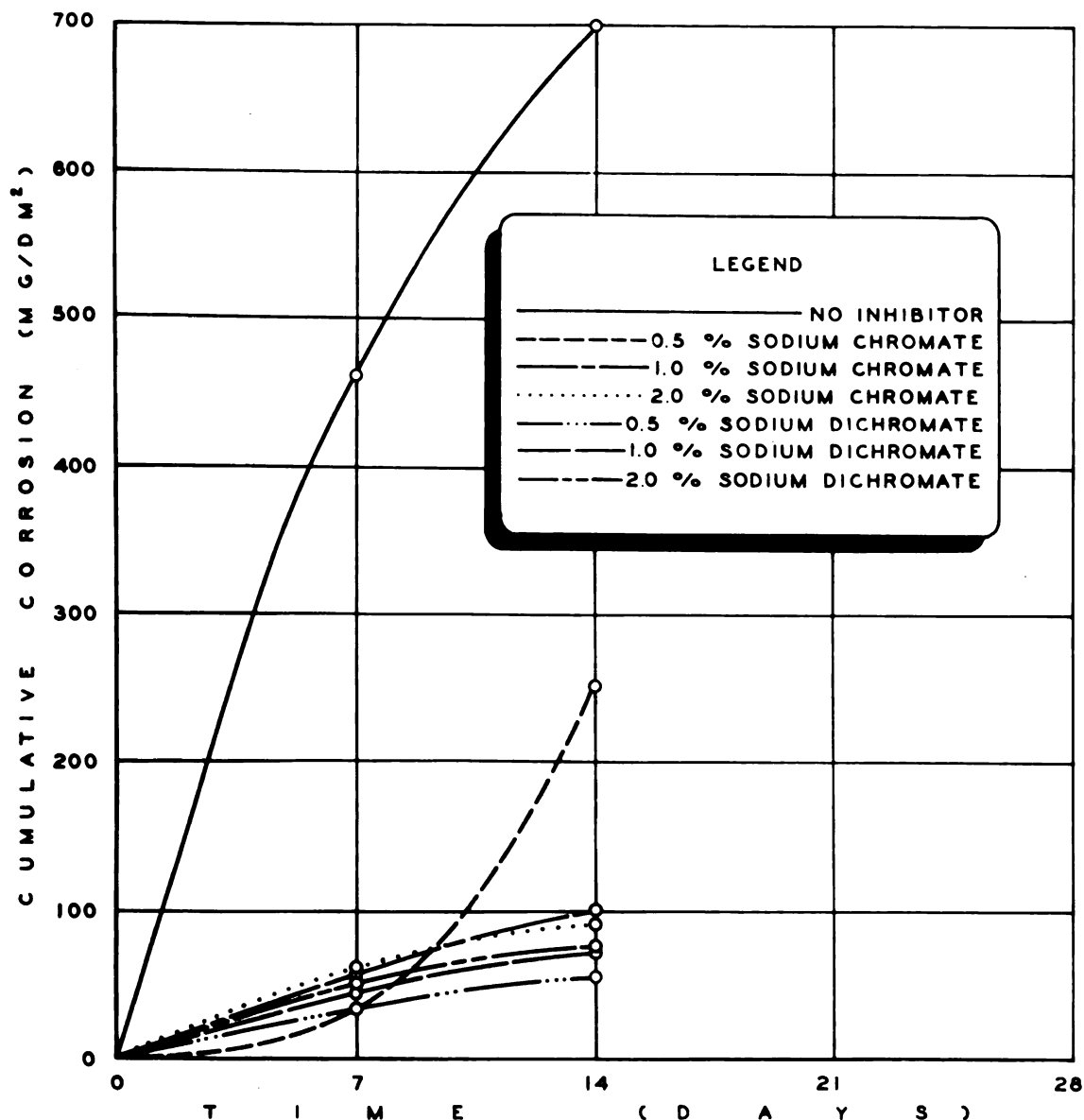
In series 4 an attempt was made to determine what effect soil particles would have on the effectiveness of inhibitors. This attempt was unsuccessful because the brine used was too highly

concentrated to show any significant trend (Table 2). A later analysis of road slush showed that the actual concentration of chloride salts present did not exceed 2 per cent, pp. 82, Appendix B. This confirms the data reported by Finney.⁽¹³⁾

From Figure 3 and Table 3, it can be seen that sodium chromate alone was fairly effective in reducing the corrosiveness of a 5 per cent calcium chloride brine, losing its effectiveness after about fourteen days. The addition of small amounts of pyridine, sodium salicylate, formaldehyde, or sodium benzoate increased the effectiveness of the inhibitor only slightly. However, the addition of hydroquinone maintained the effectiveness for at least 21 days.

The effect of quinone, hydroquinone, and quinhydrone on sodium chromate as an inhibitor is shown in Table 4 and Figure 4. They all appear to affect the inhibitive properties of sodium chromate in about the same manner. This would be expected in view of their chemical similarity. Sodium dichromate behaves in the same way in the presence of hydroquinone as does sodium chromate.

An examination of Table 5 and Figure 5 reveals that, for a 5 per cent calcium chloride brine, increasing the hydroquinone-sodium chromate ratio resulted in a sharp drop in the corrosion rate down to a minimum, after which there was a comparatively gradual increase. The total concentration of inhibitor mixture was held at 0.5 per cent throughout the test. The optimum proportions of sodium chromate and hydroquinone appeared to be in the range of 80 per cent chromate-20 per cent hydroquinone to 90 per cent chromate-10 per cent hydroquinone. However, for a 20 per cent calcium chloride brine, there appeared to be little advantage to the use of hydroquinone with sodium chromate.



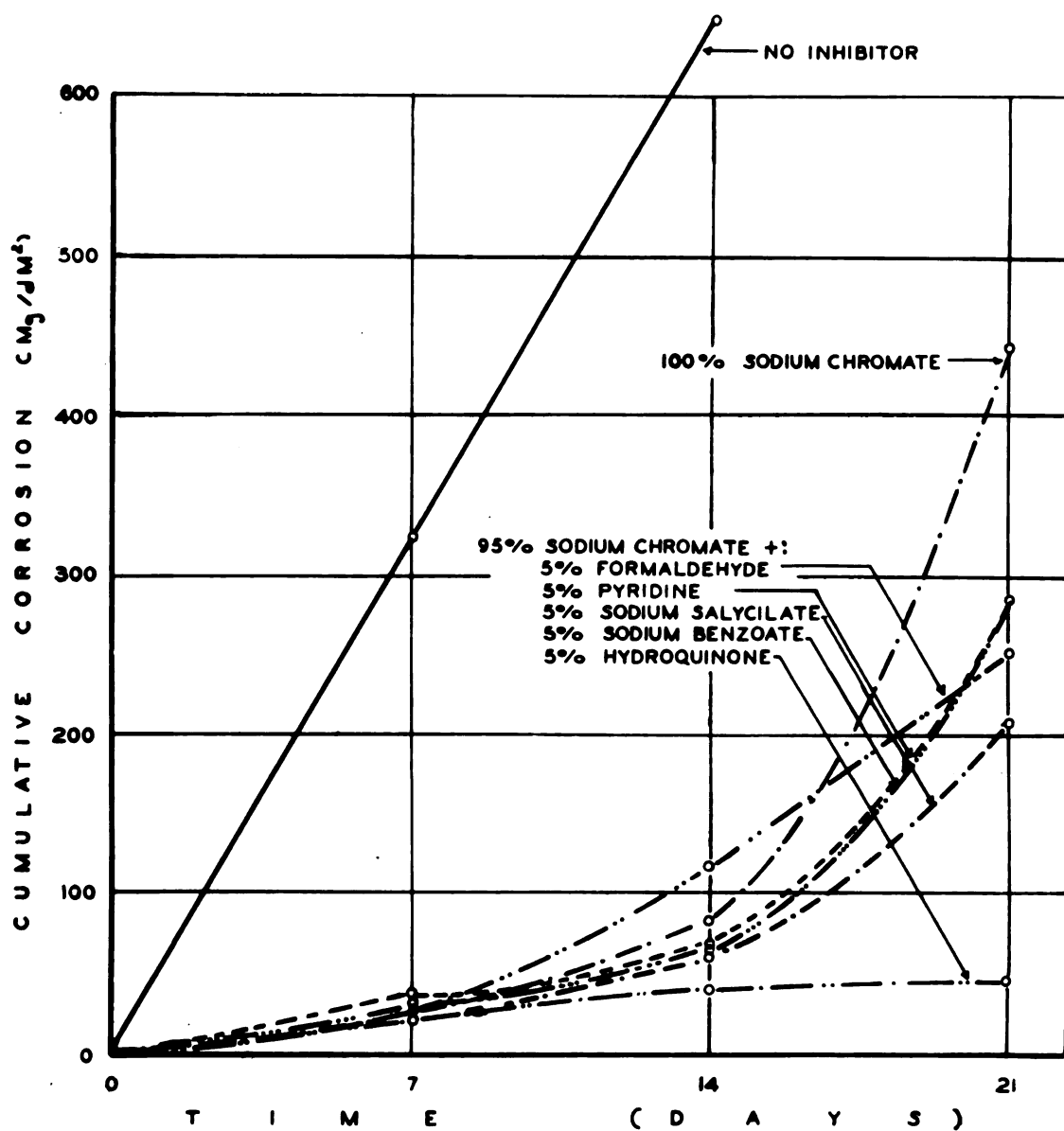
AERATED & AGITATED AT 75°F.

SERIES NO. 3

COMPARISON *of* Na_2CrO_4 *and* $\text{Na}_2\text{Cr}_2\text{O}_7$ *as* CORROSION INHIBITORS *for* ROCK SALT

19 GAUGE SAE 1008 SHEET STEEL IN A 5% ROCK SALT BRINE

Figure 2



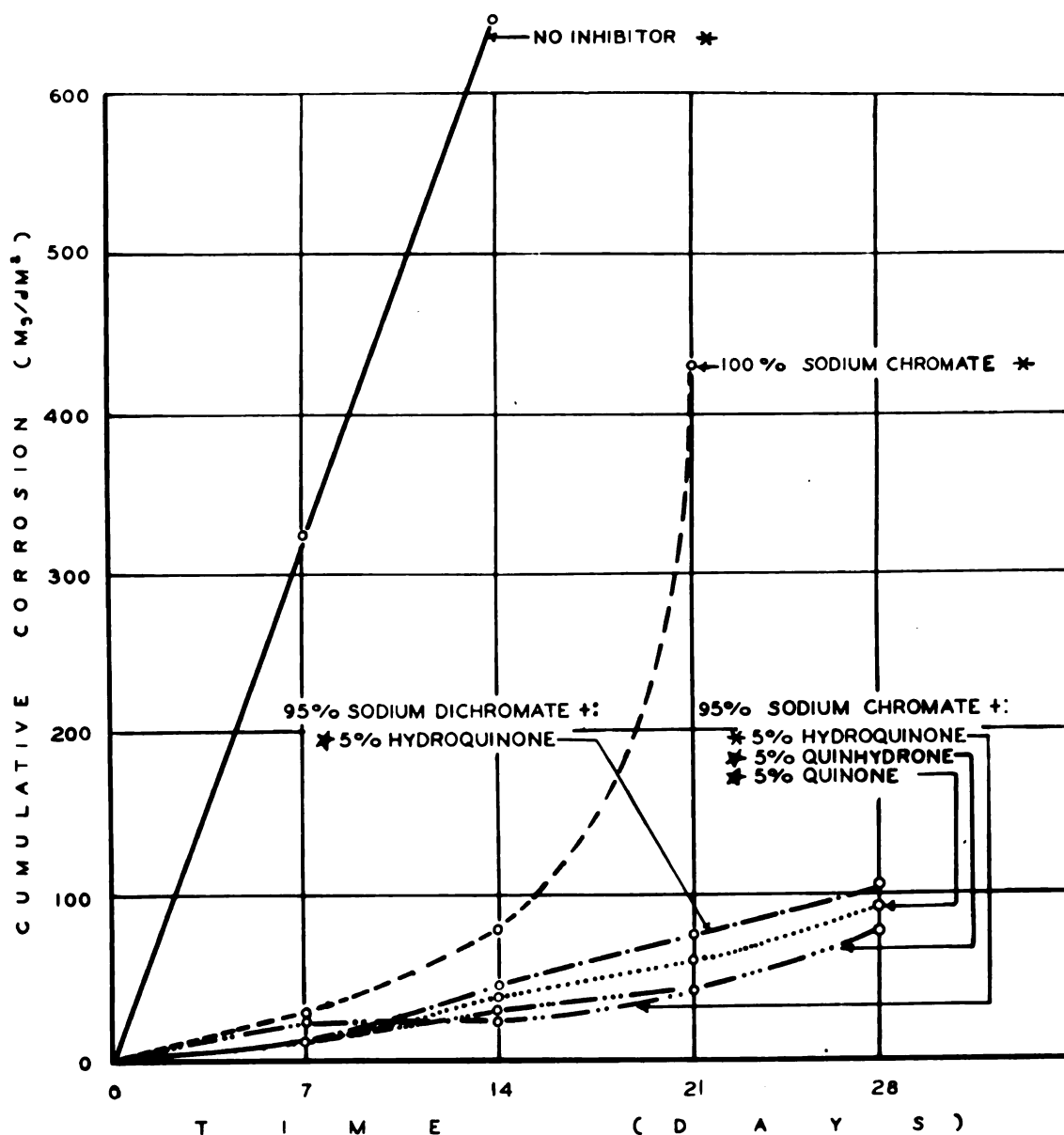
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SERIES NO. 2

The EFFECT *of* ORGANIC ADDITIVES *in* SODIUM CHROMATE *as a* CORROSION INHIBITOR

19 GAUGE SAE#1008 SHEET STEEL IN A 5% CaCl_2 BRINE, CONCENTRATION OF INHIBITOR MIXTURE
= 0.5% OF THE WEIGHT OF TOTAL CHLORIDES

Figure 5

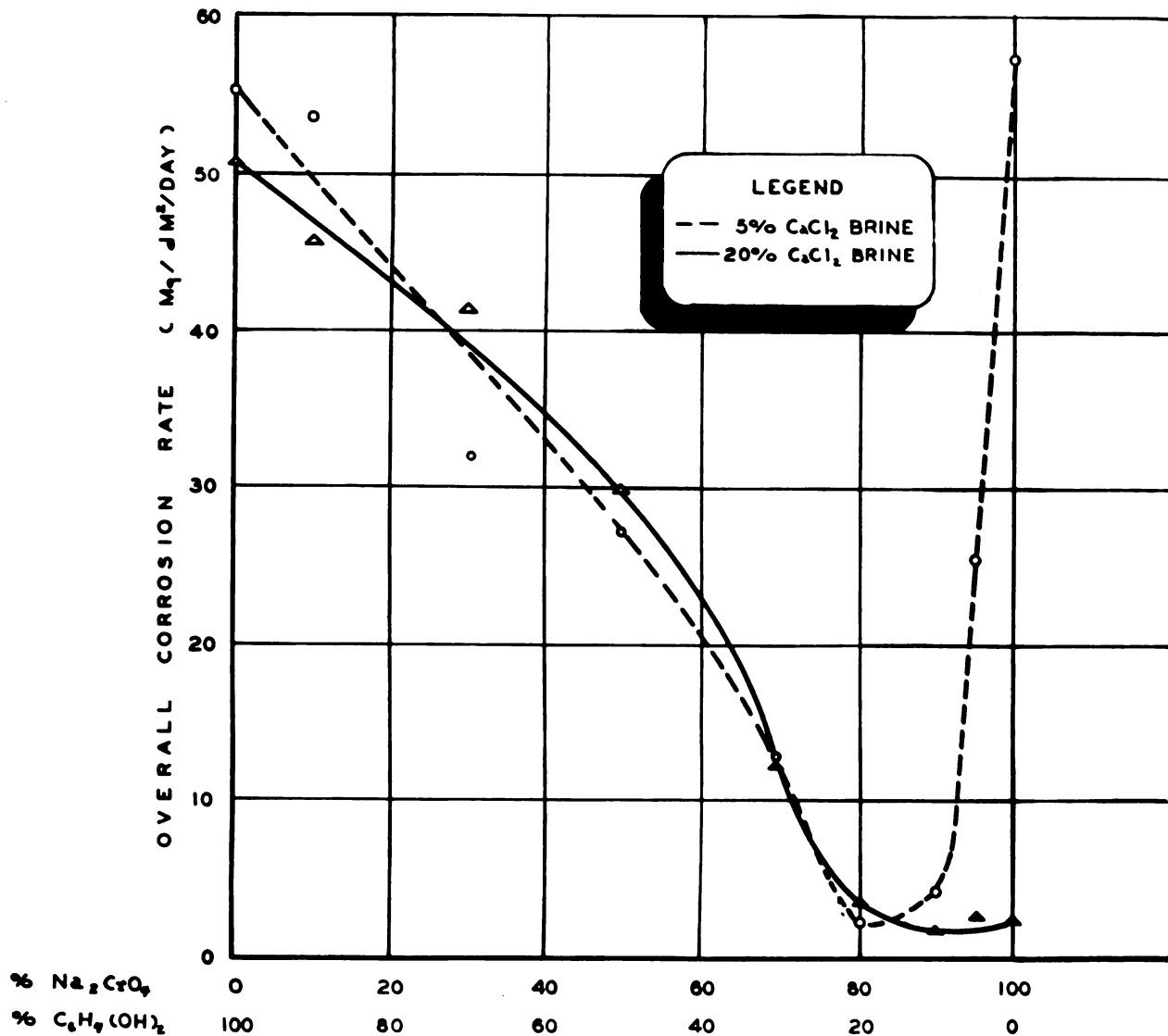


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 * SERIES 2 — * SERIES 10

EFFECT OF ORGANIC ADDITIVES ON CHROMATE CORROSION INHIBITORS

19 GAUGE SAE #1008 SHEET STEEL IN A 5% CaCl_2 - MgCl_2 BRINE, CONCENTRATION OF INHIBITOR MIXTURE
 = 0.5% OF THE WEIGHT OF TOTAL CHLORIDES

Figure 4



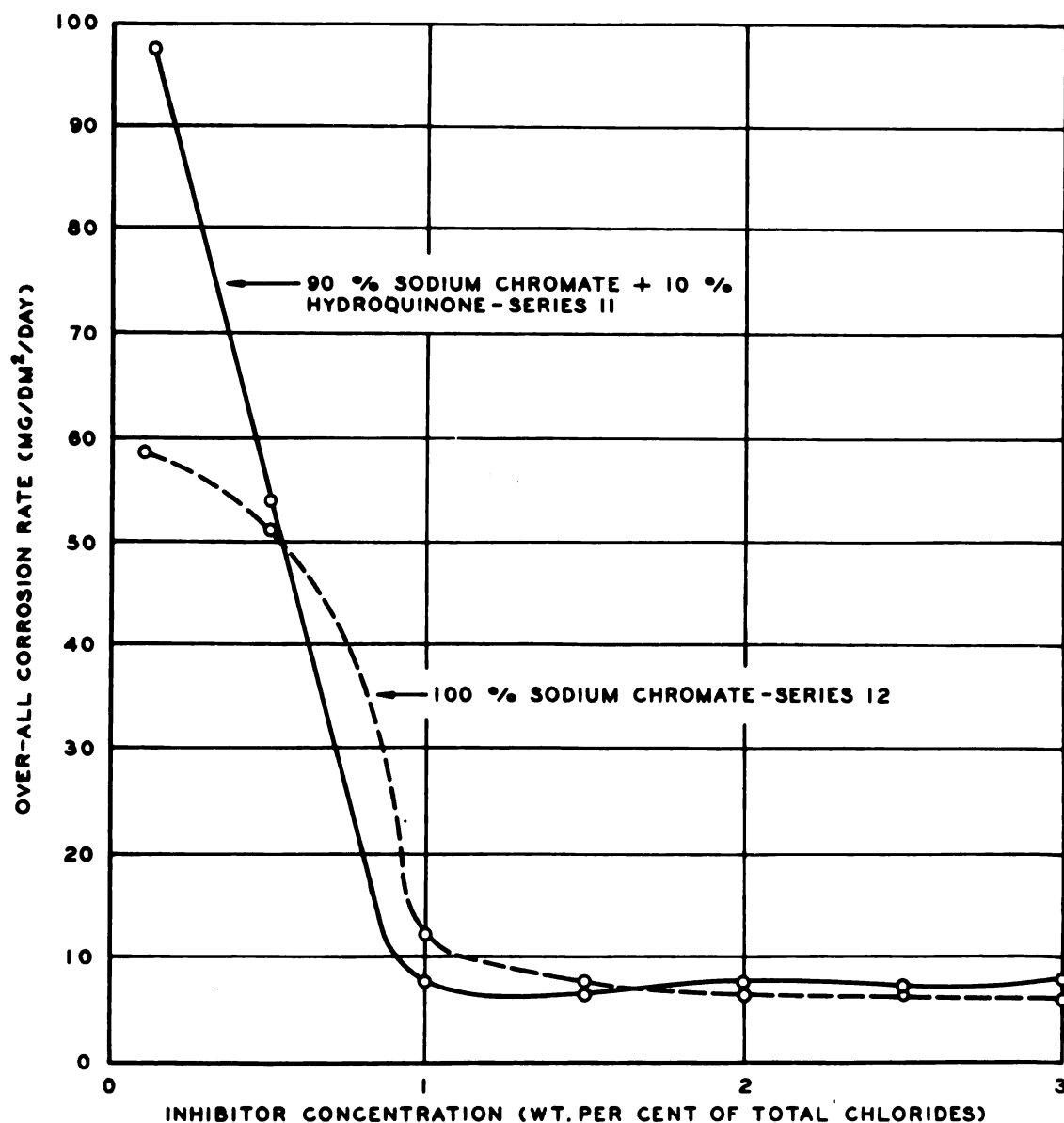
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SERIES NO. 6

Effect of SODIUM CHROMATE-HYDROQUINONE MIXTURES on OVERALL CORROSION RATE

19 GAUGE, SAE #1108, SHEET STEEL, CONCENTRATION OF INHIBITOR MIXTURE = 0.5% OF THE WT. OF TOTAL CHLORIDES

Figure 5



AERATED & AGITATED AT 75°F.

Effect of INHIBITOR CONCENTRATION *on* OVER-ALL CORROSION RATE

19 GAUGE SAE #1008 SHEET STEEL IN A 5% CaCl_2 BRINE

Figure 6

In series 11 and 12 it was desired to learn at what concentration the sodium chromate was most effective, and what influence the addition of hydroquinone exerted on this concentration. Tables 6, 7, and Figure 6 show the minimum effective concentration to be about 1.5 per cent of the weight of the total chloride salts in solution, whether or not hydroquinone was present. In fact, the curves indicate that the presence of small amounts of hydroquinone has practically no effect on the inhibitive properties of sodium chromate. Although these results were not in agreement with those of Figures 4, 5, and 6 time limitations did not permit a duplication of the tests.

In spite of the lack of agreement with the previous data, some interesting information can be obtained from series 11 and 12. An examination of Figures 13 and 14 reveals that at low inhibitor concentrations, the corrosion appears to be rather evenly distributed over the surface of the metal as evidenced by the even coating of light red rust. As the inhibitor concentration is increased, the appearance of large uncorroded areas can be noticed, accompanied by rather hard, dark red blisters over the corroded regions. This type of corrosion is known as pitting corrosion.

It can also be noticed that areas which were once pitted and then cleaned during the weekly cleaning and weighing were not necessarily subject to continued attack on being reimmersed in solution. On the contrary these areas often appear to be completely protected. This can probably be explained on the basis of a change in polarity of the pitted areas. It is now widely accepted that rust ordinarily forms by electrochemical loss of metal at an anodic region, the corrosion products being deposited at the cathode. (11) For this reason, it would

seem that the once-pitted areas had, after cleaning, become cathodic relative to certain other areas on the metal surface.

It will also be noted that pitting appeared at about the same inhibitor concentration, see Figure 6, at which the corrosion rate became relatively constant. In the light of this fact and the pitting exhibited by the photographs, it can be seen that although the rate of corrosion has decreased, the area actually subjected to corrosion has decreased also. This indicates that the corrosion taking place under the blisters is probably more rapid than the data lead one to believe. (12) This indicates that the metal may actually corrode completely through in a much shorter time over a small area under pitting conditions than under conditions of overall corrosion. (9) According to Hoar and Evans, (12) pitting diminishes and finally ceases as the chromate concentration increases.

Although some of the preceding data regarding hydroquinone as an additive to sodium chromate are contradictory, there is a strong indication that hydroquinone may have some beneficial effect. The opinion of some authors is that the chromates could not be expected to maintain their effectiveness as inhibitors in the presence of easily oxidized material. (14)(15) It would seem that these statements were based on the fact that the chromates, being oxidizing agents, would be reduced in the presence of easily oxidizable material. The results of these tests show, however, that the chromates maintained their effectiveness whether or not hydroquinone was present. Moreover, the effectiveness of the chromates was, in some cases, actually increased.

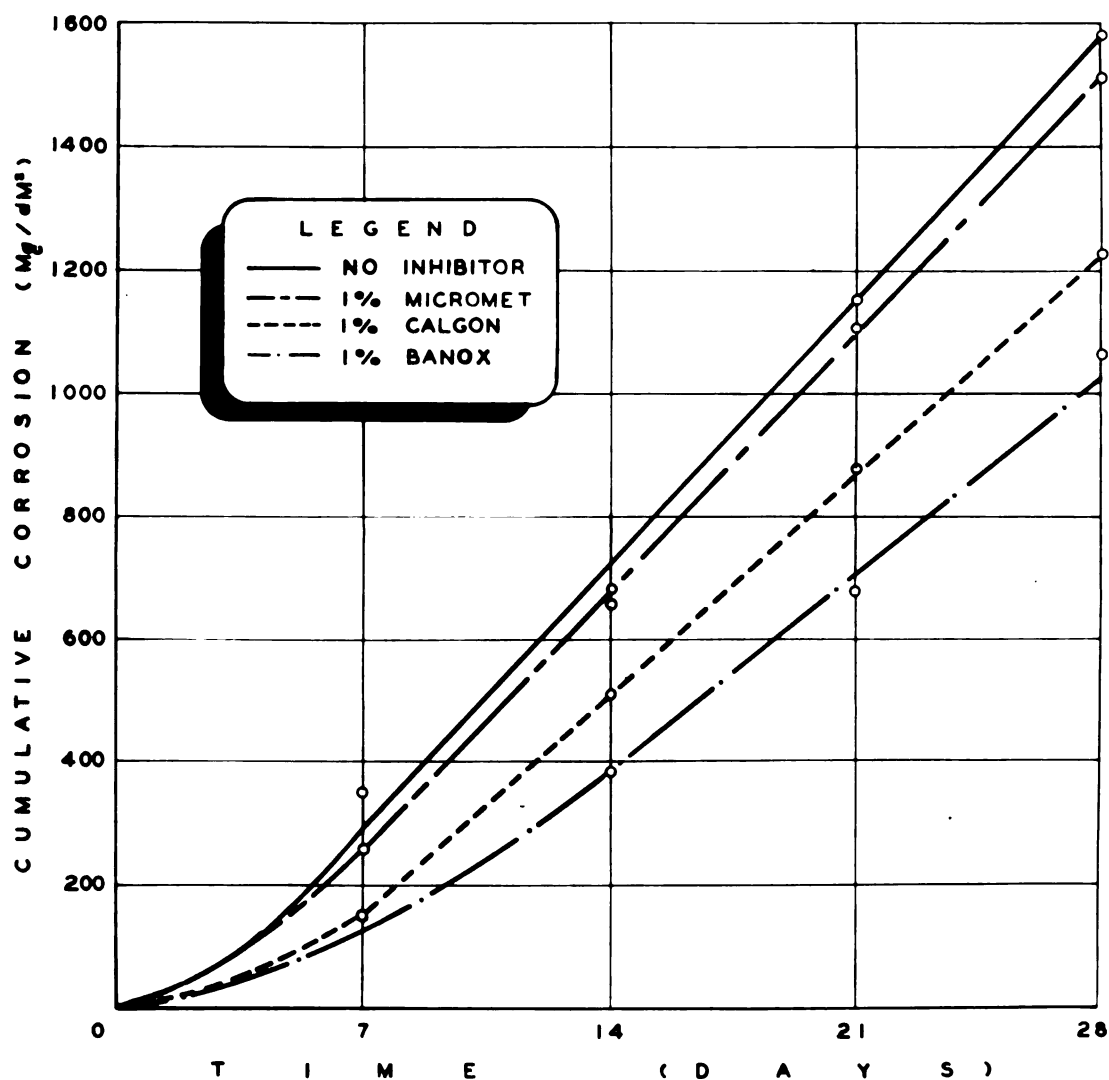
Acceptance of the fact that the chromates would be reduced by easily oxidizable material, such as hydroquinone, merely leads to speculation as to the effect of chromous ion as a corrosion inhibitor.

Generally, these data show that there may be some merit to the addition of hydroquinone to sodium chromate for corrosion inhibition, although this is not conclusive. Pitting conditions persist at chromate concentrations of 3 per cent of the weight of dissolved chloride salts, even though the data indicates marked leveling off in corrosion rate at about 1.5 per cent.

Phosphate Inhibitors

In studying the phosphate inhibitors, the tests were performed with a twofold purpose: First, to evaluate certain commercial glassy sodium phosphates for use in reducing the corrosiveness of sodium chloride and calcium chloride brines. Second, to compare the aerated method of test to the alternate immersion method being used by some phosphate manufacturers. Three proprietary products were studied primarily and used as a guide in evaluating the other phosphates. These products may be identified as follows:

1. - Micromet - A slightly soluble complex sodium-calcium hexametaphosphate used for rust prevention in household water systems.
2. - Calgon - Sodium hexametaphosphate, containing about 67 per cent P_2O_5 , used extensively for feed water treatment.
3. - Banox - Reported to be a mixture of Calgon and calcium chloride, it is used as a corrosion inhibitor for surface treatment of steel prior to painting and for addition to



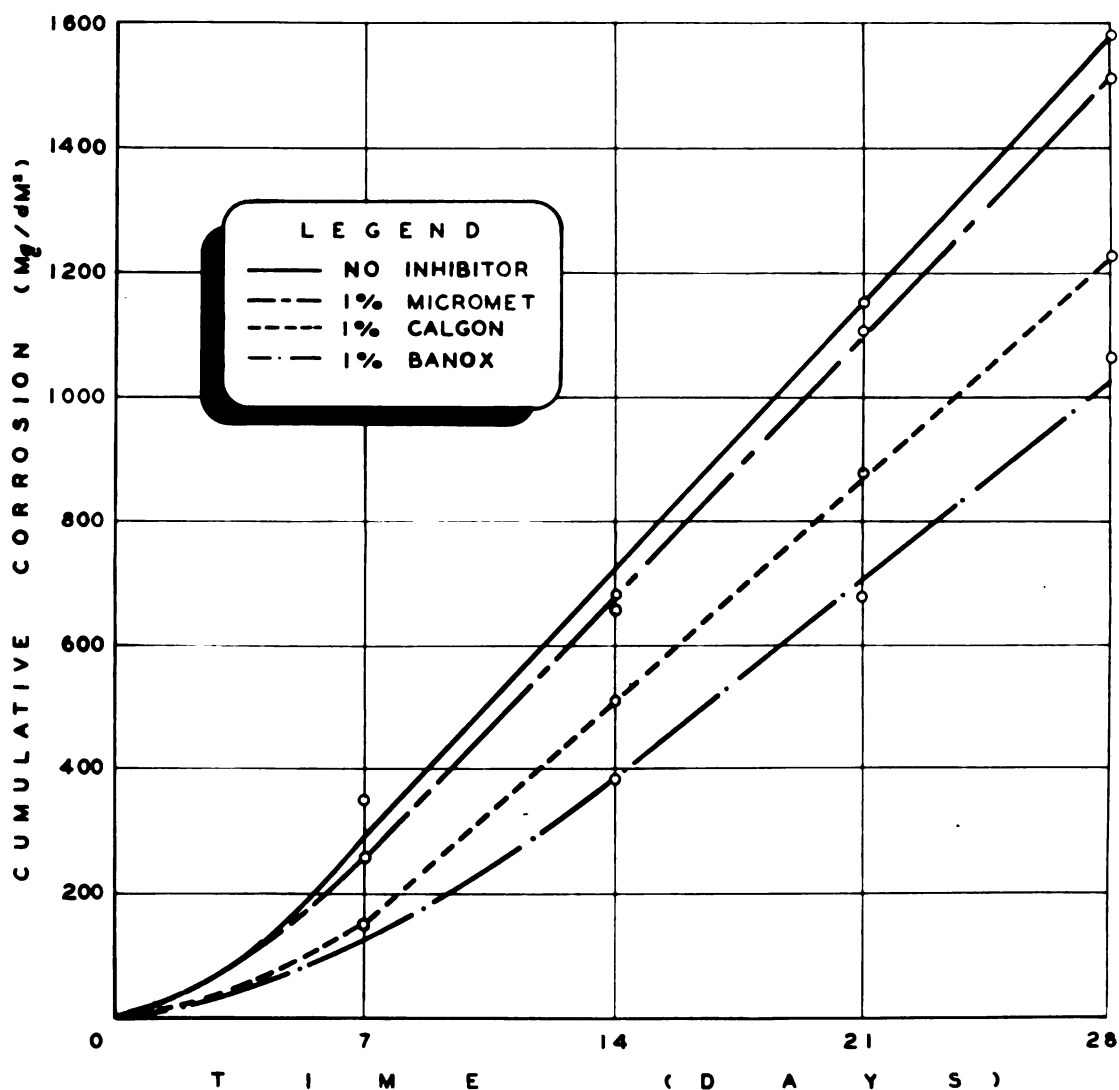
AERATION & AGITATION AT 75°F

SERIES NO.8

EFFECT *of* GLASSY PHOSPHATES *as* CORROSION INHIBITORS *in* 5% CaCl_2 - MgCl_2 BRINE

19 GAUGE SAE 1008 SHEET STEEL

Figure 7



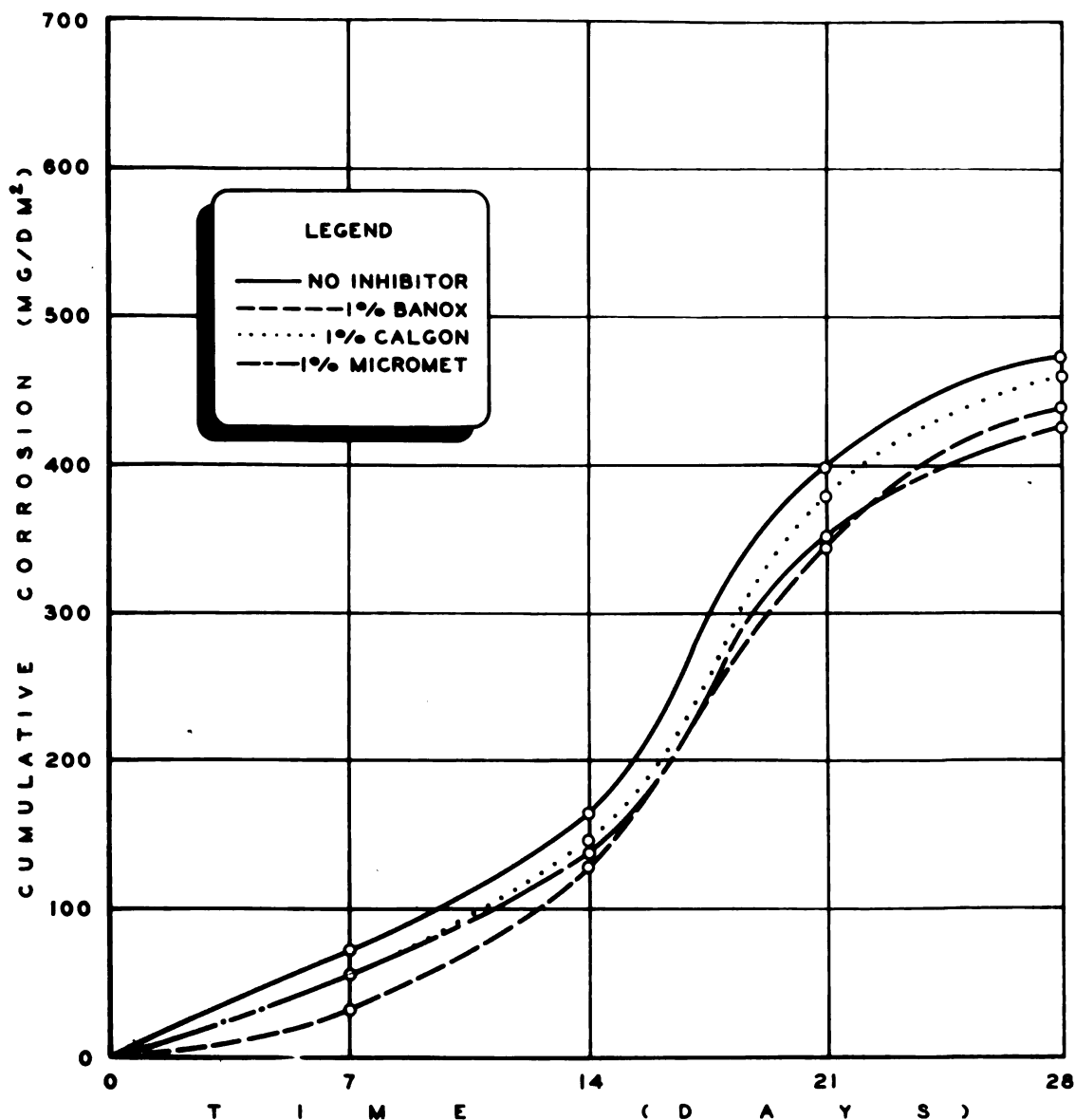
AERATION & AGITATION AT 75°F

SERIES NO.8

EFFECT *of* GLASSY PHOSPHATES *as* CORROSION INHIBITORS *in* 5% CaCl_2 - MgCl_2 BRINE

19 GAUGE SAE 1008 SHEET STEEL

Figure 7

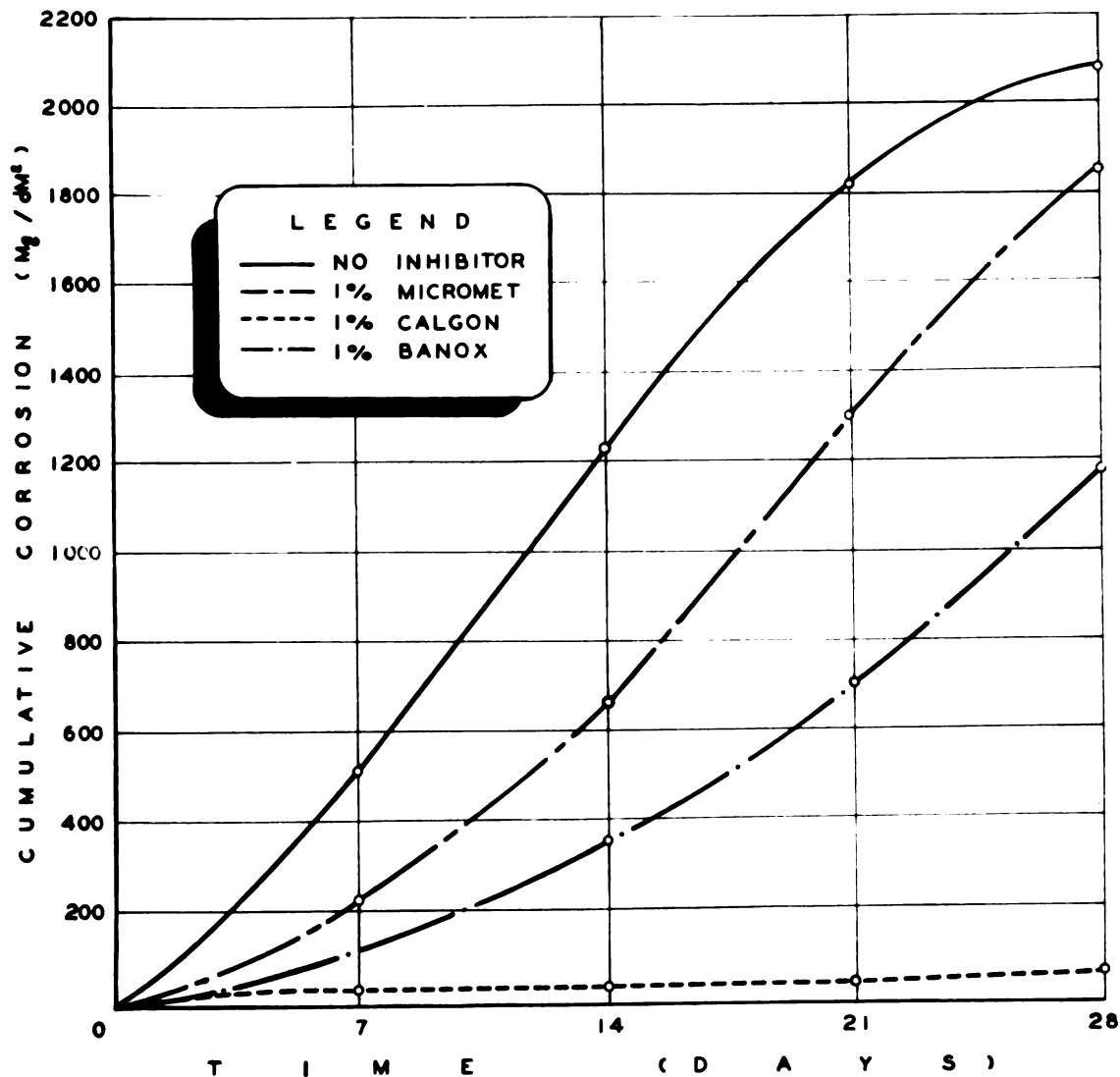


SERIES NO. 7

EFFECT of GLASSY PHOSPHATES as CORROSION INHIBITORS in 5% CaCl_2 - MgCl_2 BRINE

ALTERNATE IMMERSION AT 75°F, 19 GAUGE SAE*1008 SHEET STEEL

Figure 8



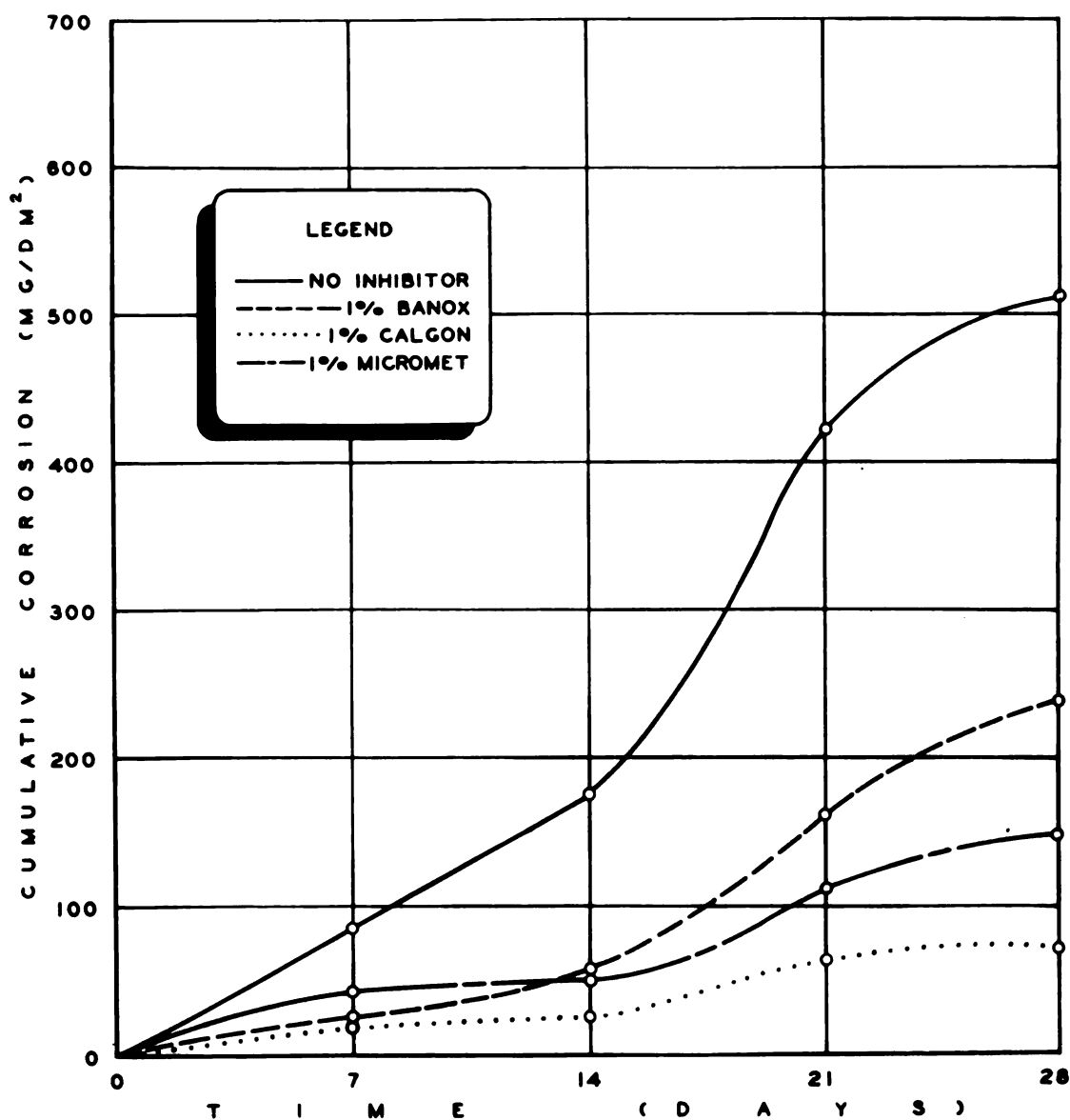
AERATION & AGITATION AT 75°F

SERIES NO. 8

EFFECT *of* GLASSY PHOSPHATES *as* CORROSION INHIBITORS *in* 5% ROCK SALT BRINE

19 GAUGE SAE 1008 SHEET STEEL

Figure 9



SERIES NO. 7

EFFECT OF GLASSY PHOSPHATES as CORROSION INHIBITORS in 5% ROCK SALT BRINE

19 GAUGE SAE#1008 SHEET STEEL, ALTERNATE IMMERSION AT 75°F

Figure 10

rock salt for use on highways.

A glance at the data of Tables 8 and 9 and Figures 7 and 8 show that in concentrations of 1 per cent the above-mentioned phosphates were ineffective in reducing the corrosiveness of calcium chloride brine. In sodium chloride, however, (see Figures 9 and 10) it is evident that the behavior of Micromet and Banox was about the same as in calcium chloride, while Calgon stood out as being very effective.

The data of Table 10 are in general agreement with the preceding data. However, disodium phosphate and trisodium phosphate were ineffective in rock salt brine. Nalco 519, a commercial sodium septaphosphate, deserves mention as being very effective with rock salt.

The behavior of these inhibitors can probably be explained on the basis that the sodium hexametaphosphate prevalent in these materials forms a relatively insoluble calcium phosphate complex in calcium chloride. This would remove a large portion of inhibitor from solution by precipitation before a sufficiently protective film could be formed on the metal surface. In the case of sodium chloride (rock salt) the basic reason would probably be the same, with the calcium ion being furnished by the inhibitors themselves (Micromet and Banox) on being dissolved, along with a small amount of calcium ion present in the rock salt as gypsum. The calcium present in the rock salt was apparently not sufficient to affect the inhibitive properties of the plain sodium hexametaphosphate.

The results of the alternate immersion test, series 7, and the aerated test, series 8, were in qualitative agreement with each other. However, the degree of corrosion obtained in the aerated test was much

higher than in the alternate immersion test. Apparently, then, the aerated test would be a more rapid means for laboratory evaluation of the properties of corrosion inhibitors.

From these data it appears that the presence of considerable amounts of calcium ion relative to the amount of phosphate is undesirable when the phosphate inhibitors are used. This is in general agreement with the work of Hatch and Rice. (13)

These data show that the phosphates are not suitable inhibitors for calcium chloride salts. However, Calgon and Nalco 519 show promise of being effective for sodium chloride. The continuously aerated test seemed to be more severe than the alternate immersion test, although their correlation was fairly good.

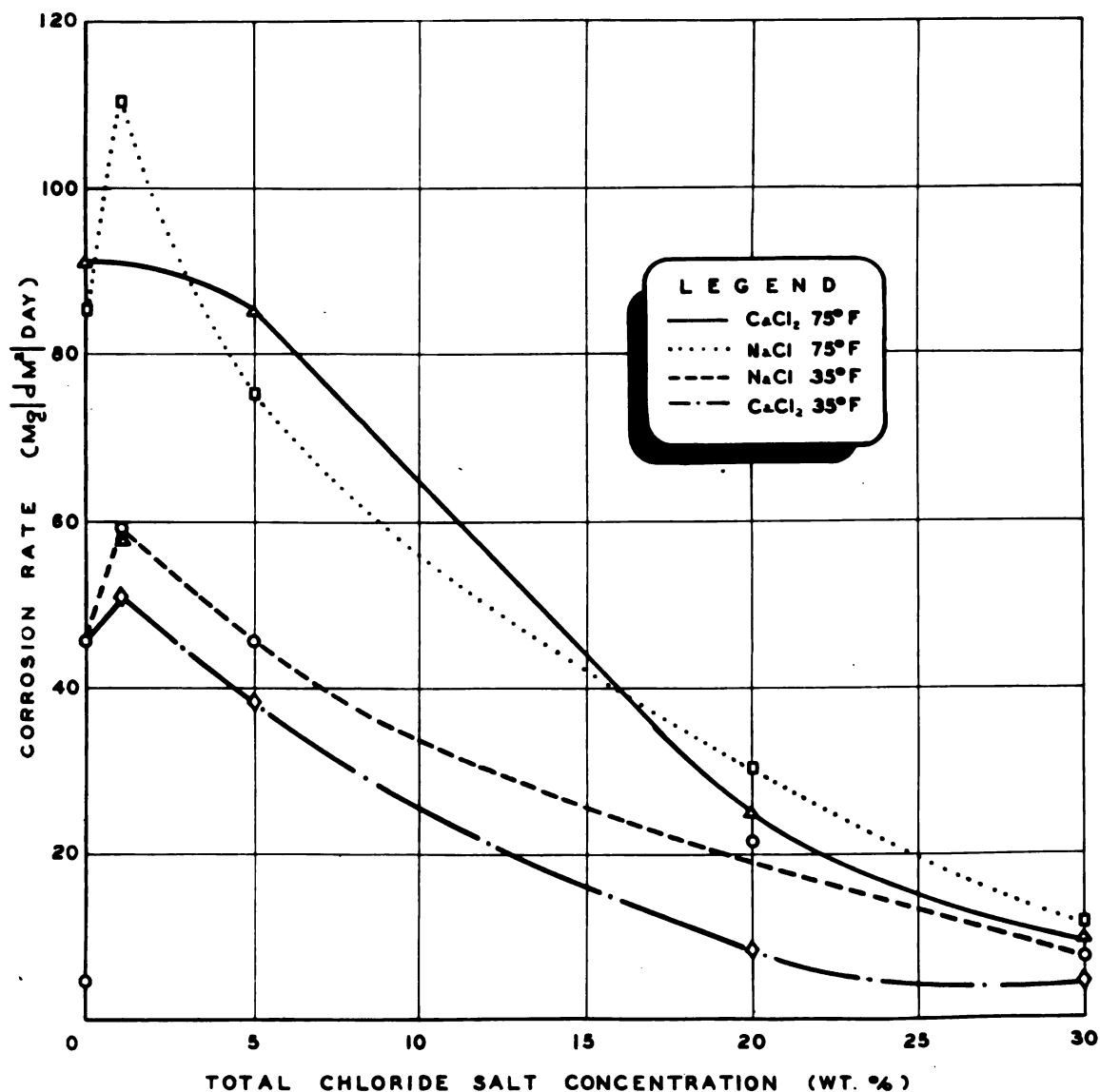
All the inhibitors included in this study may be classified as anodic inhibitors. It is a characteristic of anodic inhibitors that they sometimes cause the pitting effects shown in Figures 13 and 14. (9) This would be especially true at the crevices and corners under an automobile body where access is difficult. It would, therefore, seem that use of these inhibitors, particularly in low concentrations involves a certain amount of risk.

If these data are plotted to show the cumulative loss in weight (corrosion) versus time, as in Figures 2, 3, 4, 7, 8, 9, and 10 the length of time any given inhibitor retains its effectiveness may be ascertained. As the inhibitor loses its efficiency, the slope of the corrosion curve for the inhibited solution becomes steeper, until it is approximately parallel to the corrosion curve for the same uninhibited solution. In other words, the rate of corrosion gradually increases

until it becomes about the same as that of an uninhibited solution.

Corrosive Media

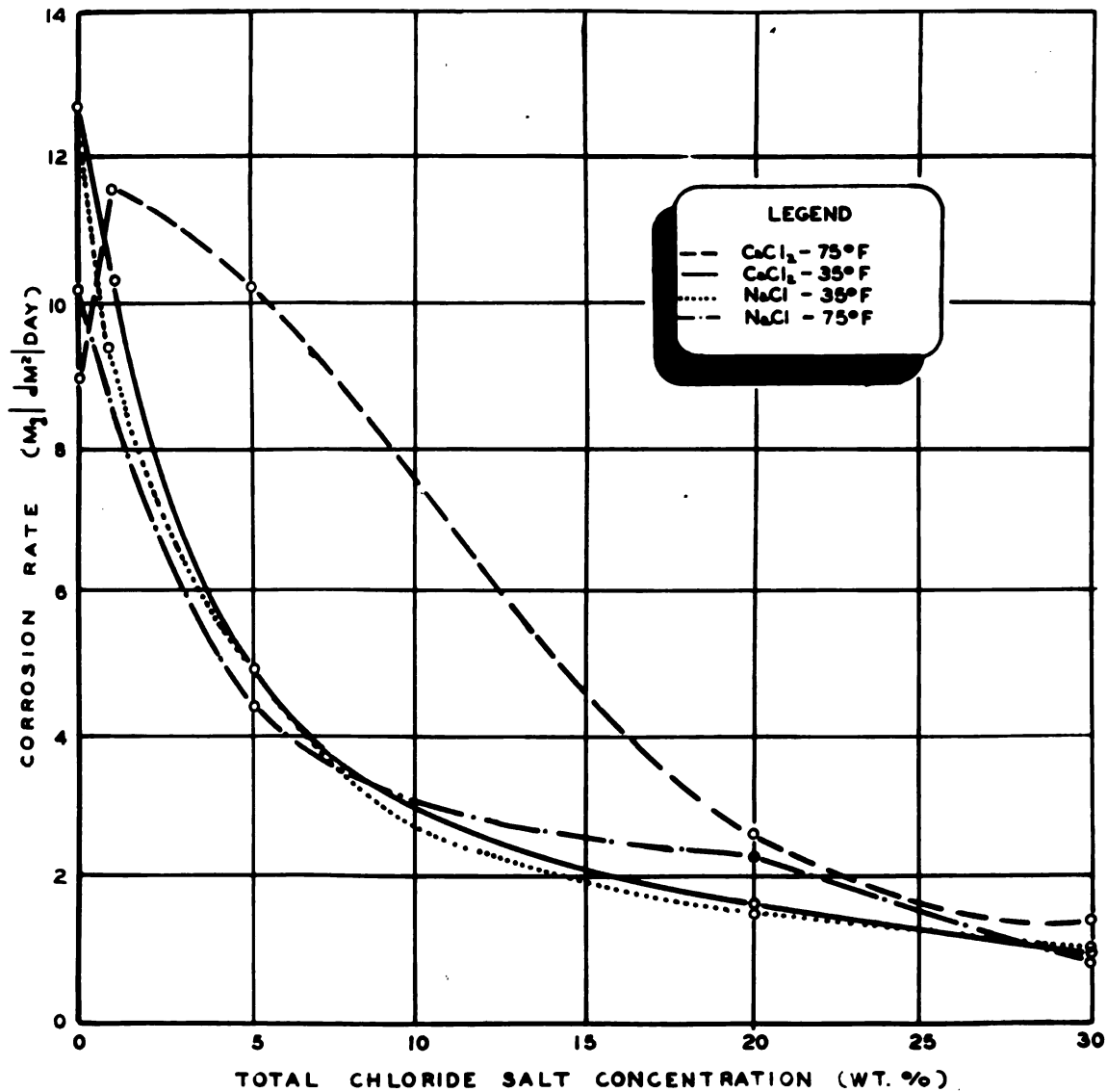
In series 5, 13, 14, 15, and 16 an attempt was made to shed some light on the question as to whether solutions of chloride salts were more or less corrosive than water. This was deemed necessary in view of the volume of seemingly contradictory data to be found in the literature. Whitman, Russell, and Davis⁽¹⁷⁾ show that dilute solutions of chloride salts are more corrosive than water, with a gradual decrease in corrosion as the chloride salt content is increased. Spell-⁽¹⁸⁾er reports Richardson as showing distilled water less corrosive than a 10 per cent salt brine for six different irons in both the stagnant and aerated alternate wetting and drying type tests at room temperature. Richardson also shows distilled water as being more corrosive than a 10 per cent salt brine for the same irons in both the stagnant and aerated continuous immersion type tests at room temperature.⁽¹⁹⁾ Friend and Marshall indicate tap water as being only very slightly less corrosive than a 3 per cent NaCl solution for a three month continuous immersion test.⁽²⁰⁾ Friend later reports tap water as being more corrosive than a 3 per cent NaCl solution for three different steels in⁽⁴⁾ a one-year continuous immersion test at 50° F. Friend and Brown report that at about 13° C. dilute NaCl solutions and distilled water are about equally corrosive. At temperatures above 13° C., dilute solutions of NaCl are more corrosive than distilled water, while at temperatures below 13° C. dilute NaCl solutions are less corrosive than distilled water. Corrosion gradually decreases for higher concentrations at all temperatures.



CONTINUOUSLY AERATED AND AGITATED
 SERIES 14 & 15

EFFECT of TEMPERATURE on the CORROSIVENESS
 of CaCl_2 and NaCl BRINES

Figure 11



STAGNANT, LIMITED ACCESS TO AIR

SERIES 13 & 16

EFFECT of TEMPERATURE on the CORROSIVENESS
of CaCl_2 and NaCl BRINES

Figure 12

A 722

The results of series 5, 13, 14, 15, and 16 given in Tables 11 and 12 contain some of the above-mentioned discrepancies. In these tests it is believed that the variations were due to difficulty in control of the rate of aeration. However, the general trends shown in Figures 11 and 12 are fairly well indicated. The results of the aerated tests, Figure 11, exhibit the same trends as those of Whitman, Russell, and Davis,⁽¹⁷⁾ and of Friend and Brown for temperatures below 13° C. However, the relation between the corrosiveness of dilute salt solutions and water did not reverse with change in temperature as reported by Friend and Brown, even though the temperatures used were in the same range. The results of the unaerated tests, Figure 12, follow the pattern of Friend and Brown at temperatures above 13° C.

The overall corrosion rate of series 5, Table 11, follows the same pattern as does Figure 11 for CaCl_2 at 75° F. However, the weekly rates show considerable variation for dilute solutions.

The character of the corrosion which took place in series 13, 14, 15, and 16 is illustrated in the photographs of Figures 15, 16, 17, and 18. There were two distinct layers of corrosion products formed on the surface of the metal. The outer layer consisted of a hydrated ferric oxide mixture varying in color from an orange-red for distilled water and dilute brines to a red-brown for the more concentrated solutions. The darker colored products seemed to adhere to the metal more firmly than did the light colored scale.

A dark blue-black layer of ferrous oxides and hydroxides was found underneath the outer layer. This dark layer was particularly noticeable in series 13 and 16 where the air supply was limited, indicating insufficient oxygen to convert the ferrous products to the ferric

state.

Plates 1a, 1b, 1c of series 14 for distilled water exhibited very little corrosion as may be seen in Figure 15-1. However, these plates seemed to have a rather peculiar yellow-green film over the surface at conclusion of the tests. This film was not present in the other distilled water tests. For this reason, the results of plates 1a, 1b, and 1c were discarded and the results of plates 6a, 6b, 6c substituted.

The results of the unaerated series 13 and 16, Figure 12, show distilled water at 35° F. to be more corrosive than any concentration of either NaCl or CaCl₂ at the same temperature. However, at 75° F. dilute CaCl₂ solutions appear to be more corrosive than distilled water, while NaCl exhibits the same characteristics as at 35° F. The increase in corrosion by the dilute CaCl₂ over that for distilled water was about 25 per cent. The corrosion rates shown here appear to follow very closely the same pattern as the oxygen solubility curves for (21) solutions of various salts given by Speller. Increasing the temperature from 35 to 75° F. did not appear to affect the corrosiveness of NaCl appreciably.

Figure 11, series 14 and 15, shows that at 35° F. dilute solutions of both NaCl and CaCl₂ increase corrosion over that for distilled water by about 20 per cent. At 75° F. dilute NaCl solutions continue to be more corrosive than distilled water. However, the behavior of dilute CaCl₂ solutions at 75° F. is not understood.

Increasing the temperature from 35 to 75° F. resulted in a marked increase in corrosion for all but the most concentrated solutions. At 35° F. no concentration of either CaCl₂ or NaCl showed as much corrosion as did distilled water at 75° F.

Furthermore, it can be seen that the corrosion rates are much higher at either temperature under conditions of aeration and agitation than under limited air supply and quiescent conditions. The combined effects of agitation and air supply produced a corrosion rate from 50 to 80 times greater than in their absence. Apparently the presence or absence of oxygen at the metal surface is of prime importance in the corrosion reactions taking place.

However, the mere presence or absence of oxygen does not explain the results shown in Figure 11. There appear to be several variables which contribute to the results shown and greatly complicate the situation. Speller shows that for water with free access to air corrosion increases with temperature up to about 175° F. and then decreases with further increase in temperature. ⁽²²⁾ This is explainable on the basis that oxygen solubility decreases as temperature increases. However, the increase in temperature affects those factors which increase the transfer of the dissolved oxygen to the metal surface as follows:

- (1) The viscosity of the solution decreases, resulting in more efficient distribution of oxygen throughout the liquid.
- (2) The rate of diffusion of oxygen across the liquid film at the liquid-metal interface increases, thus carrying the oxygen to the metal faster.
- (3) The liquid film at the liquid-metal interface decreases in thickness, thus decreasing the time required for diffusion.

In addition to these factors, the corrosion reactions take place faster at the higher temperatures provided there is enough oxygen present to permit the reactions to take place. It is, therefore, apparent that the corrosion will increase with increasing temperatures, until the factors tending to

increase corrosion can no longer compensate for the decrease in oxygen solubility. Beyond this point corrosion will decrease as Speller has demonstrated.

It seems that these conditions would also be true for solutions of salts, with the additional condition that oxygen solubility decreases (22) with increasing salt concentrations. There should, therefore, be an inversion temperature similar to that for water in the case of salt solutions. However, this temperature may be different for each concentration and type of salt. Further work certainly seems to be indicated on the effect of temperature on oxygen solubility in various concentrations of different salts, and on the corrosiveness of these salt solutions.

Generally, these data show that oxygen is of major importance in the corrosion reactions. Under identical ordinary conditions, dilute chloride salts were about 20 to 25 per cent more corrosive than distilled water. However, distilled water at 75° F. was nearly twice as corrosive as any chloride salt solution at 35° F.

CONCLUSIONS

Although these results must be interpreted cautiously until confirmed by tests under field conditions, the following conclusions may be made:

1. - In order for an inhibitor to be considered satisfactory, it must reduce corrosion without setting up pitting conditions; and it must do so at concentrations that are economically practical for highway usage.
2. - Of the inhibitors studied, only three appear to merit further

consideration for use. The chromates should be considered for use in either sodium or calcium chloride, while Calgon and Nalco 519 should be considered for use in rock salt only. No inhibitor should be used, however, unless it has been thoroughly tested, since it may actually increase the corrosion in localized areas by setting up pitting conditions rather than reducing the damage due to corrosion.

3. - Although there appears to be strong indications that hydroquinone, quinone, or quinhydrone may have some beneficial action on the effectiveness of the chromate inhibitors, this is not conclusive. Further work on this point is indicated, including study of the effect of chromous ion as an inhibitor.
4. - Under the same conditions, chloride salts are generally from 20 to 25 per cent more corrosive than distilled water. However, distilled water is much more corrosive at ordinary spring and summer temperatures than any solution of chloride salts is at ordinary winter temperatures.
5. - Chloride salts probably do not contribute nearly as much to the corrosion of automobile bodies as is popularly believed.
6. - Although the inhibitors tested may possibly reduce the corrosiveness of the chloride salts, inhibition of these salts cannot be justified on the basis of present information.

APPENDIX A

TABLE 1

DATA SUMMARY																									
CORROSIVE SOLUTION				INHIBITOR MIXTURE				AVERAGE CORROSION (WT LOSS)												INITIAL WEIGHT OF METAL PLATES (G)					
TEST SERIES NUMBER	SPECIMEN NUMBER	ANALYSIS NUMBER	TYPE	ZINC CONCENTRATION %	MAJOR COMPONENTS		COMPOSITION		PARTS BY WT	MINOR COMPONENTS	PARTS BY WT	CONCENTRATION %	ZINC CONCENTRATION %	FIRST 7 DAYS		SECOND 7 DAYS		THIRD 7 DAYS		FOURTH 7 DAYS		OVER-ALL RATE MG/DAY			
					MAJOR COMPONENTS	MAJOR COMPONENTS	COMPOSITION	COMPOSITION						CUMULATIVE MG / DAY	RATE MG / DAY	CUMULATIVE MG / DAY	RATE MG / DAY	CUMULATIVE MG / DAY	RATE MG / DAY	CUMULATIVE MG / DAY	RATE MG / DAY				
3	1		Rock Salt (NaCl)	5										459.0	65.6	702.0	34.6					50.1			
3	2		Rock Salt (NaCl)	5								0.5		34.9	9.3	249.0	26.3					17.8			
3	3		Rock Salt (NaCl)	5								1.0		55.8	8.0	98.9	6.2					7.1			
3	4		Rock Salt (NaCl)	5								2.0		51.3	8.2	88.9	4.5					6.4			
3	5		Rock Salt (NaCl)	5								0.5		34.7	5.0	58.6	3.4					4.2			
3	6		Rock Salt (NaCl)	5								1.0		42.9	6.1	68.8	3.7					4.9			
3	7		Rock Salt (NaCl)	5								2.0		52.6	7.5	75.9	3.3					5.4			
3	8		Rock Salt (NaCl)	5								0.5		233.0	33.3	640.0	58.2					45.7			
3	9		Rock Salt (NaCl)	5								1.0		194.8	27.8	662.0	66.8					47.3			
3	10		Rock Salt (NaCl)	5								2.0		67.1	9.6	384.0	45.3					27.5			

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TABLE 2

DATA SUMMARY																			
CORROSIVE SOLUTION				INHIBITOR MIXTURE				INITIAL WEIGHT OF METAL PLATES (GMS)			AVERAGE CORROSION (WT LOSS)								
TEST NUMBER	SPECIMEN NUMBER	ANALYSIS NUMBER	TYPE	MAJOR COMPONENTS	PARTS BY WT	COMPOSITION	PARTS BY WT	MINOR COMPONENTS	PARTS BY WT	ZINC ANALYSIS NUMBER	FIRST 7 DAYS CUMULATIVE RATE MG./DM ² DAY	SECOND 7 DAYS CUMULATIVE RATE MG./DM ² DAY	THIRD 7 DAYS CUMULATIVE RATE MG./DM ² DAY	FOURTH 7 DAYS CUMULATIVE RATE MG./DM ² DAY	OVERALL RATE PER DAY				
4	1	2	CaCl ₂ - MgCl ₂	60	---	---	---	---	---	---	16.3	2.3	34.1	2.5	85.1	7.3	173.5	12.6	6.2
4	2	2	CaCl ₂ - MgCl ₂	60	---	Sodium Chromate	100	---	---	0.1	16.9	2.4	29.9	1.9	80.5	7.2	167.5	12.4	6.0
4	3	2	CaCl ₂ - MgCl ₂	60	---	Sodium Chromate	100	---	---	0.2	3.9	0.6	18.4	2.1	69.0	7.2	147.5	11.2	5.3
4	4	2	CaCl ₂ - MgCl ₂	60	---	Sodium Chromate	100	---	---	0.3	1.9	0.2	10.9	1.3	70.9	8.6	147.4	10.9	5.3
4	5	2	CaCl ₂ - MgCl ₂	60	---	Sodium Chromate	100	---	---	0.4	1.5	0.2	11.5	1.4	73.2	8.8	160.0	12.4	5.7
4	6	2	CaCl ₂ - MgCl ₂	60	---	Sodium Chromate	100	---	---	0.5	1.3	0.2	7.2	0.8	50.4	6.2	117.8	9.6	4.2
4	7	2	CaCl ₂ - MgCl ₂	60	---	Sodium Dichromate	100	---	---	0.1	5.6	0.8	18.7	1.9	79.1	8.6	124.2	6.4	4.4
4	8	2	CaCl ₂ - MgCl ₂	60	---	Sodium Dichromate	100	---	---	0.2	1.5	0.2	6.1	0.7	69.4	9.0	122.0	7.6	4.4
4	9	2	CaCl ₂ - MgCl ₂	60	---	Sodium Dichromate	100	---	---	0.3	1.3	0.2	11.5	1.5	63.3	7.4	95.2	5.0	3.5
4	10	2	CaCl ₂ - MgCl ₂	60	---	Sodium Dichromate	100	---	---	0.4	1.3	0.2	12.2	1.6	63.8	7.4	98.8	5.0	3.5
4	11	2	CaCl ₂ - MgCl ₂	60	---	Sodium Dichromate	100	---	---	0.5	- 1.1	- 0.2	10.6	1.7	62.1	7.4	95.7	4.8	3.4

TABLE 3

CORROSIVE SOLUTION			INHIBITOR MIXTURE			DATA SUMMARY										AVERAGE CORROSION (WT LOSS)										OVERALL	
TEST SERIES	SPECIMEN NUMBER	ANALYSIS NUMBER	TYPE	COCCION	MAJOR COMPONENTS	PARTS BY WT	MINOR COMPONENTS	PARTS BY WT	COCCION	NO. OF PLATES	INITIAL WEIGHT OF METAL	FIRST 7 DAYS		SECOND 7 DAYS		THIRD 7 DAYS		FOURTH 7 DAYS		RATE		RATE		RATE		RATE	
												CUMULATIVE	RATE	CUMULATIVE	RATE	CUMULATIVE	RATE	CUMULATIVE	RATE	CUMULATIVE	RATE	CUMULATIVE	RATE	CUMULATIVE	RATE	CUMULATIVE	RATE
												MG/DMA	MG/DM ² DAY	MG/DMA	MG/DM ² DAY	MG/DMA	MG/DM ² DAY	MG/DMA	MG/DM ² DAY	MG/DMA	MG/DM ² DAY	MG/DMA	MG/DM ² DAY	MG/DMA	MG/DM ² DAY	MG/DMA	MG/DM ² DAY
2	1	1	CaCl ₂ - MgCl ₂	5	Sodium Chromate	95	Formaldehyde	5	0.5	5	22.6	3.2	113.5	13.0	249.5	19.4	---	---	---	---	---	---	---	---	---	---	11.8
2	2	1	CaCl ₂ - MgCl ₂	5	Sodium Chromate	95	Pyridine	5	0.5	5	34.9	5.0	76.6	6.0	282.0	29.3	---	---	---	---	---	---	---	---	---	---	13.4
2	3	1	CaCl ₂ - MgCl ₂	5	Sodium Chromate	95	Sodium Salicylate	5	0.5	5	33.2	4.8	64.0	4.4	204.0	20.0	---	---	---	---	---	---	---	---	---	---	9.7
2	4	1	CaCl ₂ - MgCl ₂	5	Sodium Chromate	95	Sodium Benzoate	5	0.5	5	30.7	4.5	72.1	5.8	284.0	30.3	---	---	---	---	---	---	---	---	---	---	13.5
2	5	1	CaCl ₂ - MgCl ₂	5	Sodium Chromate	95	Hydroquinone	5	0.5	5	21.9	3.1	22.2	2.1	43.8	1.0	---	---	---	---	---	---	---	---	---	---	2.1
2	6	1	CaCl ₂ - MgCl ₂	5	Sodium Chromate	100	---	---	0.5	5	28.2	4.0	83.1	7.9	432.0	49.7	---	---	---	---	---	---	---	---	---	---	20.5
2	7	1	CaCl ₂ - MgCl ₂	5	Chrome Alum	100	---	---	0.5	5	191.5	27.4	674.0	69.0	1072.0	56.8	---	---	---	---	---	---	---	---	---	---	50.2
2	8	1	CaCl ₂ - MgCl ₂	5	Chrome Acid	100	---	---	0.5	5	137.3	19.6	182.0	6.4	424.0	34.5	---	---	---	---	---	---	---	---	---	---	20.1

TABLE 4

CORROSIVE SOLUTION				INHIBITOR MIXTURE				DATA SUMMARY												AVERAGE CORROSION (WT. LOSS)				OVER-ALL	
NO.	TYPE	MAJOR COMPONENTS	PARTS BY WT.	MINOR COMPONENTS	PARTS BY WT.	PLATES (GMS)	INITIAL WEIGHT OF METAL	FIRST 7 DAYS	SECOND 7 DAYS	THIRD 7 DAYS	FOURTH 7 DAYS	CUMULATIVE RATE	CUMULATIVE RATE	CUMULATIVE RATE	CUMULATIVE RATE	CUMULATIVE RATE	CUMULATIVE RATE	CUMULATIVE RATE	CUMULATIVE RATE	CUMULATIVE RATE	CUMULATIVE RATE	CUMULATIVE RATE	CUMULATIVE RATE	CUMULATIVE RATE	CUMULATIVE RATE
10	1	CaCl ₂ - MgCl ₂	5	Sodium Chromate	95	Quinone	5	0.5	11.1	1.59	34.1	3.29	56.2	3.15	89.8	4.82	3.22								
10	2	CaCl ₂ - MgCl ₂	5	Sodium Chromate	95	Quinone	5	1.0	17.1	2.44	33.3	2.33	50.6	2.46	78.9	4.05	2.82								
10	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	95	Quinone	5	2.0	9.6	1.38	21.9	1.75	33.7	1.70	51.5	2.54	1.84								
10	4	CaCl ₂ - MgCl ₂	5	Sodium Chromate	95	Quinhydrone	5	0.5	9.3	1.33	27.8	2.65	43.2	2.20	73.7	4.37	2.64								
10	5	CaCl ₂ - MgCl ₂	5	Sodium Chromate	95	Quinhydrone	5	1.0	8.2	1.17	22.1	1.99	39.5	2.49	65.8	3.76	2.35								
10	6	CaCl ₂ - MgCl ₂	5	Sodium Chromate	95	Quinhydrone	5	2.0	6.7	0.95	21.7	2.15	35.8	2.01	58.2	3.21	2.08								
10	7	CaCl ₂ - MgCl ₂	5	Sodium Dichromate	95	Hydroquinone	5	0.5	7.2	1.03	41.7	4.93	76.5	4.98	106.0	4.24	3.80								
10	8	CaCl ₂ - MgCl ₂	5	Sodium Dichromate	95	Hydroquinone	5	1.0	7.0	1.01	47.4	5.78	84.8	5.35	129.8	6.41	4.64								

TABLE 5

DATA SUMMARY

CORROSIVE SOLUTION				INHIBITOR MIXTURE COMPOSITION				AVERAGE CORROSION (WT. LOSS)										OVER-ALL RATE	
TEST NUMBER	SPECIMEN NUMBER	ANALYSIS NUMBER	TYPE	CONCENTRATION	MAJOR COMPONENTS	PARTS BY WT	MINOR COMPONENTS	PARTS BY WT	INITIAL WEIGHT OF METAL PLATES	FIRST 7 DAYS	SECOND 7 DAYS	THIRD 7 DAYS	FOURTH 7 DAYS	RATE	CUMULATIVE	RATE	CUMULATIVE	MG/DM ² DAY	MG/DM ² DAY
6	1	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	100			94.6	13.5	363.0	38.3	1195.0	118.5	1645.0	64.6	57.8		
6	2	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	95	Hydroquinone	5	54.7	7.8	88.1	4.8	308.2	30.6	717.0	59.1	25.6		
6	3	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	90	Hydroquinone	10	29.3	4.2	40.4	1.6	51.0	1.5	111.5	8.6	4.0		
6	4	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	80	Hydroquinone	20	25.8	3.7	34.9	1.3	46.0	1.6	60.5	2.1	2.2		
6	5	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	70	Hydroquinone	30	38.4	5.5	55.3	2.4	174.1	17.0	348.5	24.1	18.2		
6	6	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	50	Hydroquinone	50	48.5	6.1	124.2	11.7	433.0	44.1	768.0	47.8	27.2		
6	7	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	30	Hydroquinone	70	98.7	14.1	312.0	30.5	565.0	36.0	900.0	47.9	32.1		
6	8	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	10	Hydroquinone	90	283.0	40.5	780.0	70.8	1195.0	59.5	1505.0	44.2	53.8		
6	9	3	CaCl ₂ - MgCl ₂	5	Hydroquinone	100			424.0	60.5	815.0	55.8	1190.0	53.8	1560.0	52.8	55.8		
6	10	3	CaCl ₂ - MgCl ₂	20	Sodium Chromate	100			23.5	3.4	38.0	2.1	52.9	2.1	70.5	2.5	2.5		
6	11	3	CaCl ₂ - MgCl ₂	20	Sodium Chromate	95	Hydroquinone	5	38.8	4.7	52.9	2.9	68.9	2.3	89.8	3.0	3.2		
6	12	3	CaCl ₂ - MgCl ₂	20	Sodium Chromate	90	Hydroquinone	10	26.5	3.8	36.6	1.4	48.8	1.7	56.1	1.1	2.0		
6	13	3	CaCl ₂ - MgCl ₂	20	Sodium Chromate	80	Hydroquinone	20	49.7	7.1	65.0	2.2	83.4	2.6	91.9	1.2	3.3		
6	14	3	CaCl ₂ - MgCl ₂	20	Sodium Chromate	70	Hydroquinone	30	58.6	8.4	74.7	2.3	159.0	12.0	118.0	22.7	11.3		
6	15	3	CaCl ₂ - MgCl ₂	20	Sodium Chromate	50	Hydroquinone	50	86.0	12.3	377.0	41.5	655.0	39.9	834.0	25.3	29.8		
6	16	3	CaCl ₂ - MgCl ₂	20	Sodium Chromate	30	Hydroquinone	70	245.0	35.0	599.0	50.5	984.0	55.0	1165.0	25.9	41.7		
6	17	3	CaCl ₂ - MgCl ₂	20	Sodium Chromate	10	Hydroquinone	90	315.0	45.0	667.0	50.3	1055.0	55.8	1285.0	32.5	45.9		
6	18	3	CaCl ₂ - MgCl ₂	20	Hydroquinone	100			320.5	45.8	694.0	53.4	1032.0	48.2	1425.0	56.3	50.9		

TABLE 6

DATA SUMMARY																						
CORROSIVE SOLUTION				INHIBITOR MIXTURE				AVERAGE CORROSION (WT LOSS)														
TEST SERIES	SPECIMEN NUMBER	ANALYSIS NUMBER	TYPE	CONCENTRATION, %	COMPOSITION		ZONES COATED	ZONES COATED	INITIAL WEIGHT OF METAL PLATES(GMS)	FIRST 7 DAYS		SECOND 7 DAYS		THIRD 7 DAYS		FOURTH 7 DAYS		OVER-ALL RATE				
					MAJOR COMPONENTS	PARTS BY WT				MINOR COMPONENTS	PARTS BY WT	CUMULATIVE MG / DM ²	RATE MG / DM ² DAY	CUMULATIVE MG / DM ²	RATE MG / DM ² DAY	CUMULATIVE MG / DM ²	RATE MG / DM ² DAY		CUMULATIVE MG / DM ²	RATE MG / DM ² DAY		
11	1	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	90	Hydroquinone	10	0.1	409.0	58.4	892.0	69.1	2220.0	190.2	2710.0	69.2	96.8				
11	2	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	90	Hydroquinone	10	0.5	81.6	11.6	364.0	40.4	1093.0	10.4	1590.0	70.7	53.8				
11	3	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	90	Hydroquinone	10	1.0	51.6	7.4	84.5	4.7	189.5	15.0	213.5	3.4	7.6				
11	4	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	90	Hydroquinone	10	1.5	43.6	6.2	71.0	3.9	159.2	12.6	179.2	2.9	6.4				
11	5	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	90	Hydroquinone	10	2.0	44.4	6.3	73.5	4.2	168.0	13.5	200.0	4.5	7.2				
11	6	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	90	Hydroquinone	10	2.5	43.2	6.2	67.6	3.5	156.2	12.7	183.7	3.9	6.6				
11	7	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	90	Hydroquinone	10	3.0	47.6	6.9	81.4	4.8	180.5	14.2	216.5	5.1	7.8				

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TABLE 7

DATA SUMMARY																		
CORROSIVE SOLUTION				INHIBITOR MIXTURE				AVERAGE CORROSION (WT. LOSS)										
TEST SERIES	SPECIMEN NUMBER	ANALYSIS NUMBER	TYPE	CONCENTRATION (%)	COMPOSITION				INITIAL WEIGHT OF METAL PLATES (GMS)	FIRST 7 DAYS		SECOND 7 DAYS		THIRD 7 DAYS		FOURTH 7 DAYS		OVER-ALL RATE MG/DAY
					MAJOR COMPONENTS	PARTS BY WT	MINOR COMPONENTS	PARTS BY WT		CUMULATIVE MG/DAY	RATE MG/DAY	CUMULATIVE MG/DAY	RATE MG/DAY	CUMULATIVE MG/DAY	RATE MG/DAY	CUMULATIVE MG/DAY	RATE MG/DAY	
12	1	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	100			0.1	317.0	48.2	756.0	60.0	1200.0	63.4	1660.0	65.5	59.4
12	2	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	100			0.5	393.5	27.6	509.0	56.6	1024.0	60.8	1413.0	57.0	50.7
12	3	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	100			1.0	324.0	17.7	358.5	5.0	389.2	4.4	336.0	20.9	12.0
12	4	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	100			1.5	319.0	17.0	351.0	4.6	370.3	2.7	398.5	4.0	7.1
12	5	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	100			2.0	91.8	13.1	125.0	4.8	151.8	3.8	176.8	3.6	6.3
12	6	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	100			2.5	90.7	12.9	121.0	4.3	147.5	3.8	180.3	4.7	6.4
12	7	3	CaCl ₂ - MgCl ₂	5	Sodium Chromate	100			3.0	89.1	12.7	115.8	3.8	138.8	3.3	163.5	3.6	5.8

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TABLE 8

CORROSIVE SOLUTION				INHIBITOR MIXTURE				AVERAGE CORROSION (WT. LOSS)										OVER-ALL RATE MG/DW7DAY
TEST NUMBER	SPECIMEN NUMBER	ANALYSIS NUMBER	TYPE	COMPOSITION		NO. OF COUPONS	INITIAL WEIGHT OF METAL PLATES(GMS)	FIRST 7 DAYS		SECOND 7 DAYS		THIRD 7 DAYS		FOURTH 7 DAYS				
				MAJOR COMPONENTS BY WT	PARTS BY WT			RATE MG/DW7DAY	CUMULATIVE MG/DMA	RATE MG/DW7DAY	CUMULATIVE MG/DMA	RATE MG/DW7DAY	CUMULATIVE MG/DMA	RATE MG/DW7DAY	CUMULATIVE MG/DMA			
7	1	3	CaCl ₂ - MgCl	5	-----	-----	-----	70.6	10.1	160.0	12.8	401.0	34.5	478.0	10.9	17.1		
7	2	3	Rock Salt	5	-----	-----	-----	87.2	12.4	175.5	12.6	426.0	35.9	510.0	11.9	18.2		
7	3	3	CaCl ₂ - MgCl	5	Basor	100	-----	28.9	4.1	128.2	14.2	345.0	31.0	441.0	13.8	15.8		
7	4	3	Rock Salt	5	Basor	100	-----	23.8	3.4	56.4	4.7	166.8	15.8	237.0	10.0	8.5		
7	5	3	CaCl ₂ - MgCl	5	Mieromet	100	-----	56.0	8.0	137.5	11.7	351.0	30.5	426.0	10.6	15.2		
7	6	3	Rock Salt	5	Mieromet	100	-----	39.5	5.6	50.5	1.6	109.0	8.4	127.5	2.6	4.6		
7	7	3	CaCl ₂ - MgCl	5	Calgon	100	-----	56.0	8.0	146.8	13.0	381.0	33.4	461.0	11.4	16.5		
7	8	3	Rock Salt	5	Calgon	100	-----	17.8	2.5	26.4	1.2	61.8	5.1	72.5	1.5	2.6		

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TABLE 9

CORROSIVE SOLUTION			INHIBITOR MIXTURE			AVERAGE CORROSION (WT LOSS)											
TEST SERIES	ANALYSIS NUMBER	TYPE	MAJOR COMPONENTS	PARTS BY WT	MINOR COMPONENTS	PARTS BY WT	NO. OF PLATES	INITIAL WEIGHT OF METAL PLATES (GMS)	FIRST 7 DAYS		SECOND 7 DAYS		THIRD 7 DAYS		FOURTH 7 DAYS		OVERALL RATE
									CUMULATIVE MG/DMA	RATE MG/DMA ² /DAY	CUMULATIVE MG/DMA	RATE MG/DMA ² /DAY	CUMULATIVE MG/DMA	RATE MG/DMA ² /DAY	CUMULATIVE MG/DMA	RATE MG/DMA ² /DAY	W/L/DAY
8	1	3	CaCl ₂ - MgCl ₂	5	---	---	---	---	347.0	49.5	645.0	68.9	1151.0	72.4	1580.0	61.2	63.1
8	2	---	Rock Salt	5	---	---	---	---	509.0	72.9	1217.0	101.0	1810.0	85.0	2085.0	38.8	74.5
8	3	3	CaCl ₂ - MgCl ₂	5	---	---	0.5	---	298.0	42.6	615.0	45.2	1140.0	75.3	1532.0	55.8	54.8
8	4	---	Rock Salt	5	---	---	0.5	---	241.0	34.4	856.0	88.0	1555.0	100.0	2205.0	92.6	78.9
8	5	3	CaCl ₂ - MgCl ₂	5	---	---	1.0	---	279.0	39.9	661.0	54.5	1095.0	62.8	1517.0	60.3	54.2
8	6	---	Rock Salt	5	---	---	1.0	---	217.0	31.0	653.0	62.3	1295.0	91.9	1845.0	75.9	65.3
8	7	3	CaCl ₂ - MgCl ₂	5	---	---	1.0	---	157.6	22.5	517.0	51.3	881.0	52.3	1225.0	48.8	43.8
8	8	---	Rock Salt	5	---	---	1.0	---	29.1	4.2	41.1	1.7	53.5	1.8	61.6	1.2	2.2
8	9	3	CaCl ₂ - MgCl ₂	5	---	---	1.0	---	---	---	382.0	54.6	675.0	41.9	1060.0	55.2	50.4
8	10	---	Rock Salt	5	---	---	1.0	---	---	---	353.0	51.1	704.0	49.5	1193.0	68.5	56.2

TABLE 10

DATA SUMMARY

DATA SUMMARY																					
CORROSIVE SOLUTION				INHIBITOR MIXTURE				AVERAGE CORROSION (WT LOSS)													
TEST SERIES NUMBER	SPECIMEN NUMBER	ANALYSIS NUMBER	TYPE	CONCENTRATION, %	COMPOSITION		PARTS BY WT	MAJOR COMPONENTS	PARTS BY WT	MINOR COMPONENTS	PARTS BY WT	INITIAL WEIGHT OF METAL PLATES (GMS)	FIRST 7 DAYS		SECOND 7 DAYS		THIRD 7 DAYS		FOURTH 7 DAYS		OVER-ALL RATE MG/DAY
					CUMULATIVE RATE MG/DAY	RATE MG/DAY							CUMULATIVE RATE MG/DAY	RATE MG/DAY	CUMULATIVE RATE MG/DAY	RATE MG/DAY	CUMULATIVE RATE MG/DAY	RATE MG/DAY			
9	1	3	CaCl ₂ - MgCl ₂	5	100	100	Sodium phosphate	100	---	---	---	493.0	70.5	70.5	794.0	43.0	1188.0	56.1	1620.0	61.8	57.9
9	2	3	CaCl ₂ - MgCl ₂	5	100	100	Trisodium phosphate	100	---	---	---	539.0	76.9	76.9	869.0	47.1	1146.0	39.9	1559.0	58.8	55.6
9	3	3	CaCl ₂ - MgCl ₂	5	100	100	Maleo 519	100	---	---	---	758.0	108.3	108.3	1100.0	48.9	1652.0	79.3	2050.0	56.1	73.3
9	4	3	CaCl ₂ - MgCl ₂	5	100	100	Calgen	100	---	---	---	481.0	68.8	68.8	817.0	48.1	1189.0	53.1	1590.0	57.4	56.8
9	5	---	Rock Salt	5	100	100	Sodium phosphate	100	---	---	---	786.0	112.5	112.5	1422.0	91.8	2195.0	109.0	3030.0	120.5	108.2
9	6	---	Rock Salt	5	100	100	Trisodium phosphate	100	---	---	---	963.0	137.5	137.5	1660.0	99.6	2345.0	98.1	3015.0	95.2	107.8
9	7	---	Rock Salt	5	100	100	Maleo 519	100	---	---	---	29.3	4.2	4.2	39.3	1.4	134.5	13.6	709.0	81.9	25.3
9	8	---	Rock Salt	5	100	100	Calgen	100	---	---	---	27.1	3.9	3.9	37.8	1.5	225.0	26.9	778.0	77.1	27.9

TABLE 11

DATA SUMMARY																								
CORROSIVE SOLUTION				INHIBITOR MIXTURE				AVERAGE CORROSION (WT LOSS)																
TEST NUMBER	SPECIMEN NUMBER	ANALYSIS NUMBER	TYPE	ZONES INCLD IN CL		MAJOR COMPONENTS		PARTS BY WT		COMPOSITION		PARTS BY WT		INITIAL WEIGHT OF METAL PLATES(GMS)	FIRST 7 DAYS		SECOND 7 DAYS		THIRD 7 DAYS		FOURTH 7 DAYS		OVER-ALL RATE	
				NO. 1	NO. 2	BY WT	BY WT	BY WT	BY WT	BY WT	BY WT	CUMULATIVE MG/DAY	RATE MG/DAY		CUMULATIVE MG/DAY	RATE MG/DAY	CUMULATIVE MG/DAY	RATE MG/DAY	CUMULATIVE MG/DAY	RATE MG/DAY	CUMULATIVE MG/DAY	RATE MG/DAY	CUMULATIVE MG/DAY	RATE MG/DAY
5	1	3	Distilled Water	100	-	-	-	-	-	-	-	-	-	-	484.0	69.1	818.0	47.8	1340.0	75.0	1810.0	66.7	64.6	
5	2	3	CaCl ₂ - MgCl ₂	5	-	-	-	-	-	-	-	-	-	-	401.0	57.3	855.0	65.0	1258.0	57.5	1597.0	48.3	57.1	
5	3	3	CaCl ₂ - MgCl ₂	10	-	-	-	-	-	-	-	-	-	-	297.0	42.5	640.0	49.0	1155.0	73.5	1480.0	46.6	53.0	
5	4	3	CaCl ₂ - MgCl ₂	20	-	-	-	-	-	-	-	-	-	-	115.1	16.4	273.5	22.6	459.0	26.4	616.0	22.6	22.0	
5	5	3	CaCl ₂ - MgCl ₂	30	-	-	-	-	-	-	-	-	-	-	50.6	7.2	104.5	7.7	174.5	10.0	247.0	10.3	8.8	
5	6	3	CaCl ₂ - MgCl ₂	40	-	-	-	-	-	-	-	-	-	-	4.6	0.7	39.8	5.0	67.9	4.0	89.6	3.1	3.2	

END

TABLE 12

DATA SUMMARY

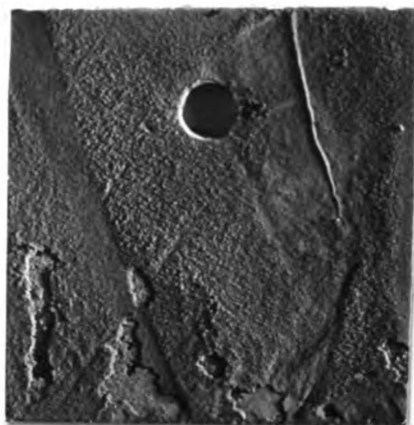
Corrosive Solution		Overall Corrosion Rate (14 day test period)									
		Series 13		Series 14		Series 15		Series 16			
Type	Concentration (wt. %)	Spec. No.	mg/dm ² /day	Spec. No.	mg/dm ² /day	Spec. No.	mg/dm ² /day	Spec. No.	mg/dm ² /day	Spec. No.	mg/dm ² /day
Distilled H ₂ O	100	1	12.7	1	5.1	1	90.7	1	9.0		
CaCl ₂ - MgCl ₂	1	2	10.3	2	51.2	2	57.4	2	11.7		
CaCl ₂ - MgCl ₂	5	3	5.1	3	37.9	3	86.2	3	10.2		
CaCl ₂ - MgCl ₂	20	4	1.7	4	8.0	4	24.5	4	2.6		
CaCl ₂ - MgCl ₂	30	5	0.9	5	4.5	5	9.0	5	1.3		
Distilled Water	100	(not tested)		6	46.6	6	85.3	6	10.2		
Rock Salt	1	6	9.4	7	58.6	7	110.0	7	8.4		
Rock Salt	5	7	5.1	8	45.6	8	76.5	8	4.4		
Rock Salt	20	8	1.6	9	21.8	9	30.2	9	2.3		
Rock Salt	30	9	1.0	10	7.6	10	11.7	10	0.8		



1-A



2-A



1-B



2-B



1-C



2-C

SERIES II

EFFECT OF CHROMATE CONCENTRATION ON CHARACTER OF CORROSION

5% CaCl_2 - MgCl_2 BRINE, AERATED & AGITATED AT 75°F

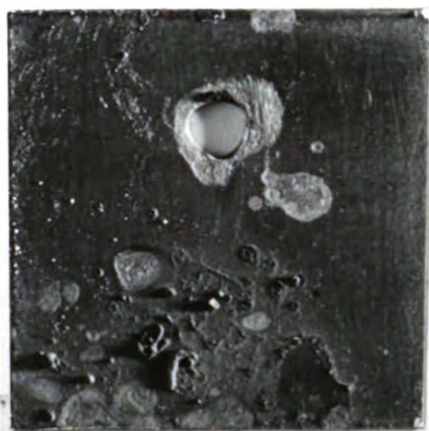
FIGURE 13-1



3-A



4-A



3-B



4-B



3-C



4-C

SERIES II

EFFECT OF CHROMATE CONCENTRATION ON CHARACTER OF CORROSION

5% CaCl_2 - MgCl_2 BRINE, AERATED & AGITATED AT 75°F

FIGURE 13-2



5-A



6-A



5-B



6-B



5-C



6-C

SERIES II

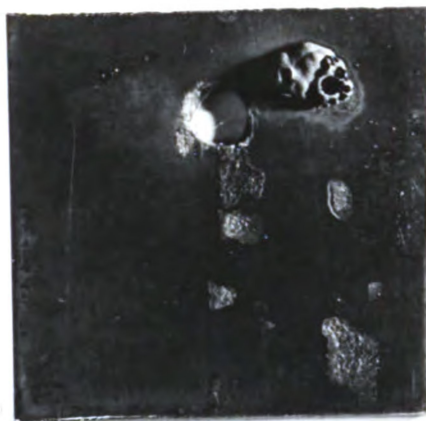
EFFECT OF CHROMATE CONCENTRATION ON CHARACTER OF CORROSION

5% CaCl_2 - MgCl_2 BRINE, AERATED & AGITATED AT 75°F

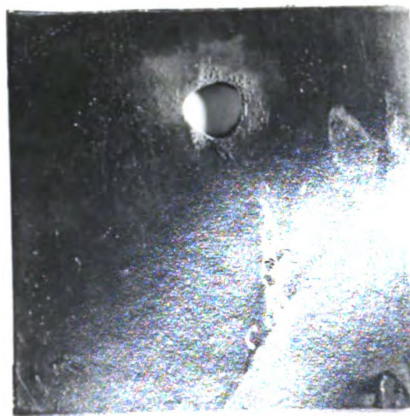
FIGURE 13-3



7-A



7-B



7-C

SERIES II

EFFECT OF CHROMATE CONCENTRATION ON CHARACTER OF CORROSION

5% CaCl_2 - MgCl_2 BRINE, AERATED & AGITATED AT 75°F

FIGURE 13-4



1-A



2-A



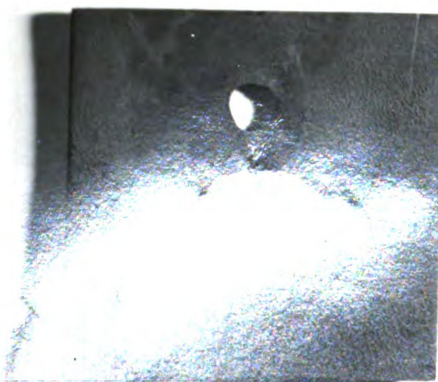
1-B



2-B



1-C



2-C

SERIES 12

**EFFECT OF CHROMATE - HYDROQUINONE CONCENTRATION ON
CHARACTER OF CORROSION**

5% CaCl_2 - MgCl_2 BRINE, AERATED & AGITATED AT 75°F

FIGURE 14-1



3-A



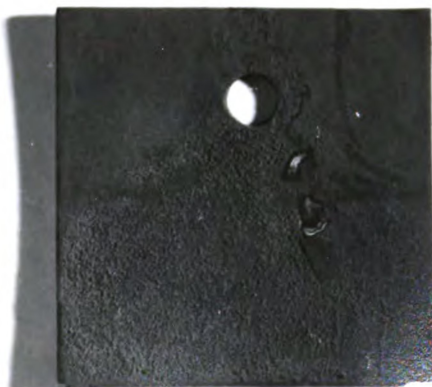
4-A



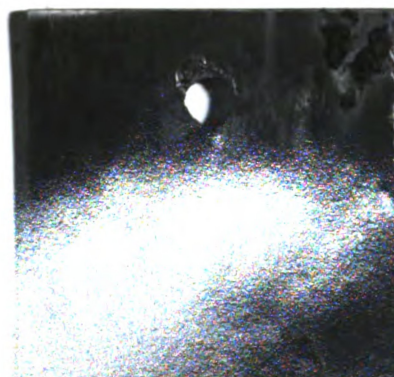
3-B



4-B



3-C



4-C

SERIES 12

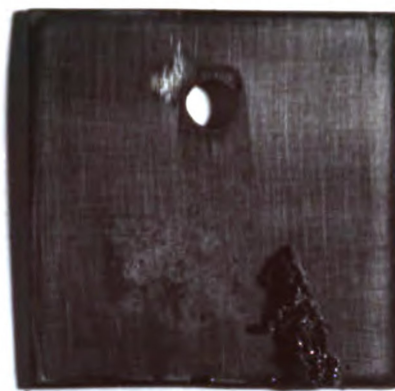
EFFECT OF CHROMATE - HYDROQUINONE CONCENTRATION ON CHARACTER OF CORROSION

5% C_6Cl_2 - M_2Cl_2 BRINE, AERATED & AGITATED AT 75°F

FIGURE 14-2



5-A



6-A



5-B



6-B



5-C



6-C

SERIES 12

EFFECT OF CHROMATE - HYDROQUINONE CONCENTRATION ON CHARACTER OF CORROSION

5% CaCl_2 - MgCl_2 BRINE, AERATED & AGITATED AT 75°F

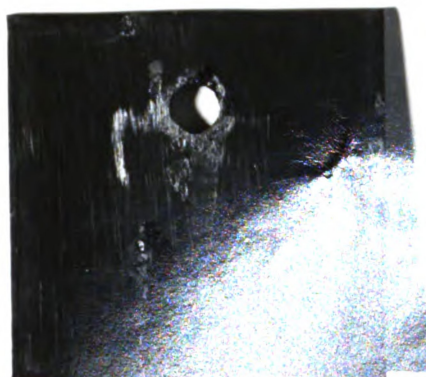
FIGURE 14-3



7-A



7-B



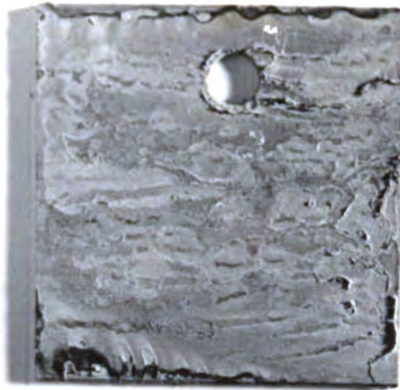
7-C

SERIES 12

**EFFECT OF CHROMATE - HYDROQUINONE CONCENTRATION ON
CHARACTER OF CORROSION**

5% CaCl_2 - MgCl_2 BRINE, AERATED & AGITATED AT 75°F

FIGURE 14-4



1-A



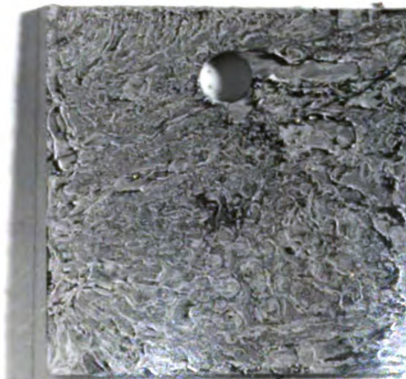
2-A



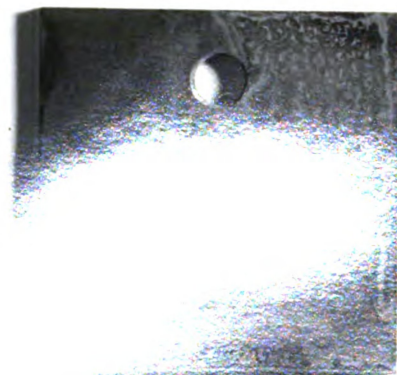
1-B



2-B



1-C



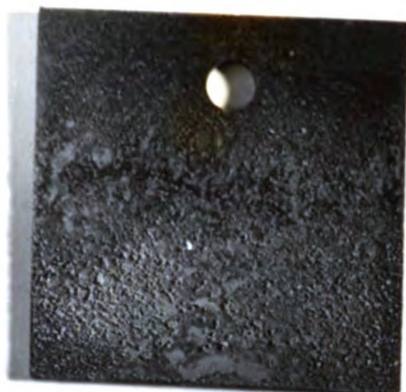
2-C

SERIES 13

CORROSIVE EFFECTS OF H_2O , $CaCl_2-MgCl_2$
AND N_2Cl AT $35^\circ F$ (NOT AERATED)

FIGURE 15-1





3-A



4-A



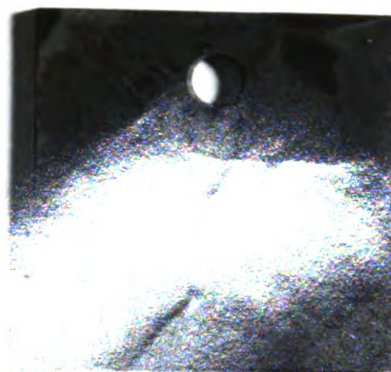
3-B



4-B



3-C

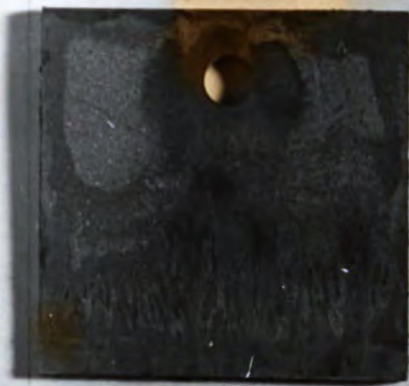


4-C

SERIES 13

CORROSIVE EFFECTS OF H_2O , $C_2Cl_2-M_2Cl_2$
AND N_2Cl AT $35^\circ F$ (NOT AERATED)

FIGURE 15-2



5-A



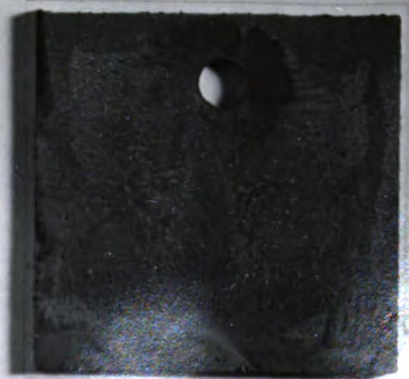
6-A



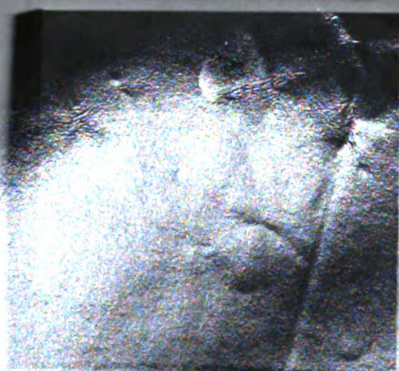
5-B



6-B



5-C



6-C

SERIES 13

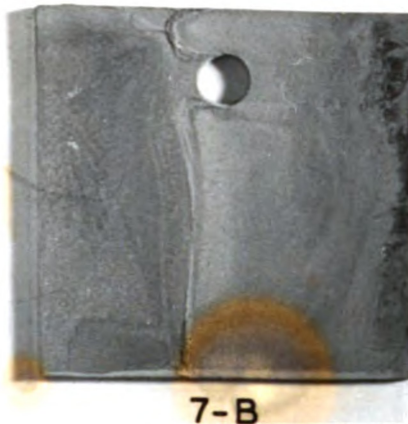
CORROSIVE EFFECTS OF H_2O , $CaCl_2-MgCl_2$
AND $NaCl$ AT $35^\circ F$ (NOT AERATED)



7-A



8-A



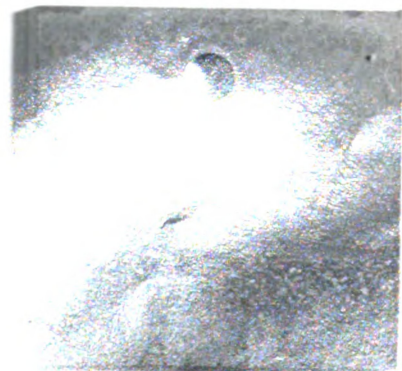
7-B



8-B



7-C



8-C

SERIES 13

CORROSIVE EFFECTS OF H_2O , $CaCl_2-MgCl_2$
AND N_2Cl AT $35^\circ F$ (NOT AERATED)

FIGURE 15-4



9-A



9-B

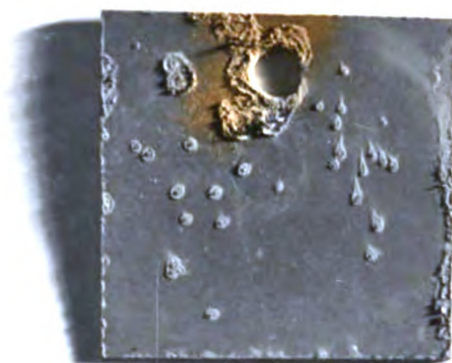


9-C

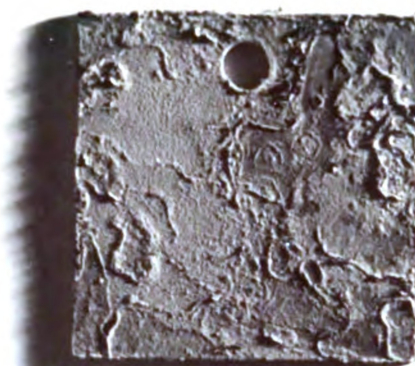
SERIES 13

CORROSIVE EFFECTS OF H_2O , $CaCl_2-MgCl_2$
AND $NaCl$ AT $35^\circ F$ (NOT AERATED)

FIGURE 15-5



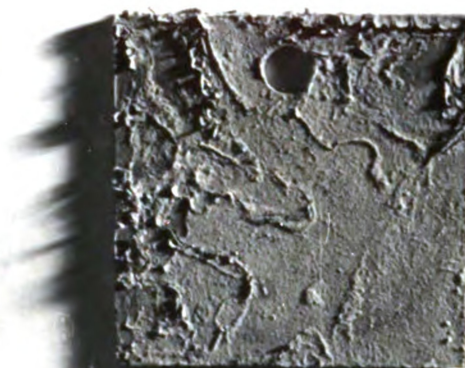
1-A



2-A



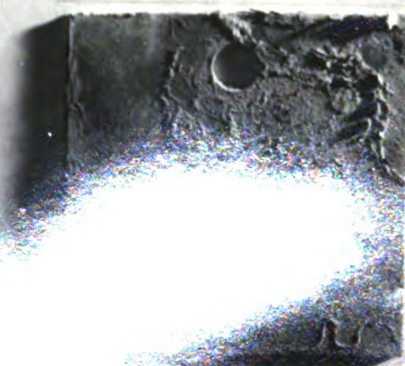
1-B



2-B



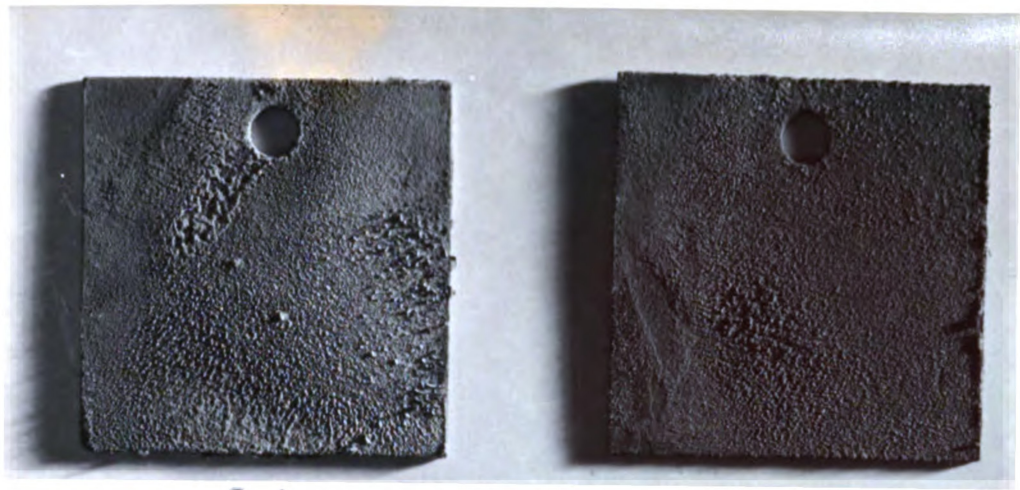
1-C



2-C

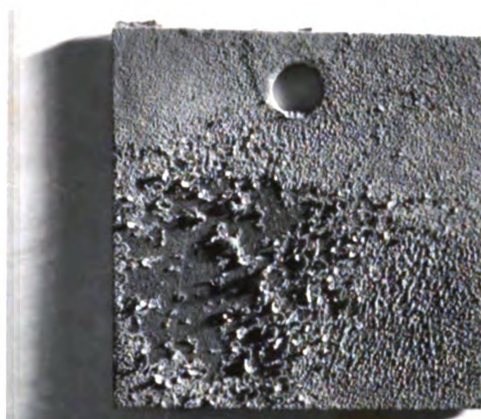
CORROSIVE EFFECTS OF H_2O , $\text{CaCl}_2\text{-MgCl}_2$
AND NaCl AT 35°F (AERATED)

FIGURE 16-1



3-A

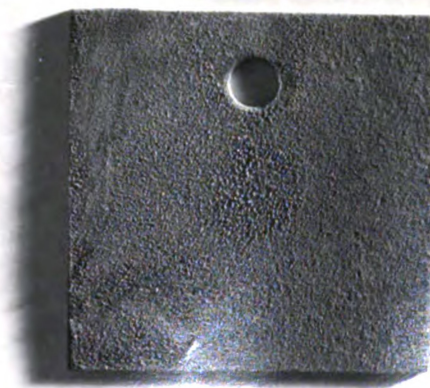
4-A



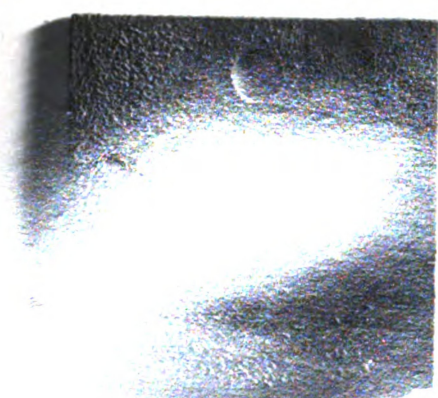
3-B



4-B



3-C

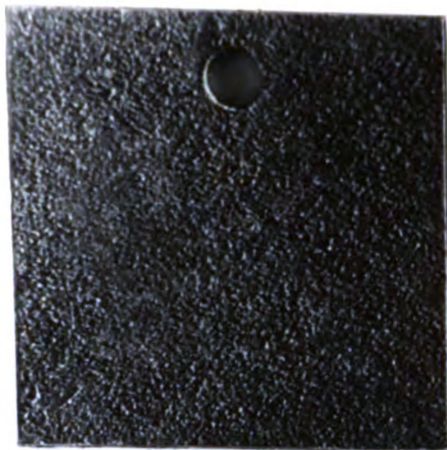


4-C

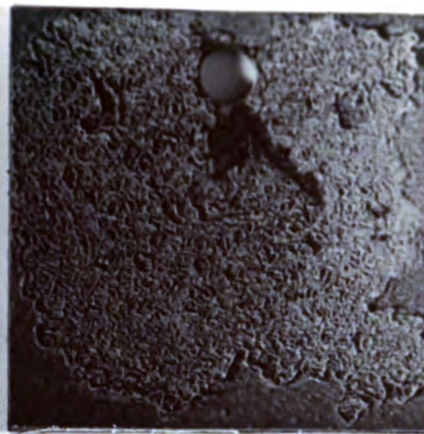
1 SEP

CORROSIVE EFFECTS OF H_2O , $\text{CaCl}_2\text{-MgCl}_2$
AND NaCl AT 35°F (AERATED)

FIGURE 16-2



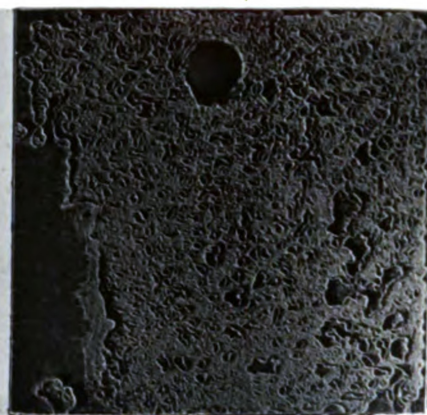
5-A



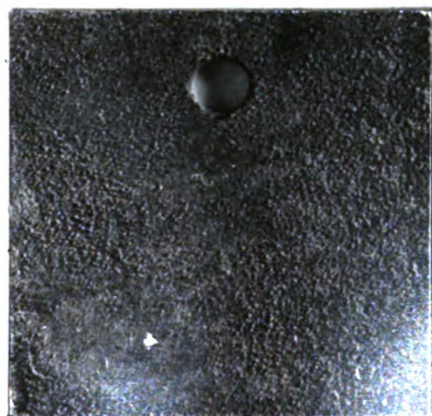
6-A



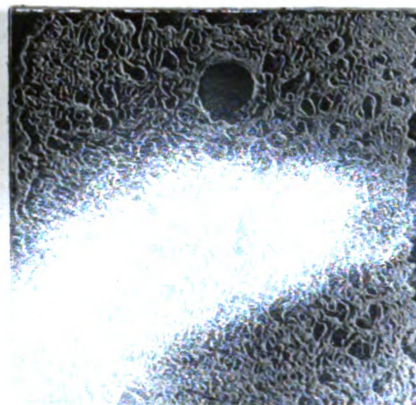
5-B



6-B



5-C



6-C

SERIES 14

CORROSIVE EFFECTS OF H_2O , $CaCl_2-MgCl_2$
AND $NaCl$ AT $35^\circ F$ (AERATED)

FIGURE 16-3



7-A



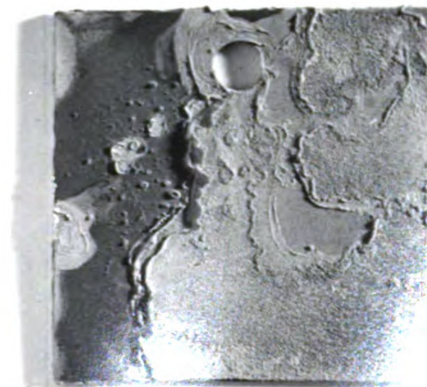
8-A



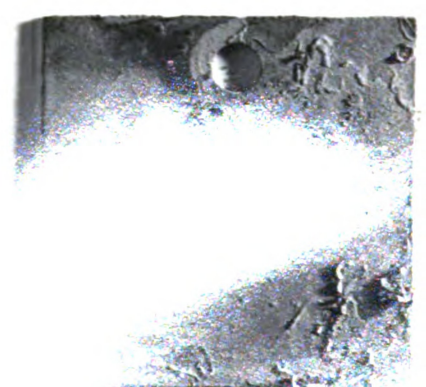
7-B



8-B



7-C



8-C

SERIES 14

CORROSIVE EFFECTS OF H_2O , $CaCl_2-MgCl_2$
AND $NaCl$ AT $35^\circ F$ (AERATED)

FIGURE 16-4



9-A



10-A



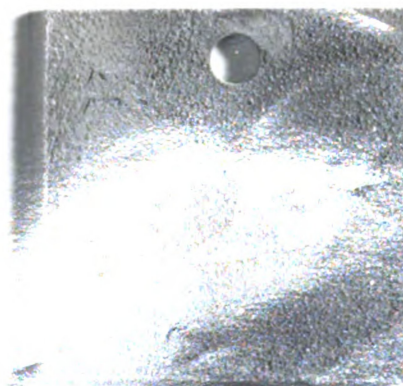
9-B



10-B



9-C

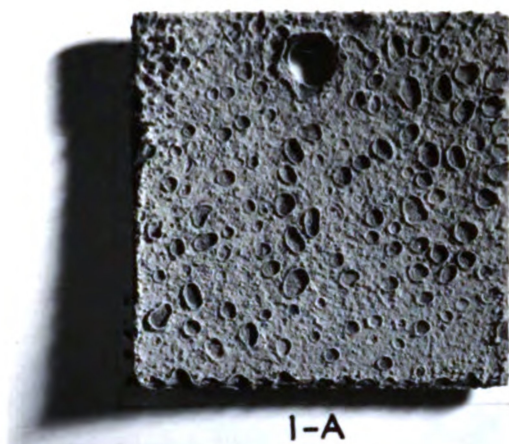


10-C

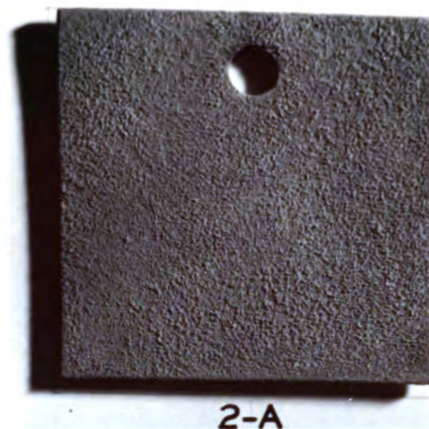
SERIES 14

CORROSIVE EFFECTS OF H_2O , $CaCl_2-MgCl_2$
AND $NaCl$ AT $35^\circ F$ (AERATED)

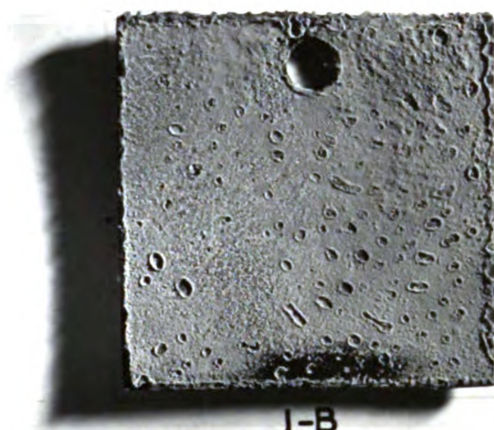
FIGURE 16-5



1-A



2-A



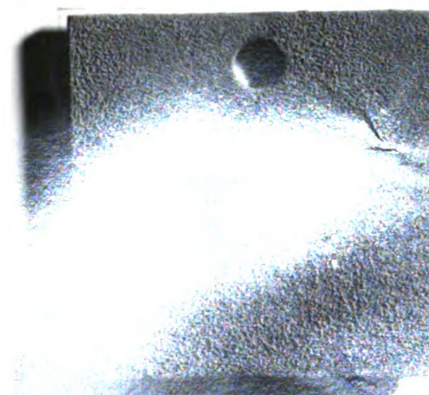
1-B



2-B



1-C

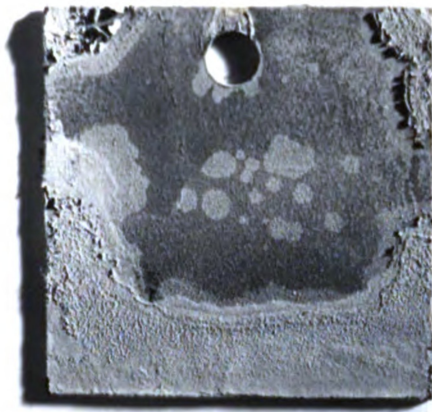


2-C

SERIES 15

CORROSIVE EFFECTS OF H_2O , $\text{CaCl}_2\text{-MgCl}_2$
AND NaCl AT 75°F (AERATED)

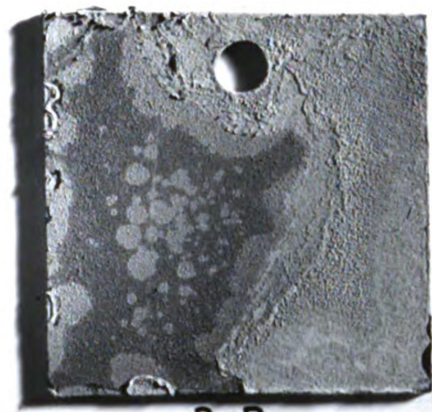
FIGURE 17-1



3-A



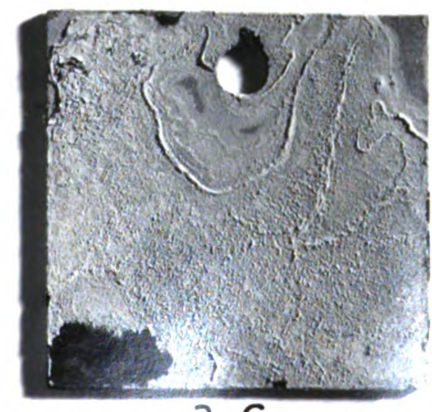
4-A



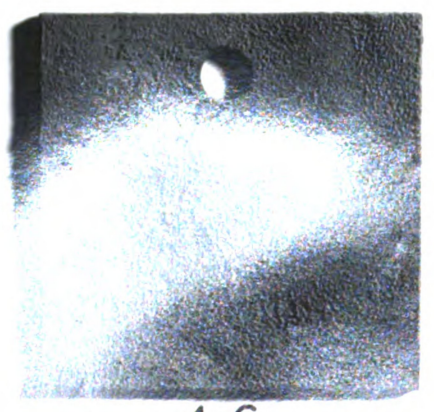
3-B



4-B



3-C



4-C

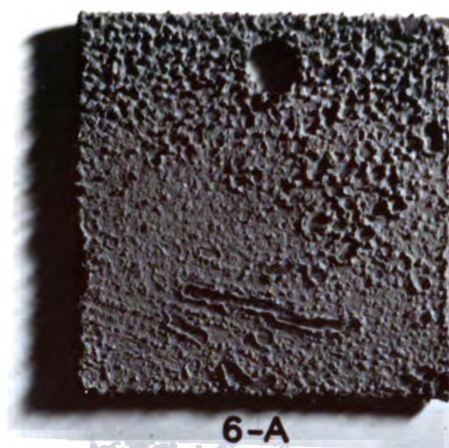
SERIES 15

CORROSIVE EFFECTS OF H_2O , $CaCl_2$ - $MgCl_2$
AND $NaCl$ AT $75^\circ F$ (AERATED)

FIGURE 17-2



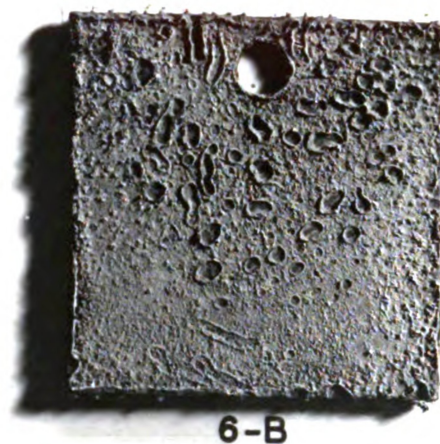
5-A



6-A



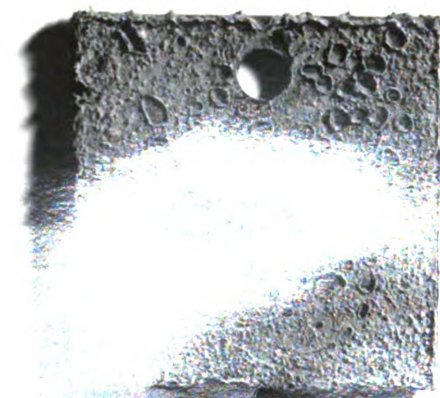
5-B



6-B



5-C

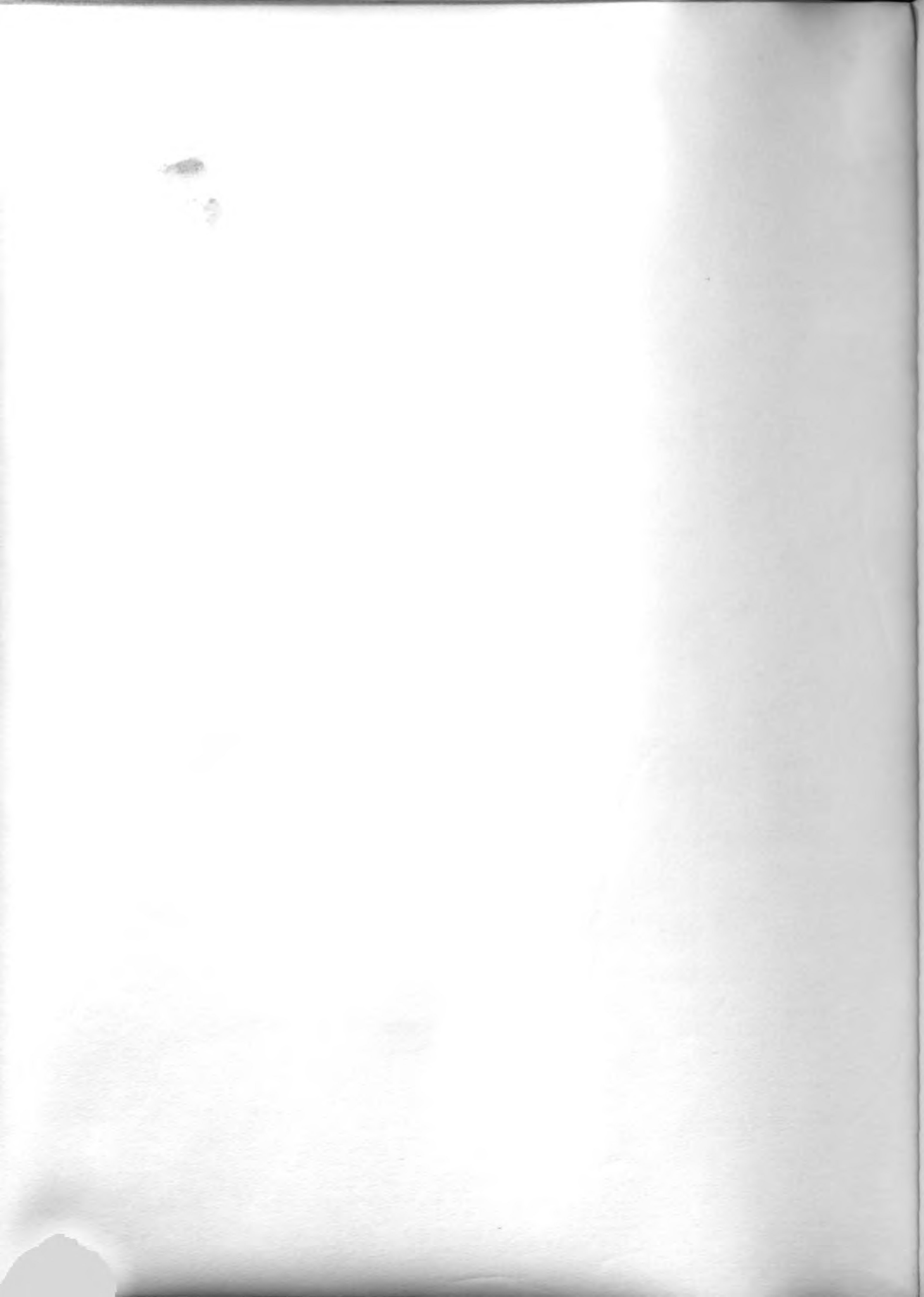


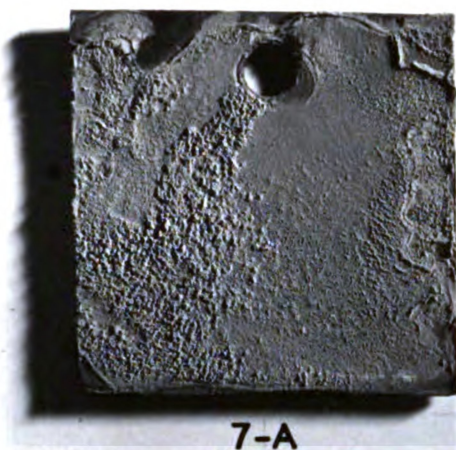
6-C

SERIES 15

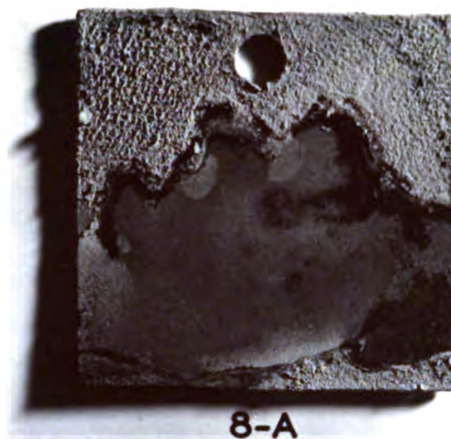
CORROSIVE EFFECTS OF H_2O , $CaCl_2-MgCl_2$
AND $NaCl$ AT $75^\circ F$ (AERATED)

FIGURE 17-3





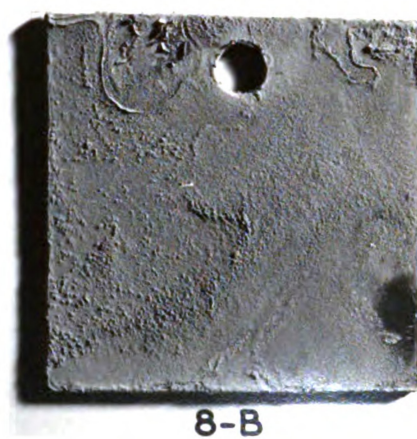
7-A



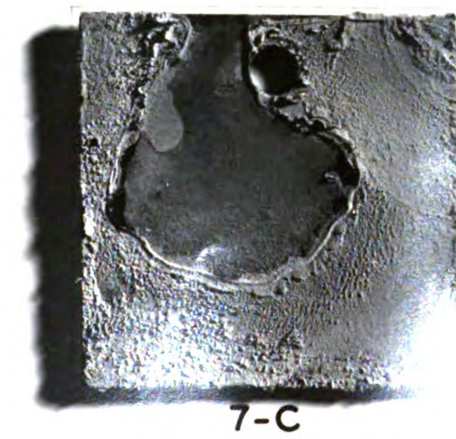
8-A



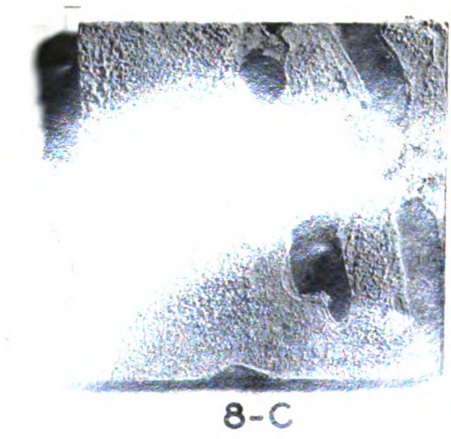
7-B



8-B



7-C

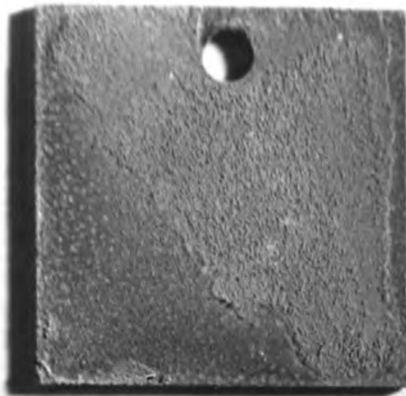


8-C

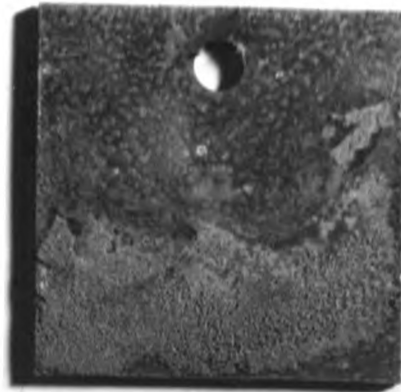
SERIES 15

CORROSIVE EFFECTS OF H_2O , $CaCl_2-MgCl_2$
AND $NaCl$ AT $75^\circ F$ (AERATED)

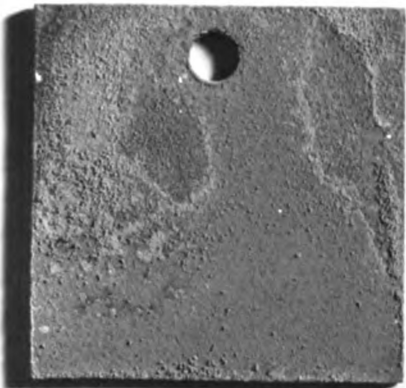
FIGURE 17-4



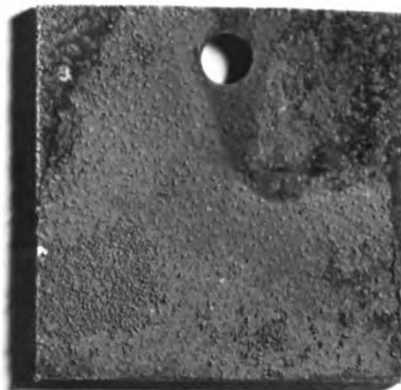
9-A



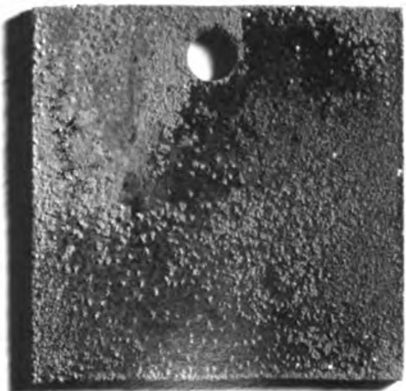
10-A



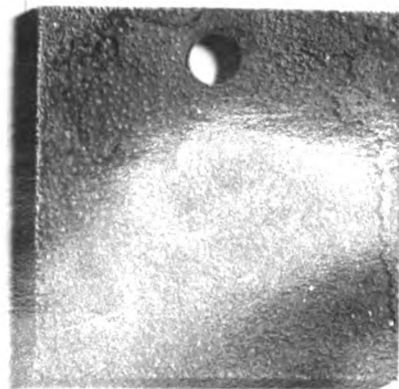
9-B



10-B



9-C

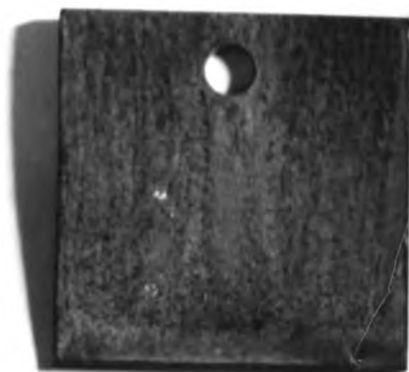


10-C

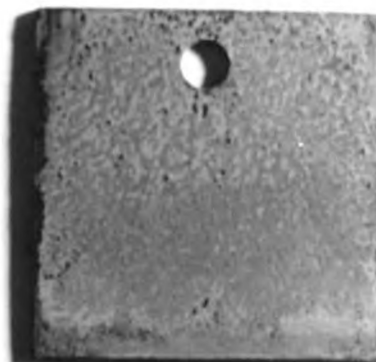
SERIES 15

CORROSIVE EFFECTS OF H_2O , $CaCl_2-MgCl_2$
AND $NaCl$ AT $75^\circ F$ (AERATED)

FIGURE 17-5



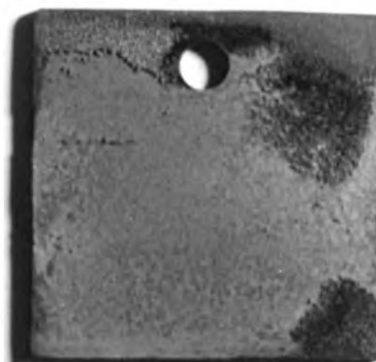
1-A



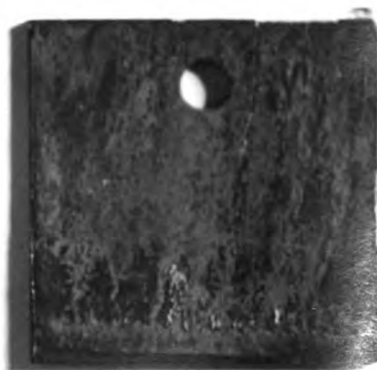
2-A



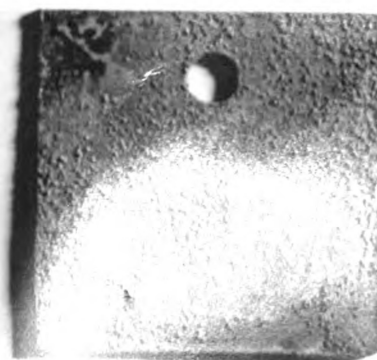
1-B



2-B



1-C

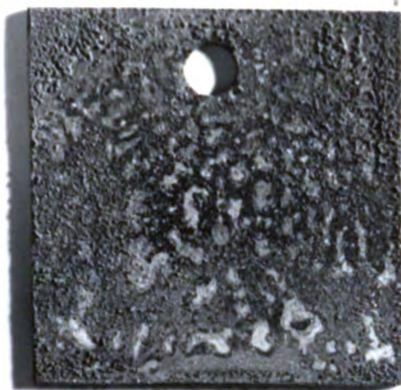


2-C

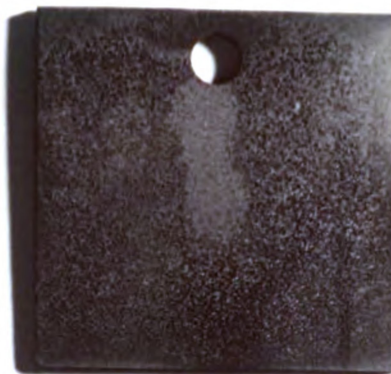
L SERIES 16

CORROSIVE EFFECTS OF H_2O , $CaCl_2-MgCl_2$
AND $NaCl$ AT $75^\circ F$ (NOT AERATED)

FIGURE 18-1



3-A



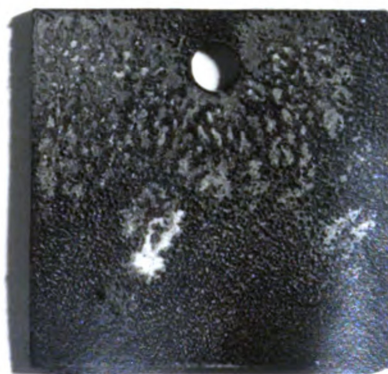
4-A



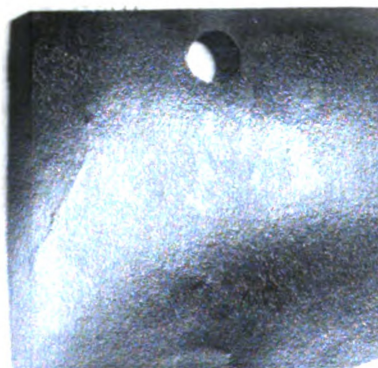
3-B



4-B



3-C

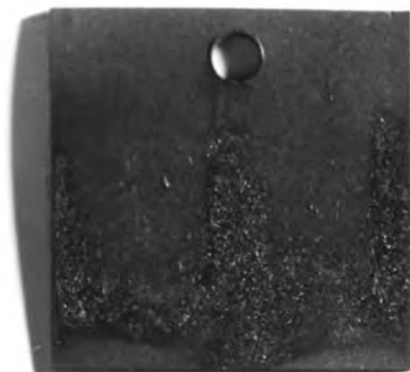


4-C

SERIES 16

CORROSIVE EFFECTS OF H_2O , $\text{CaCl}_2\text{-MgCl}_2$
AND NaCl AT 75°F (NOT AERATED)

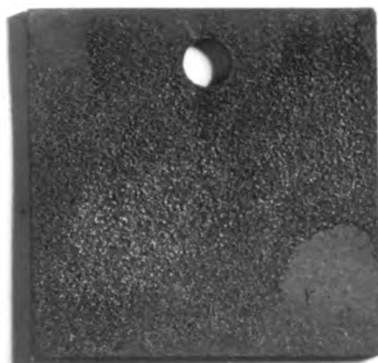
FIGURE 18-2



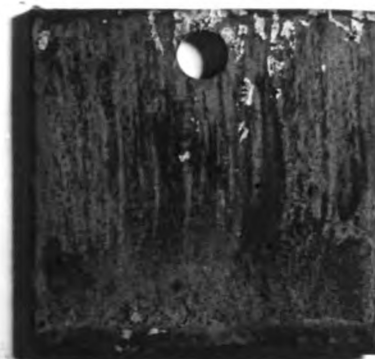
5-A



6-A



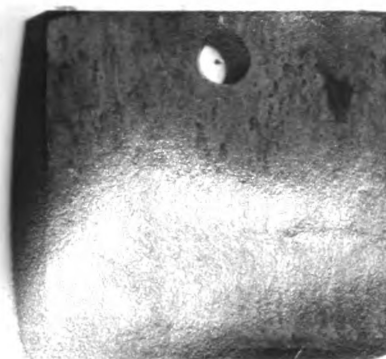
5-B



6-B



5-C

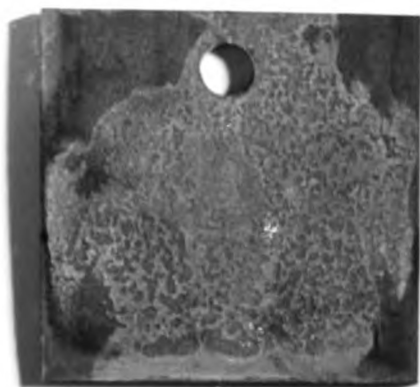


6-C

SERIES 16

CORROSIVE EFFECTS OF H_2O , $CaCl_2-MgCl_2$
AND $NaCl$ AT $75^\circ F$ (NOT AERATED)

FIGURE 18-3



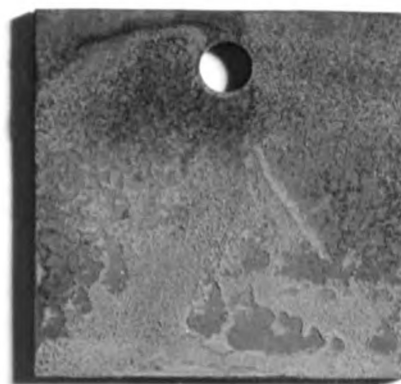
7-A



8-A



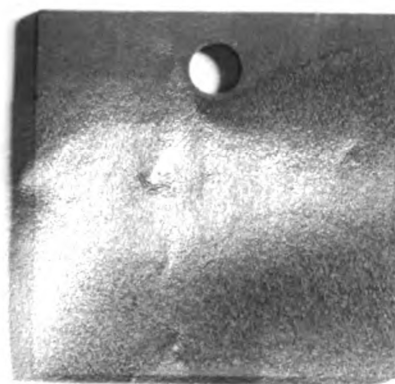
7-B



8-B



7-C

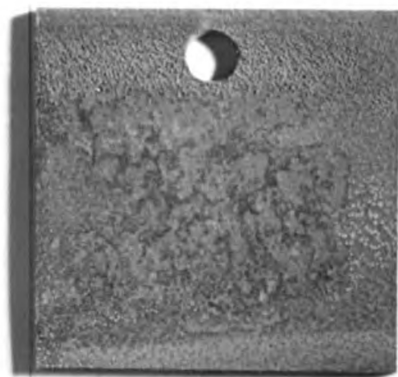


8-C

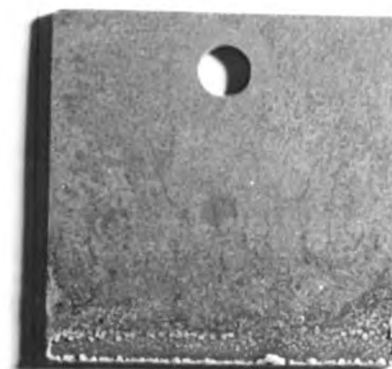
SERIES 16

CORROSIVE EFFECTS OF H_2O , $\text{CaCl}_2\text{-MgCl}_2$
AND NaCl AT 75°F (NOT AERATED)

FIGURE 18-4



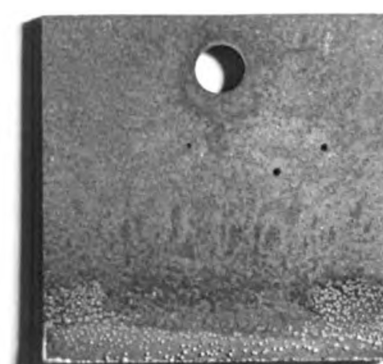
9-A



10-A



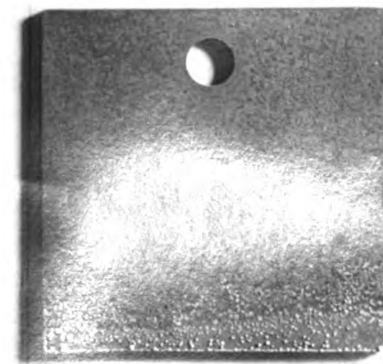
9-B



10-B



9-C



10-C

SERIES 16

CORROSIVE EFFECTS OF H_2O , $\text{CaCl}_2\text{-MgCl}_2$
AND NaCl AT 75°F (NOT AERATED)

FIGURE 18-5

APPENDIX B

LABORATORY PROCEDURE

Preparation of Solutions

The solutions were prepared by weighing out the amount of chloride salt necessary to obtain the desired concentration and adding enough distilled water to bring the volume up to 300 ml. In the event that the chloride salt was in brine form, the brine was measured volumetrically and diluted to the desired concentration with distilled water. The salts used were, in all cases, the technical grades used in highway applications. Inhibitors, when used, were weighed out and placed in this solution. All inhibitor concentrations were based on the total chloride salt content of the solution.

Preparation of Metal Plates

The metal used was 19 gauge, S.A.E. No. 1008 sheet steel, which

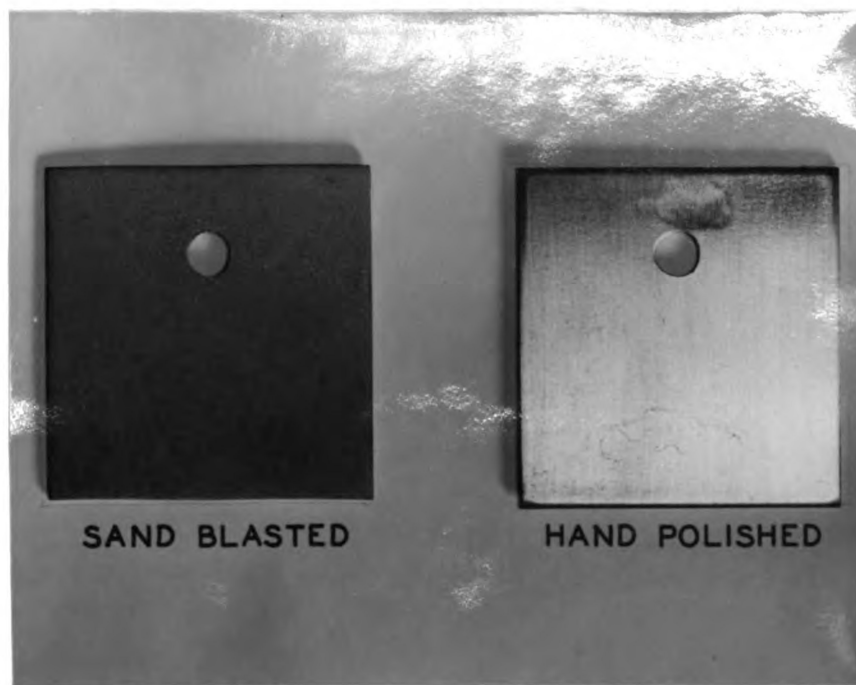


Figure 19. Freshly prepared test plates.

was the same as that used in the 1947-1949 Oldsmobile bodies. The metal was cut into plates 2 in. by 2 in. A 1/4 in. diameter hole was drilled through the plates near one edge in such a manner as to leave no burrs around the hole. The plates were then polished with No. 280 wet and dry emery paper and finally with crocus cloth to produce a uniform surface, (see Note). The plates were then cleaned in carbon tetrachloride or trichlorethylene to remove any grease or oil from handling, dried in an oven at 220° F. for one hour and weighed to constant weight.

Note: Sand-blasting may be substituted for the above polishing method, providing it is used throughout the experiment.

Tests

The tests were run according to one of the following cycles. Since pH control on the highway did not seem feasible, no attempt at pH control was made in the laboratory. However, the pH was checked periodically throughout the tests. The inhibitor was not replenished during the test, since it was desired to learn how long a given application of inhibitor would remain effective. Triplicate samples were run in all cases. The amount of corrosion was calculated in milligrams per square decimeter and in milligrams per square decimeter per day, using the equations given on pp. 80.

Corrosion Cycle No. 1

300 ml. of prepared solution were placed in a 400 ml. beaker and the weighed metal plate suspended in the solution by means of a glass hook. The solutions were kept saturated with oxygen by continuously bubbling filtered air through the solution, which also supplied agitation. The beaker was kept covered insofar as possible, to reduce

evaporation losses and to keep dust and other foreign material from entering. Any evaporation losses were made up by adding distilled water periodically in order to maintain the solution volume at 300 ml. Tests were run at $75 \pm 5^\circ \text{ F.}$ and at $35 \pm 2^\circ \text{ F.}$

The metal plate was removed from the solution at 7 day intervals, cleaned, dried at 220° F. for one hour, weighed to constant weight and returned to the solution. The cleaning was done by thoroughly brushing with a stiff bristle or brass brush under a stream of water in order to remove as much of the corrosion products as possible. The duration of

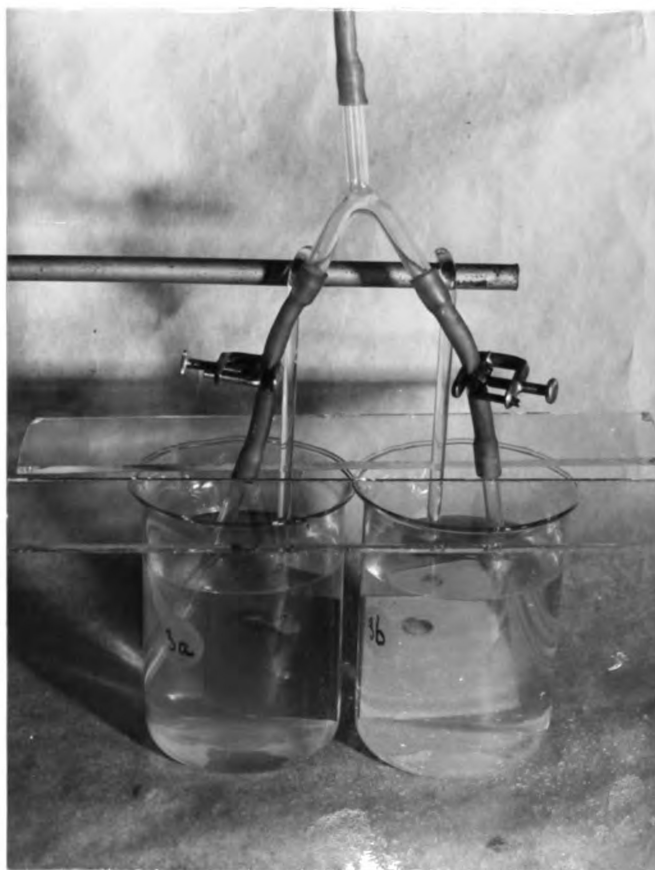


Figure 20. Detailed Set-up for Corrosion Cycle No. 1.

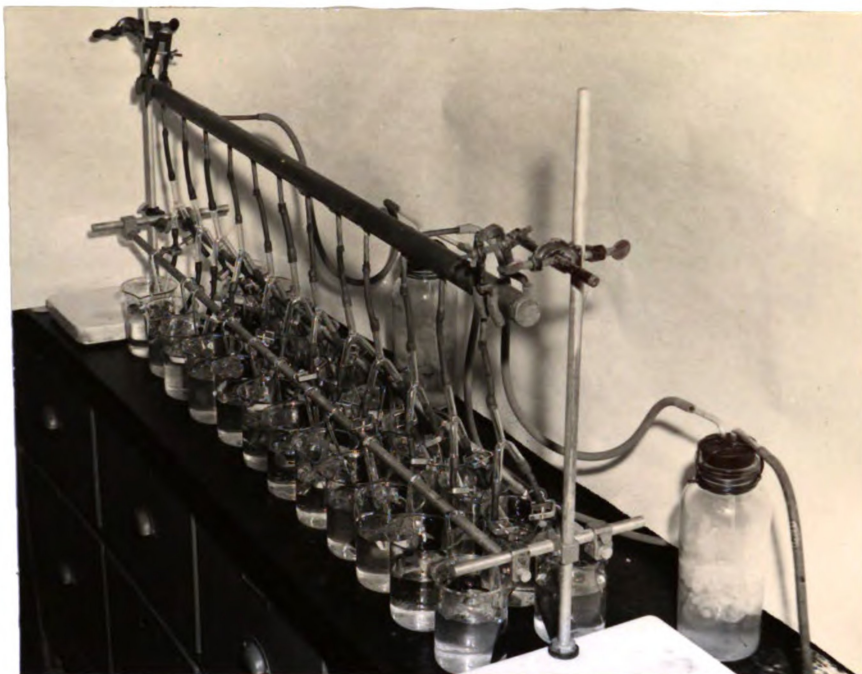


Figure 21. Battery of Tests for Corrosion Cycle No. 1.

the test was 28 days.

Corrosion Cycle No. 2

300 ml. of prepared solution were placed in a 400 ml. beaker and the weighed metal plate placed in the beaker with one edge resting on the bottom of the beaker and the top of the plate leaning against the side of the beaker. The beaker was covered with a glass plate to exclude foreign matter, but in such a way as to allow air circulation over the beaker. The plate was alternately immersed and exposed to air as follows:

- 16 hours - immersion
- 2 hours - air exposure
- 4 hours - immersion
- 2 hours - air exposure

The plate was removed from the solution at 7 day intervals, cleaned, weighed, and returned to the solution as in Cycle No. 1. The duration

of the test was 28 days. Temperature was $75 \pm 5^\circ \text{F.}$

Corrosion Cycle No. 3

The solution was prepared as previously stated, except that the distilled water was freshly boiled for 15 minutes to remove dissolved oxygen before preparing the solution. The prepared solution and weighed metal plate were placed, as described in Cycle No. 2, in a 16 ounce specimen bottle and the cap tightened to limit the oxygen supply. The plate was cleaned and weighed at the end of the test only, using the cleaning method of Cycles No. 1 and 2. Tests were run at $75 \pm 5^\circ \text{F.}$ and at $35 \pm 2^\circ \text{F.}$

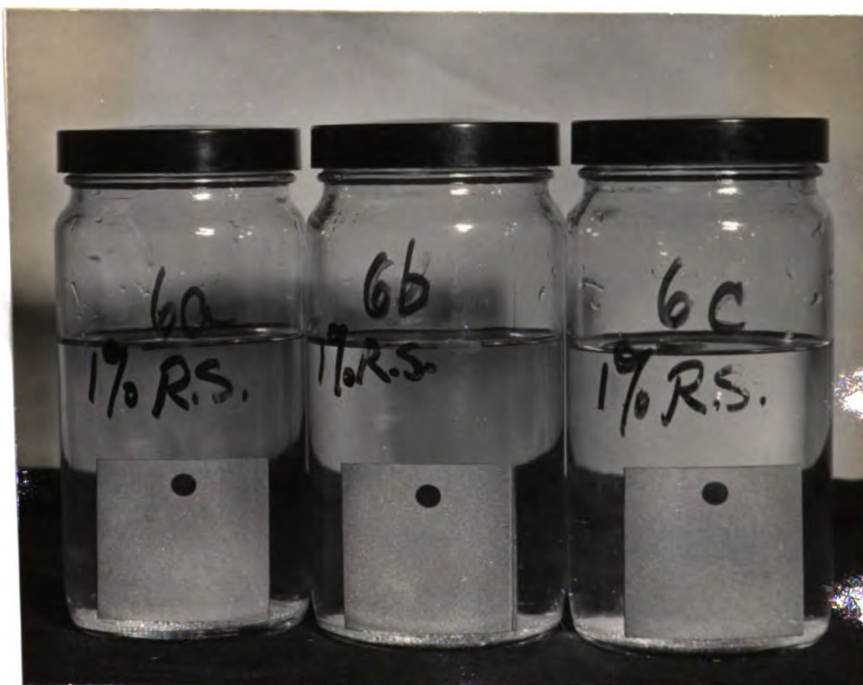


Figure 22. Detailed Set-up for Corrosion Cycle No. 3.

EQUATIONS USED FOR CORROSION CALCULATIONS

General Equations

$$\text{Corrosion Rate} = \frac{1000 W}{A t} \quad \text{in mg/dm}^2/\text{day}$$

$$\text{Cumulative Corrosion} = \frac{1000 W}{A} \quad \text{in mg/dm}^2$$

For Series 1 to 12, Inclusive

$$\text{Corrosion Rate} = \frac{1000 W}{0.54 t} = 1854 \frac{W}{t}$$

$$\text{Cumulative Corrosion} = \frac{1000 W}{0.54} = 1854 W$$

For Series 13 to 16, Inclusive

$$\text{Corrosion Rate} = \frac{1000 W}{0.48 t} = 2085 \frac{W}{t}$$

$$\text{Cumulative Corrosion} = \frac{1000 W}{0.48} = 2085 W$$

A = Average total surface area of test plate. (dm²)

W = Weight loss which occurred during time interval "t". (gms)

t = Time during which corrosion took place. (days)

TABLE 13
ANALYSES OF CALCIUM CHLORIDE BRINES USED FOR CORROSION STUDIES

	No. 1	No. 2	No. 3
Calcium Chloride, per cent by weight	37.48	40.57	39.78
Magnesium Chloride, per cent by weight	1.54	1.76	1.47
Sodium Chloride, per cent by weight	0.99	0.51	0.56
Specific Gravity 25.0/25.0° C.	1.399	1.431	1.422
Sum of Calcium and Magnesium Chlorides	39.02	42.33	41.25

These brines were obtained from Michigan Chemical Co., St. Louis, Michigan. Analyzed by the Solvay Method.

The Rock Salt used in these tests was obtained from the Michigan State Highway Department, and was identical to that used on highways.

TABLE 14
CHLORIDE CONTENT OF WINTER ROAD SLUSH

Sample No.	Location	Sample Temp. (° F.)	CaCl ₂ (Wt. %)
1	Gr. River-Abbott Rd-center of intersection	32.0	0.28
2	" " " " right gutter, east bound	31.3	0.30
3	" " " " left gutter, east bound	32.2	0.59
4	" " " " right gutter, west bound	31.5	1.52
5	Mich. Ave.-Delta St-right gutter, west bound	31.8	0.41
6	" " " " -center of intersection	31.6	0.24
7	" " Beal St.-right gutter, west bound	30.8	1.47
8	" " " " left gutter, west bound	31.9	0.50
9	" " " " center of intersection	30.7	1.24

These samples were taken about 6 hours after application of a calcium chloride-sand mixture to the streets of East Lansing, Michigan. Air Temperature = 28° F., February 16, 1949. Pavement: Concrete.

TABLE 16

MEASUREMENTS TO DETERMINE AVERAGE TOTAL PLATE AREA FOR CORROSION TEST

SERIES NO. 13-16, INCLUSIVE

Dimensions of Sampled Plates			
Length (in.)	Width (in.)	Thickness (in.)	Hole Diameter (in.)
1.86	1.86	0.044	0.250
1.91	1.91	0.044	0.250
1.91	1.90	0.044	0.250
1.91	1.90	0.044	0.250
1.86	1.86	0.044	0.250
1.91	1.91	0.044	0.250
1.91	1.91	0.044	0.250
1.91	1.90	0.044	0.250
1.88	1.84	0.044	0.250
1.90	1.91	0.044	0.250
Mean 1.90	1.89	0.044	0.250

$$\text{Face Area} = 2(1.90)(1.89) - \frac{(0.25)^2}{4} = 7.08 \text{ in.}^2$$

$$\text{Edge Area} = 2(1.90 + 1.89)(0.044) + (0.25)(0.044) = 0.33 \text{ in.}^2$$

$$\text{Average Total Area} = 7.08 + 0.33 = 7.41 \text{ in.}^2$$

$$1 \text{ in.}^2 = 0.0645 \text{ dm}^2$$

$$\text{Average Total Area} = 0.48 \text{ dm}^2$$

WEIGHT LOSS DATA - CORROSION TEST SERIES NO. 2

DATE		CORROSIVE SOLUTION		INHIBITOR MIXTURE				LOSS OF WEIGHT (GMS.)				REMARKS				
START	END	SPECIMEN NUMBER	ANVIL NO.	TYPE	PARTS BY WT.	MAJOR COMPONENTS	PARTS BY WT.	MINOR COMPONENTS	PARTS BY WT.	CONCENTRATION (% BY WT.)	INITIAL WEIGHT OF METAL PLATE (GMS.)		1ST 7 DAYS	2ND 7 DAYS	3RD 7 DAYS	4TH 7 DAYS
7-2-48	7-25-48	1a	1	$\text{CaCl}_2 - \text{MgCl}_2$	5	"	95	Formaldehyde	5	0.5	20.0696	0.0142	0.1178	0.1746	0.3066	All tests in this series discontinued after 21 days. Metal plates were hand-polished.
		1b	1	"	"	"	"	"	"	"	20.1514	0.0117	0.0147	0.0119	0.0383	
		1c	1	"	"	"	"	"	"	"	"	20.2488	0.0108	0.0246	0.0334	
		2a	1	$\text{CaCl}_2 - \text{MgCl}_2$	5	"	95	Pyridine	5	0.5	19.9190	0.0256	0.0183	0.1698	0.2137	Continuously aerated and agitated. Temperature = $75 \pm 5^\circ\text{F}$. Corrosion Cycle # 1.
		2b	1	"	"	"	"	"	"	"	20.6181	0.0182	0.0377	0.1498	0.2057	
		2c	1	"	"	"	"	"	"	"	"	20.6706	0.0125	0.0116	0.0125	
		3a	1	$\text{CaCl}_2 - \text{MgCl}_2$	5	"	95	Sodium Salicylate	5	0.5	19.6820	0.0177	0.0097	0.0044	0.0318	
		3b	1	"	"	"	"	"	"	"	19.9589	0.0176	0.0245	0.1426	0.1847	
		3c	1	"	"	"	"	"	"	"	"	21.3060	0.0185	0.0150	0.0793	
		4a	1	$\text{CaCl}_2 - \text{MgCl}_2$	5	"	95	Sodium Benzoate	5	0.5	19.9999	0.0149	0.0086	0.0113	0.0348	
		4b	1	"	"	"	"	"	"	"	21.0910	0.0227	0.0188	0.1679	0.2094	
		4c	1	"	"	"	"	"	"	"	"	19.9017	0.0138	0.0380	0.1635	
		5a	1	$\text{CaCl}_2 - \text{MgCl}_2$	5	"	95	Hydroquinone	5	0.5	19.8944	0.0096	0.0081	0.0063	0.0240	
		5b	1	"	"	"	"	"	"	"	20.1727	0.0176	0.0089	0.0030	0.0295	
		5c	1	"	"	"	"	"	"	"	"	19.2703	0.0082	0.0071	0.0021	
		6a	1	$\text{CaCl}_2 - \text{MgCl}_2$	5	"	100			0.5	20.3563	0.0151	0.0262	0.1833	0.2246	
		6b	1	"	"	"	"			"	21.6560	0.0153	0.0257	0.2235	0.2645	
		6c	1	"	"	"	"			"	"	21.1113	0.0152	0.0369	0.1564	
		7a	1	$\text{CaCl}_2 - \text{MgCl}_2$	5	"	100	Chrome Alum		0.5	19.2157	0.0878	0.2512	0.1978	0.5368	
		7b	1	"	"	"	"	"	"	"	20.1801	0.1180	0.2584	0.1808	0.5572	
		7c	1	"	"	"	"	"	"	"	"	20.7783	0.1038	0.2715	0.2639	
		8a	1	$\text{CaCl}_2 - \text{MgCl}_2$	5	"	100	Chromic Acid		0.5	20.5867	0.0723	0.0420	0.1959	0.3102	
		8b	1	"	"	"	"	"	"	"	20.7738	0.0786	0.0148	0.1362	0.2296	
		8c	1	"	"	"	"	"	"	"	"	20.3758	0.0713	0.0159	0.0586	

WEIGHT LOSS DATA - CORROSION TEST SERIES NO. 2

DATE	SPECIMEN NUMBER	CORROSIVE SOLUTION		INHIBITOR MIXTURE			INITIAL WEIGHT OF METAL PLATE (GMS)	LOSS OF WEIGHT (GMS)				REMARKS
		ANVLS NO.	TYPE	PARTS BY WT.	MAJOR COMPONENTS	COMPOSITION PARTS BY WT.		1ST 7 DAYS	2ND 7 DAYS	3RD 7 DAYS	4TH 7 DAYS	
7-28-48	9-13-48	1a	Rock Salt (NaCl)	5			19.8584	0.2549	0.1896			0.3045
		1b	"	"			19.8568	0.3541	0.1913			0.5454
		1c	"	"			20.1791	0.1337	0.0713			0.2050
		2a	Rock Salt	5	Sodium Chromate	100	20.2296	0.0432	0.1593			0.2025
		2b	"	"	"	"	19.9088	0.0281	0.0247			0.0528
		2c	"	"	"	"	19.6938	0.0336	0.1135			0.1471
		3a	Rock Salt	5	Sodium Chromate	100	19.7425	0.0301	0.0160			0.0461
		3b	"	"	"	"	19.6262	0.0223	0.0147			0.0370
		3c	"	"	"	"	19.5847	0.0378	0.0390			0.0768
		4a	Rock Salt	5	Sodium Chromate	100	19.4593	0.0243	0.0134			0.0382
		4b	"	"	"	"	19.9631	0.0326	0.0180			0.0506
		4c	"	"	"	"	18.9941	0.0357	0.0195			0.0552
		5a	Rock Salt	5	Sodium Dichromate	100	19.9008	0.0230	0.0156			0.0386
		5b	"	"	"	"	19.4251	0.0186	0.0094			0.0280
		5c	"	"	"	"	20.6514	0.0146	0.0138			0.0284
		6a	Rock Salt	5	Sodium Dichromate	100	20.6488	0.0254	0.0154			0.0408
		6b	"	"	"	"	19.7203	0.0231	0.0133			0.0364
		6c	"	"	"	"	19.9357	0.0209	0.0132			0.0341
		7a	Rock Salt	5	Sodium Dichromate	100	20.5670	0.0244	0.0125			0.0369
		7b	"	"	"	"	19.5632	0.0358	0.0125			0.0483
		7c	"	"	"	"	20.3569	0.0251	0.0124			0.0375
		8a	Rock Salt	5	Sodium Silicate	100	19.5582	0.1341	0.1301			0.2642
		8b	"	"	"	"	20.7849	0.0941	0.2188			0.3129
		8c	"	"	"	"	20.4966	0.1481	0.3100			0.4581
		9a	Rock Salt	5	Sodium Silicate	100	19.9380	0.0944	0.2582			0.3526
		9b	"	"	"	"	20.1778	0.0936	0.2738			0.3674
		9c	"	"	"	"	20.1018	0.1771	0.2243			0.3514
		10a	Rock Salt	5	Sodium Silicate	100	20.1300	0.0281	0.1804			0.2085
		10b	"	"	"	"	20.1107	0.0622	0.1540			0.2162
		10c	"	"	"	"	20.4456	0.0883	0.1790			0.1973

All tests in this series discontinued after 14 days.
Metal plates were hand-polished.
Continuously aerated and agitated.
Temperature = 75 ± 5°F.
Corrosion Cycle #1.

WEIGHT LOSS DATA - CORROSION TEST SERIES NO. 4

DATE		CORROSIVE SOLUTION			INHIBITOR MIXTURE				LOSS OF WEIGHT (GMS)					REMARKS		
START	END	ANLYS NO	TYPE *	PARTS BY WT	MAJOR COMPONENTS	COMPOSITION	PARTS BY WT	CONCENTRATION (% BY WT)	INITIAL WEIGHT OF METAL PLATE (GMS)	1ST 7 DAYS	2ND 7 DAYS	3RD 7 DAYS	4TH 7 DAYS		TOTAL	
8-24-48	9-23-48	1a	2	CaCl ₂ - MgCl ₂	60					20.1163	0.0089	0.0085	0.0279	0.0510	0.0963	* The corrosive medium for this series was a typical sample of surface from a gravel road, saturated with the solution indicated.
		1b	"	"	"	"	"	"	"	19.5184	0.0075	0.0107	0.0253	0.0452	0.0887	
		1c	"	"	"	"	"	"	"	20.6790	0.0099	0.0096	0.0292	0.0466	0.0953	
		2a	2	CaCl ₂ - MgCl ₂	60	Sodium Chromate	100	0.1	20.0802	0.0085	0.0067	0.0273	0.0444	0.0869	It was found that the inhibitor would not dissolve wt added to the highly concentrated brine. This was overcome by first dissolving the required amount of inhibitor in a few ml. of distilled water and then adding a solution to the brine. The dilution caused by the small amount of water was assumed negligible.	
		2b	"	"	"	"	"	"	"	20.6943	0.0075	0.0083	0.0291	0.0546		0.0995
		2c	"	"	"	"	"	"	"	20.2450	0.0112	0.0061	0.0253	0.0416		0.0842
		3a	2	CaCl ₂ - MgCl ₂	60	Sodium Chromate	100	0.2	19.6859	0.0037	0.0104	0.0274	0.0453	0.0868	Cycle used was 8 hrs. immersion in the mud and 16 hrs. exposure to air. A minus sign before a weight loss indicates that the plate showed a gain in weight for that period.	
		3b	"	"	"	"	"	"	"	19.7575	0.0002	0.0014	0.0234	0.0393		0.0643
		3c	"	"	"	"	"	"	"	20.6473	0.0023	0.0116	0.0312	0.0423		0.0874
		4a	2	CaCl ₂ - MgCl ₂	60	Sodium Chromate	100	0.3	20.1756	0.0016	0.0068	0.0305	0.0445	0.0834	Corrosion Cycle # 1.	
		4b	"	"	"	"	"	"	"	20.1574	0.0007	0.0030	0.0322	0.0371		0.0730
		4c	"	"	"	"	"	"	"	20.2513	0.0007	0.0048	0.0342	0.0422		0.0819
		5a	2	CaCl ₂ - MgCl ₂	60	Sodium Chromate	100	0.4	20.4820	0.0006	0.0052	0.0284	0.0373	0.0715	A minus sign before a weight loss indicates that the plate showed a gain in weight for that period.	
		5b	"	"	"	"	"	"	"	20.4040	0.0015	0.0071	0.0381	0.0527		0.0994
		5c	"	"	"	"	"	"	"	20.0949	0.0003	0.0038	0.0335	0.0507		0.0883
		6a	2	CaCl ₂ - MgCl ₂	60	Sodium Chromate	100	0.5	19.7282	0.0014	0.0016	0.0228	0.0316	0.0574	Corrosion Cycle # 1.	
		6b	"	"	"	"	"	"	"	19.4417	0.0006	0.0025	0.0268	0.0382		0.0681
		6c	"	"	"	"	"	"	"	19.4841	0.0002	0.0054	0.0202	0.0392		0.0650
		7a	2	CaCl ₂ - MgCl ₂	60	Sodium Dichromate	100	0.1	19.3924	0.0026	0.0076	0.0289	0.0228	0.0619	Corrosion Cycle # 1.	
		7b	"	"	"	"	"	"	"	19.3005	0.0051	0.0090	0.0301	0.0261		0.0703
		7c	"	"	"	"	"	"	"	20.1326	0.0014	0.0046	0.0387	0.0239		0.0686
		8a	2	CaCl ₂ - MgCl ₂	60	Sodium Dichromate	100	0.2	19.6253	-0.0001	0.0036	0.0288	0.0249	0.0572	Corrosion Cycle # 1.	
		8b	"	"	"	"	"	"	"	19.3129	0.0029	-0.0007	0.0337	0.0253		0.0612
		8c	"	"	"	"	"	"	"	19.5898	-0.0005	0.0047	0.0398	0.0352		0.0792
		9a	2	CaCl ₂ - MgCl ₂	60	Sodium Dichromate	100	0.3	19.7412	0.0005	0.0041	0.0244	0.0204	0.0494	Corrosion Cycle # 1.	
		9b	"	"	"	"	"	"	"	20.0086	-0.0005	0.0038	0.0264	0.0168		0.0465
		9c	"	"	"	"	"	"	"	20.6738	0.0020	0.0087	0.0330	0.0194		0.0631
		10a	2	CaCl ₂ - MgCl ₂	60	Sodium Dichromate	100	0.4	20.0627	0.0000	0.0073	0.0273	0.0175	0.0521	Corrosion Cycle # 1.	
		10b	"	"	"	"	"	"	"	19.3775	0.0003	0.0042	0.0276	0.0201		0.0522
		10c	"	"	"	"	"	"	"	20.3723	0.0017	0.0063	0.0286	0.0190		0.0555
		11a	2	CaCl ₂ - MgCl ₂	60	Sodium Dichromate	100	0.5	20.3624	0.0007	0.0028	0.0216	0.0186	0.0437	Corrosion Cycle # 1.	
		11b	"	"	"	"	"	"	"	19.7125	-0.0004	0.0084	0.0253	0.0138		0.0471
		11c	"	"	"	"	"	"	"	20.6091	-0.0020	0.0077	0.0364	0.0218		0.0639

WEIGHT LOSS DATA - CORROSION TEST SERIES NO. 5

DATE		CORROSIVE SOLUTION			INHIBITOR MIXTURE				INITIAL WEIGHT OF METAL PLATE (GMS)	LOSS OF WEIGHT (GMS)					REMARKS
START	END	ANAL. NO.	TYPE	PARTS BY WT	MAJOR COMPONENTS	PARTS BY WT	MINOR COMPONENTS	PARTS BY WT	CONCENTRATION (% BY WT)	1ST 7 DAYS	2ND 7 DAYS	3RD 7 DAYS	4TH 7 DAYS	TOTAL	
11-24-48	12-24-48														
1a		3	Distilled H ₂ O	100						0.2528	0.1379	0.2301	0.2236	0.8444	Continuously aerated and agitated. Metal plates were hand-polished. Temperature = 75 ± 5°F.
1b		"	"	"						0.0841	0.0888	0.1296	0.1839	0.4864	
1c		"	"	"						0.4454	0.3144	0.4884	0.3477	1.5959	
2a		3	CaCl ₂ - MgCl ₂	5						0.2050	0.2416	0.2045	0.1813	0.8324	Corrosion Cycle # 1
2b		"	"	"						0.2390	0.2496	0.2305	0.1878	0.9069	
2c		"	"	"						0.2050	0.2440	0.2163	0.1777	0.8430	
3a		3	CaCl ₂ - MgCl ₂	10						0.1857	0.2196	0.1946	0.1673	0.7672	
3b		"	"	"						0.1477	0.1573	0.1890	0.1499	0.6439	
3c		"	"	"						0.1472	0.1785	0.4485	0.2110	0.9852	
4a		3	CaCl ₂ - MgCl ₂	20						0.0626	0.0839	0.1073	0.0998	0.3536	
4b		"	"	"						0.0588	0.0773	0.0792	0.0711	0.2864	
4c		"	"	"						0.0649	0.0949	0.1124	0.0847	0.3569	
5a		3	CaCl ₂ - MgCl ₂	30						0.0270	0.0315	0.0358	0.0479	0.1422	
5b		"	"	"						0.0279	0.0328	0.0400	0.0327	0.1334	
5c		"	"	"						0.0269	0.0229	0.0374	0.0360	0.1232	
6a		3	CaCl ₂ - MgCl ₂	40						0.0020	0.0283	0.0181	0.0159	0.0643	
6b		"	"	"						0.0034	0.0187	0.0145	0.0087	0.0453	
6c		"	"	"						0.0021	0.0100	0.0126	0.0105	0.0352	

DATE STARTED	TEST SERIES NO.	SOLUTION	pH (BECKMAN)									
			2 days	5 days	7 days	11 days	13 days	16 days	18 days	22 days	24 days	
11-24-46	5											
	1a	6.94	7.55	7.19	8.02	7.95	7.00	7.31	7.18	6.79	6.58	
	1b	6.94	7.55	7.11	7.82	7.92	7.30	7.55	7.21	7.20	6.82	
	1c	6.94	7.14	7.82	7.51	6.72	6.88	7.10	7.18	6.76	6.58	
	2a	8.40	6.97	6.94	6.99	6.92	6.72	6.70	6.65	6.75	6.70	
	2b	8.40	7.00	6.90	6.92	6.90	6.80	6.81	6.72	6.79	6.71	
	2c	8.40	7.02	6.94	6.98	6.96	6.84	6.82	6.76	6.80	6.71	
	3a	8.92	6.94	6.80	6.80	6.72	6.60	6.70	6.71	6.69	6.71	
	3b	8.92	6.96	6.81	6.78	6.71	6.61	6.68	6.68	6.68	6.71	
	3c	8.92	7.04	6.82	6.81	6.72	6.62	6.69	6.74	6.70	6.73	
	4a	7.90	7.17	6.52	6.46	6.30	6.16	6.22	6.36	6.32	6.33	
	4b	7.90	7.23	6.60	6.49	6.28	6.10	6.31	6.40	6.37	6.24	
	4c	7.90	7.12	6.53	6.50	6.30	6.13	6.22	6.20	6.35	6.23	
	5a	7.70	7.28	6.50	6.32	6.02	5.91	6.02	5.95	6.00	5.96	
	5b	7.70	7.16	6.35	6.05	5.98	5.84	5.95	5.92	6.00	5.93	
	5c	7.70	7.25	6.48	6.28	6.00	5.82	5.92	5.93	6.00	5.93	
	6a	7.10	7.14	6.68	6.40	5.62	5.54	5.48	5.49	5.53	5.49	
	6b	7.10	7.21	6.88	6.45	5.70	5.61	5.50	5.32	5.34	5.39	
	6c	7.10	7.20	6.98	6.69	5.82	5.76	5.60	5.52	5.50	5.40	

WEIGHT LOSS DATA - CORROSION TEST SERIES NO. 6

DATE		CORROSIVE SOLUTION			INHIBITOR MIXTURE			LOSS OF WEIGHT (GMS.)					REMARKS			
START	END	ANAL. NO.	TYPE	PARTS BY WT.	MAJOR COMPONENTS	PARTS BY WT.	MINOR COMPONENTS	PARTS BY WT.	CONCENTRATION % BY WT.	INITIAL WEIGHT OF METAL PLATE (GMS.)	1ST 7 DAYS	2ND 7 DAYS		3RD 7 DAYS	4TH 7 DAYS	TOTAL
11-9-48	12-10-48	1a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	100		0.5	19.8046	0.0564	0.2396	0.5519	0.2239	1.0718	Continuously aerated and agitated. Temperatures: 75 ± 5° F.
		1b	3	"	5	"	"	"	0.5	19.7106	0.0484	0.0597	0.3507	0.2613	0.7191	
		1c	3	"	5	"	"	"	"	20.7231	0.0481	0.1356	0.4485	0.2454	0.8716	
		2a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	95	Hydroquinone	0.5	19.7889	0.0279	0.0148	0.1316	0.2199	0.3942	Metal plates were hand-polished. Corrosion Cycle # 1.
		2b	3	"	5	"	"	"	"	20.1850	0.0314	0.0197	0.1481	0.2302	0.4294	
		2c	3	"	5	"	"	"	"	19.7408	0.0291	0.0196	0.0672	0.2199	0.3358	
		3a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	90	Hydroquinone	0.5	19.7393	0.0238	0.0090	0.0074	0.0892	0.1294	
		3b	3	"	5	"	"	"	"	21.5375	0.0190	0.0052	0.0061	0.0053	0.0356	
		3c	3	"	5	"	"	"	"	20.1793	0.0047	0.0037	0.0036	0.0033	0.0153	
		4a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	80	Hydroquinone	0.5	20.2872	0.0178	0.0053	0.0067	0.0124	0.0422	
		4b	3	"	5	"	"	"	"	19.7371	0.0174	0.0059	0.0068	0.0056	0.0357	
		4c	3	"	5	"	"	"	"	20.5716	0.0065	0.0034	0.0044	0.0055	0.0198	
		5a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	70	Hydroquinone	0.5	19.7115	0.0295	0.0127	0.1382	0.1084	0.2888	
		5b	3	"	5	"	"	"	"	19.5925	0.0261	0.0083	0.0534	0.1590	0.2468	
		5c	3	"	5	"	"	"	"	19.5959	0.0066	0.0063	0.0011	0.0047	0.0187	
		6a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	50	Hydroquinone	0.5	19.7043	0.0240	0.0128	0.1801	0.1820	0.3989	
		6b	3	"	5	"	"	"	"	20.8180	0.0343	0.0590	0.2307	0.1968	0.5208	
		6c	3	"	5	"	"	"	"	20.5307	0.0105	0.0506	0.0888	0.1627	0.3226	
		7a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	30	Hydroquinone	0.5	19.7402	0.0118	0.0095	0.0934	0.1775	0.2922	
		7b	3	"	5	"	"	"	"	19.2771	0.0265	0.0075	0.0137	0.1540	0.2017	
		7c	3	"	5	"	"	"	"	19.9002	0.1214	0.3282	0.3008	0.2105	0.9609	
		8a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	10	Hydroquinone	0.5	19.4876	0.1810	0.2791	0.2317	0.1662	0.8580	
		8b	3	"	5	"	"	"	"	19.3857	0.1848	0.2635	0.2389	0.1776	0.8648	
		8c	3	"	5	"	"	"	"	19.2521	0.0929	0.2592	0.2036	0.1567	0.7124	
		9a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	100	Hydroquinone	0.5	19.4164	0.2418	0.2697	0.2039	0.2471	0.9625	
		9b	3	"	5	"	"	"	"	20.5305	0.2366	0.1869	0.1895	0.1383	0.7513	
		9c	3	"	5	"	"	"	"	20.5851	0.2067	0.1748	0.2157	0.2118	0.8090	
		10a	3	$\text{CaCl}_2 - \text{MgCl}_2$	20	Sodium Chromate	100		0.5	20.9661	0.0081	0.0072	0.0053	0.0080	0.0286	
		10b	3	"	20	"	"	"	"	20.3420	0.0158	0.0077	0.0109	0.0103	0.0447	
		10c	3	"	20	"	"	"	"	19.9503	0.0142	0.0085	0.0077	0.0103	0.0407	
		11a	3	$\text{CaCl}_2 - \text{MgCl}_2$	20	Sodium Chromate	95	Hydroquinone	0.5	19.4270	0.0155	0.0101	0.0089	0.0113	0.0458	
		11b	3	"	20	"	"	"	"	19.6782	0.0146	0.0124	0.0075	0.0120	0.0465	
		11c	3	"	20	"	"	"	"	20.1173	0.0230	0.0099	0.0095	0.0106	0.0530	
		12a	3	$\text{CaCl}_2 - \text{MgCl}_2$	20	Sodium Chromate	90	Hydroquinone	0.5	20.2357	0.0073	0.0040	0.0080	0.0044	0.0237	
		12b	3	"	20	"	"	"	"	20.1938	0.0144	0.0050	0.0059	0.0030	0.0283	
		12c	3	"	20	"	"	"	"	20.1906	0.0212	0.0073	0.0060	0.0047	0.0392	

WEIGHT LOSS DATA - CORROSION TEST SERIES NO. 6 (continued)

DATE		CORROSIVE SOLUTION		INHIBITOR MIXTURE				INITIAL WEIGHT OF METAL PLATE (GMS)	LOSS OF WEIGHT (GMS)				REMARKS		
START	END	ANAL. NO.	TYPE	PARTS BY WT	MAJOR COMPONENTS	PARTS BY WT	COMPOSITION	CONCENTRATION (% BY WT)	1ST 7 DAYS	2ND 7 DAYS	3RD 7 DAYS	4TH 7 DAYS	TOTAL		
11-9-48	12-10-48	13a	CaCl ₂ - MgCl ₂	20	Sodium Chromate	80	Hydroquinone	20	0.5	0.0266	0.0075	0.0102	0.0051	0.0494	See Previous Sheet.
		13b	"	20	"	"	"	"	"	0.0255	0.0072	0.0092	0.0049	0.0468	
		13c	"	20	"	"	"	"	"	0.0282	0.0102	0.0102	0.0035	0.0521	
		14a	CaCl ₂ - MgCl ₂	20	Sodium Chromate	70	Hydroquinone	30	0.5	0.0296	0.0100	0.0309	0.0636	0.1341	
		14b	"	20	"	"	"	"	"	0.0293	0.0090	0.0630	0.1151	0.2164	
		14c	"	20	"	"	"	"	"	0.0359	0.0070	0.0422	0.0781	0.1632	
		15a	CaCl ₂ - MgCl ₂	20	Sodium Chromate	50	Hydroquinone	50	0.5	0.0459	0.1707	0.1374	0.0975	0.4515	
		15b	"	20	"	"	"	"	"	0.0550	0.1661	0.1590	0.0643	0.4434	
		15c	"	20	"	"	"	"	"	0.0381	0.1386	0.1556	0.1254	0.4517	
		16a	CaCl ₂ - MgCl ₂	20	Sodium Chromate	30	Hydroquinone	70	0.5	0.1497	0.1812	0.2708	0.1417	0.7434	
		16b	"	20	"	"	"	"	"	0.1497	0.2103	0.1572	0.0776	0.5898	
		16c	"	20	"	"	"	"	"	0.0892	0.1800	0.1951	0.0734	0.5467	
		17a	CaCl ₂ - MgCl ₂	20	Sodium Chromate	10	Hydroquinone	90	0.5	0.1411	0.1471	0.1728	0.1200	0.5810	
		17b	"	20	"	"	"	"	"	0.1957	0.2129	0.1891	0.0850	0.6889	
		17c	"	20	"	"	"	"	"	0.1777	0.2095	0.2693	0.1629	0.8144	
		18a	CaCl ₂ - MgCl ₂	20	-----	-----	Hydroquinone	100	0.5	0.2390	0.2107	0.1358	0.1512	0.7367	
		18b	"	20	-----	-----	-----	-----	"	0.1667	0.1584	0.2316	0.2297	0.7864	
		18c	"	20	-----	-----	-----	-----	"	0.1127	0.2354	0.1790	0.2575	0.7866	

pH (BECKMAN)

DATE STARTED	TEST SERIES NO.	SPECIMAN NO.	SOLUTION	2 days	4 days	7 days	10 days	13 days	17 days	19 days	21 days	23 days	26 days	28 days
11-9-48	6	1a	8.25	7.10	7.00	6.81	6.85	6.86	6.84	6.84	6.84	6.84	6.84	6.84
		1b	8.25	7.10	6.98	6.91	6.91	6.91	6.91	6.91	6.91	6.91	6.91	6.91
		1c	8.25	7.09	6.95	6.85	6.91	6.80	6.82	6.82	6.82	6.82	6.82	6.82
		2a	8.48	7.10	7.11	7.49	7.50	7.50	6.89	6.89	6.89	6.89	6.89	6.89
		2b	8.48	7.26	7.20	7.50	7.50	7.50	6.90	6.90	6.90	6.90	6.90	6.90
		2c	8.48	7.18	7.20	7.51	7.52	7.52	6.95	6.95	6.95	6.95	6.95	6.95
		3a	8.98	7.42	7.38	7.31	7.21	7.11	7.09	7.09	7.04	7.04	6.80	6.78
		3b	8.98	7.38	7.40	7.38	7.32	7.29	7.31	7.29	7.29	7.29	7.20	7.16
		3c	8.98	7.43	7.46	7.40	7.40	7.38	7.41	7.41	7.40	7.40	7.41	7.32
		4a	8.93	7.51	7.51	7.42	7.42	7.40	7.40	7.40	7.41	7.41	7.28	7.19
		4b	8.93	7.48	7.47	7.40	7.38	7.35	7.40	7.40	7.40	7.40	7.30	7.25
		4c	8.93	7.42	7.48	7.40	7.41	7.39	7.41	7.41	7.42	7.42	7.41	7.31
		5a	9.00	7.48	7.51	7.41	7.30	7.28	6.99	6.99	7.05	6.98	6.98	6.93
		5b	9.00	7.50	7.48	7.40	7.38	7.32	7.22	7.22	7.20	7.00	7.00	6.93
		5c	9.00	7.43	7.50	7.40	7.42	7.40	7.45	7.45	7.45	7.45	7.45	7.40
		6a	9.08	7.44	7.49	7.45	7.45	7.40	6.98	6.98	7.08	6.92	6.92	7.05
		6b	9.08	7.43	7.49	7.42	7.05	7.02	7.00	6.98	6.98	6.92	6.92	6.82
		6c	9.08	7.40	7.44	7.39	7.41	7.40	7.38	7.38	7.18	7.02	7.02	6.85
		7a	8.90	7.31	7.36	7.30	7.30	7.26	7.29	7.29	7.20	6.98	6.98	6.86
		7b	8.90	7.39	7.52	7.46	7.39	7.35	7.35	7.35	7.30	7.00	7.00	6.91
		7c	8.90	7.38	7.42	7.08	7.00	6.92	6.90	6.90	6.88	6.82	6.82	6.82
		8a	8.88	7.22	7.20	6.88	6.91	6.88	6.80	6.80	6.88	6.74	6.74	6.59
		8b	8.88	7.24	7.21	6.90	6.90	6.82	6.72	6.72	6.58	6.59	6.59	6.56
		8c	8.88	7.20	7.19	7.05	6.92	6.82	6.90	6.90	6.72	6.72	6.72	6.61
		9a	8.38	7.00	6.96	6.68	7.01	6.85	6.42	6.42	6.42	6.99	6.72	6.70
		9b	8.38	7.00	7.00	6.75	6.98	6.90	6.36	6.36	6.36	6.88	6.89	6.82
		9c	8.38	7.00	7.02	6.75	7.00	6.95	6.32	6.32	6.32	6.90	6.80	6.80
		10a	7.88	6.89	6.89	6.49	6.80	6.70	6.25	6.25	6.25	6.79	6.85	6.62
		10b	7.88	7.21	7.21	6.51	6.84	6.78	6.40	6.40	6.40	6.90	6.99	6.86
		10c	7.88	7.11	7.11	6.92	7.30	7.30	6.76	6.76	6.76	7.14	7.20	6.95
		11a	8.00	7.11	7.11	7.00	7.40	7.41	7.00	7.00	7.00	7.55	7.62	7.30
		11b	8.00	7.32	7.32	6.91	7.30	7.31	6.98	6.98	6.98	7.40	7.52	7.30
		11c	8.00	7.00	7.00	6.69	7.00	7.00	6.60	6.60	6.60	7.10	7.20	6.98
		12a	8.20	6.91	6.56	6.50	6.50	6.42	6.55	6.55	6.55	6.55	6.50	6.43
		12b	8.20	6.98	6.88	6.69	6.49	6.45	6.60	6.60	6.50	6.52	6.52	6.49
		12c	8.20	6.90	6.84	6.62	6.52	6.49	6.66	6.66	6.60	6.60	6.60	6.49

pH (BECKMAN)

DATE STARTED	TEST SERIES NO.	SPECIMEN NO.	SOLUTION	2 days	4 days	7 days	10 days	13 days	17 days	19 days	21 days	23 days	26 days	28 days
11-9-48	6	13a	8.12	6.98	6.89	6.50	6.41	6.39	---	6.52	6.52	---	6.52	6.46
	(cont.)	13b	8.12	6.99	6.72	6.61	6.50	6.45	---	6.51	6.50	---	6.50	6.42
		13c	8.12	6.95	6.71	6.59	6.51	6.43	---	6.59	6.55	---	6.52	6.46
		14a	8.22	6.87	6.70	6.52	6.48	7.41	---	6.50	6.45	---	6.40	6.30
		14b	8.22	6.90	6.89	6.62	6.51	7.42	---	6.50	6.51	---	6.47	6.40
		14c	8.22	---	6.79	6.68	6.58	7.51	---	6.55	6.51	---	6.50	6.38
		15a	8.32	---	6.62	6.58	6.51	6.40	---	6.50	6.50	---	6.40	6.32
		15b	8.32	---	6.68	6.61	6.54	6.42	---	6.50	6.52	---	6.49	6.32
		15c	8.32	---	6.53	6.62	6.55	6.44	---	6.50	6.50	---	6.42	6.35
		16a	8.15	---	6.56	6.51	6.48	6.39	---	6.49	6.40	---	6.35	6.29
		16b	8.15	---	6.62	6.68	6.60	6.50	---	6.50	6.51	---	6.42	6.34
		16c	8.15	---	6.58	6.50	6.49	6.39	---	6.30	6.42	---	6.42	6.33
		17a	8.28	---	6.52	6.50	6.46	6.38	---	6.50	6.40	---	6.35	6.26
		17b	8.28	---	6.54	6.49	6.42	6.35	---	6.39	6.34	---	6.31	6.24
		17c	8.28	---	6.50	6.48	6.41	6.31	---	6.38	6.38	---	6.29	6.14
		18a	7.90	---	6.52	6.44	6.75	6.78	---	---	6.30	6.80	6.92	6.60
		18b	7.90	---	---	6.50	6.72	6.79	---	---	6.28	6.72	6.82	6.58
		18c	7.90	---	6.38	6.28	6.71	6.70	---	---	6.28	6.70	6.78	6.48

WEIGHT LOSS DATA - CORROSION TEST SERIES NO. 1

DATE		CORROSIVE SOLUTION			INHIBITOR MIXTURE				LOSS OF WEIGHT (GMS.)					REMARKS		
START	END	SPECIMEN NUMBER	ANALS. NO.	TYPE	PARTS BY WT	MAJOR COMPONENTS	COMPOSITION	PARTS BY WT	CONCENTRATION (% BY WT)	INITIAL WEIGHT OF METAL PLATES (GMS.)	1ST 7 DAYS	2ND 7 DAYS	3RD 7 DAYS		4TH 7 DAYS	TOTAL
12-6-48	1-3-49	1a	3	CaCl ₂ - MgCl	5					19.9930	0.0424	0.0505	0.1368	0.0374	0.2671	Temperature = 75 ± 5°F. Metal plates were hand-polished. No agitation. Alternate wetting and drying cycles 16 hrs. - immersion 2 hrs. - air exposure 4 hrs. - immersion 2 hrs. - air exposure Micromet was only slightly soluble in both CaCl ₂ and NaCl. Banox was only slightly soluble in CaCl ₂ . It was more soluble in NaCl. Calgon was very slightly soluble in CaCl ₂ , but was very easily dissolved in NaCl. Compare this series with series #8.
		1b	"	"	"	"				19.8417	0.0365	0.0463	0.1248	0.0415	0.2491	
		1c	"	"	"	"				19.1961	0.0354	0.0481	0.1281	0.0448	0.2564	
2a	2b	2c	3	Rock Salt	5					19.5952	0.0468	0.0460	0.1332	0.0455	0.2715	
			"	"	"	"	"			19.6911	0.0462	0.0470	0.1335	0.0458	0.2725	
			"	"	"	"	"			19.7656	0.0479	0.0503	0.1402	0.0431	0.2815	
3a	3b	3c	3	CaCl ₂ - MgCl	5	Banox	100		1.0	19.6563	0.0105	0.0492	0.1032	0.0533	0.2162	
			"	"	"	"	"		1.0	19.8747	0.0162	0.0528	0.1172	0.0510	0.2372	
			"	"	"	"	"		1.0	19.6848	0.0201	0.0589	0.1301	0.0521	0.2612	
4a	4b	4c	3	Rock Salt	5	Banox	100		1.0	19.8093	0.0104	0.0014	0.0215	0.0336	0.0669	
			"	"	"	"	"		1.0	19.6896	0.0128	0.0222	0.0779	0.0442	0.1571	
			"	"	"	"	"		1.0	20.1383	0.0151	0.0292	0.0794	0.0357	0.1594	
5a	5b	5c	3	CaCl ₂ - MgCl	5	Micromet	100		1.0	20.2787	0.0330	0.0499	0.1256	0.0442	0.2527	
			"	"	"	"	"		1.0	20.3193	0.0284	0.0425	0.1100	0.0363	0.2172	
			"	"	"	"	"		1.0	20.7297	0.0292	0.0397	0.1094	0.0395	0.2178	
6a	6b	6c	3	Rock Salt	5	Micromet	100		1.0	20.3957	0.0214	0.0062	0.0327	0.0049	0.0652	
			"	"	"	"	"		1.0	20.3130	0.0203	0.0058	0.0283	0.0084	0.0628	
			"	"	"	"	"		1.0	20.2584	0.0221	0.0056	0.0337	0.0166	0.0780	
7a	7b	7c	3	CaCl ₂ - MgCl	5	Calgon	100		1.0	20.4286	0.0349	0.0436	0.1279	0.0410	0.2494	
			"	"	"	"	"		1.0	20.3383	0.0241	0.0499	0.1197	0.0409	0.2346	
			"	"	"	"	"		1.0	20.1734	0.0256	0.0533	0.1309	0.0473	0.2611	
8a	8b	8c	3	Rock Salt	5	Calgon	100		1.0	20.9850	0.0104	0.0029	0.0180	0.0082	0.0395	
			"	"	"	"	"		1.0	21.5586	0.0080	0.0058	0.0184	0.0041	0.0363	
			"	"	"	"	"		1.0	21.6682	0.0105	0.0052	0.0208	0.0051	0.0416	

WEIGHT LOSS DATA - CORROSION TEST SERIES NO. 8

DATE		CORROSIVE SOLUTION			INHIBITOR MIXTURE					LOSS OF WEIGHT (GMS.)					REMARKS	
START	END	SPECIMEN NUMBER	ANLYS. NO.	TYPE	PARTS BY WT	MAJOR COMPONENTS	COMPOSITION		CONCENTRATION (% BY WT)	1ST 7 DAYS	2ND 7 DAYS	3RD 7 DAYS	4TH 7 DAYS	TOTAL		
12-7-48	1-4-49	1a	3	CaCl ₂ - MgCl ₂	5						0.1967	0.2414	0.2425	0.2128	0.8934	Continuously aerated and agitated. Temperature = 75 ± 5°. Metal plates were hand-polished. Micromet was only slightly soluble in both CaCl ₂ and MgCl ₂ . Banox was only slightly soluble in CaCl ₂ but was easily dissolved in NaCl. Compare this series with series #7. Include data from series #9 and #17 in any evaluation of phosphate inhibitors. Corrosion Cycle # 1.
		1b								0.2077	0.2779	0.3107	0.2311	1.0274		
		1c								0.1567	0.2620	0.2666	0.2497	0.9350		
		2a		Rock Salt	5					0.2888	0.4354	0.3327	0.1579	1.2148		
		2b								0.3099	0.3743	0.2350	0.1415	1.0607		
		2c								0.2250	0.3334	0.3946	0.1401	1.0931		
		3a	3	CaCl ₂ - MgCl ₂	5	Banox	100			0.5	0.1664	0.1392	0.3265	0.2299	0.8620	
		3b								0.5	0.1549	0.1710	0.2576	0.2121	0.7956	
		3c								0.5	0.1608	0.2016	0.2682	0.1902	0.8208	
		4a		Rock Salt	5	Banox	100			0.5	0.1928	0.3138	0.3335	0.2838	1.1239	
4b								0.5	0.1455	0.3304	0.3807	0.3828	1.2394			
4c								0.5	0.0513	0.3517	0.4180	0.3821	1.2031			
		5a	3	CaCl ₂ - MgCl ₂	5	Micromet	100			1.0	0.1607	0.1985	0.2432	0.2463	0.8487	Compare this series with series #7. Include data from series #9 and #17 in any evaluation of phosphate inhibitors. Corrosion Cycle # 1.
		5b							1.0	0.1279	0.2334	0.2339	0.2265	0.8217		
		5c							1.0	0.1634	0.1848	0.2268	0.2099	0.7849		
		6a		Rock Salt	5	Micromet	100			1.0	0.1548	0.2685	0.3284	0.2491	1.0008	
		6b							1.0	0.1226	0.2134	0.4266	0.3600	1.1226		
		6c							1.0	0.0738	0.2734	0.2848	0.2492	0.8312		
		7a	3	CaCl ₂ - MgCl ₂	5	Calgon	100			1.0	0.0909	0.1960	0.1943	0.1705	0.6517	
		7b							1.0	0.0665	0.1855	0.1888	0.1846	0.6254		
		7c							1.0	0.0977	0.1990	0.2092	0.1973	0.7032		
		8a		Rock Salt	5	Calgon	100			1.0	0.0151	0.0076	0.0066	0.0049	0.0342	
		8b							1.0	0.0171	0.0063	0.0073	0.0037	0.0344		
		8c							1.0	0.0148	0.0057	0.0061	0.0045	0.0311		
		9a	3	CaCl ₂ - MgCl ₂	5	Banox	100			1.0	(See page 10)	0.1876	0.1598	0.2090	0.5564	
		9b							1.0	0.2099	0.1878	0.2187	0.2187	0.6164		
		9c							1.0	0.2206	0.1258	0.1978	0.1978	0.5462		
		10a		Rock Salt	5	Banox	100			1.0	0.0194	0.2279	0.3308	0.3308	0.5675	
		10b							1.0	0.1827	0.1522	0.3419	0.3419	0.6768		
		10c							1.0	0.3762	0.1803	0.1803	0.1134	0.6699		

WEIGHT LOSS DATA - CORROSION TEST SERIES NO. 2

DATE	SPECIMEN NUMBER	CORROSIVE SOLUTION		INHIBITOR MIXTURE			INITIAL WEIGHT OF METAL PLATE (GMS)	LOSS OF WEIGHT (GMS.)					REMARKS
		ANVLS NO.	TYPE	PARTS BY WT.	MAJOR COMPONENTS	COMPOSITION		1ST. 7 DAYS	2 ND. 7 DAYS	3RD. 7 DAYS	4TH. 7 DAYS	TOTAL	
12-16-48	1a	3	CaCl ₂ - MgCl ₂	5	100	100	0.5	0.2836	0.1601	0.2040	0.2207	0.8684	Continuously aerated and agitated. Temperature = 75 ± 5°F. Metal plates were hand-polished. Minus sign indicates a gain in weight for that period. Include this data with data from series #8 and #17. Corrosion Cycle # 1.
	1b	"	"	"	"	"	0.5	0.2741	0.1548	0.2246	0.2339	0.8874	
	1c	"	"	"	"	"	0.5	0.2399	0.1721	0.2072	0.2441	0.8633	
	2a	3	CaCl ₂ - MgCl ₂	5	100	100	0.5	0.2824	0.1970	0.2312	0.2298	0.9404	
	2b	"	"	"	"	"	0.5	0.2919	0.1829	0.2552	0.2662	0.9962	
	2c	"	"	"	"	"	0.5	0.2969	0.1542	0.0963	0.2085	0.6533	
	3a	3	CaCl ₂ - MgCl ₂	5	100	100	0.5	0.2730	0.2257	0.1887	0.2105	0.8979	
	3b	"	"	"	"	"	0.5	0.4871	0.1488	0.4647	0.2147	1.3153	
	3c	"	"	"	"	"	0.5	0.4659	0.1793	0.2423	0.2114	1.0989	
	4a	3	CaCl ₂ - MgCl ₂	5	100	100	0.5	0.1983	0.1767	0.1849	0.2117	0.7716	
	4b	"	"	"	"	"	0.5	0.2661	0.1847	0.2497	0.2232	0.9237	
	4c	"	"	"	"	"	0.5	0.3132	0.1824	0.1668	0.2151	0.8775	
	5a	3	Rock Salt	5	100	100	0.5	0.5072	0.3829	0.4677	0.5180	1.8758	
	5b	"	"	"	"	"	0.5	0.6930	0.3704	0.4280	0.4507	1.9423	
	5c	"	"	"	"	"	0.5	0.0703	0.2780	0.3366	0.3970	1.0819	
	6a	3	Rock Salt	5	100	100	0.5	0.5976	0.3321	0.2780	0.2644	1.4721	
	6b	"	"	"	"	"	0.5	0.4510	0.4272	0.4481	0.3839	1.7102	
	6c	"	"	"	"	"	0.5	0.5079	0.3683	0.3842	0.4300	1.6904	
	7a	3	Rock Salt	5	100	100	0.5	0.0149	0.0068	0.0948	0.3483	0.4668	
	7b	"	"	"	"	"	0.5	0.0165	0.0048	0.0463	0.3078	0.3754	
	7c	"	"	"	"	"	0.5	0.0860	0.0046	0.0127	0.2719	0.3052	
	8a	3	Rock Salt	5	100	100	0.5	0.0150	0.0065	0.1291	0.3713	0.5219	
	8b	"	"	"	"	"	0.5	0.0148	0.0052	0.0667	0.2389	0.3196	
	8c	"	"	"	"	"	0.5	0.0139	0.0058	0.1068	0.2932	0.4177	

WEIGHT LOSS DATA - CORROSION TEST SERIES NO. 10

DATE		CORROSIVE SOLUTION			INHIBITOR MIXTURE				LOSS OF WEIGHT (GMS)				REMARKS				
START	END	SPECIMEN NUMBER	ANVLS NO.	TYPE	PARTS BY WT.	MAJOR COMPONENTS	PARTS BY WT.	MINOR COMPONENTS	PARTS BY WT.	CONCENTRATION (% BY WT.)	INITIAL WEIGHT OF METAL PLATE (GMS)	1ST 7 DAYS		2ND 7 DAYS	3RD 7 DAYS	4TH 7 DAYS	TOTAL
12-29-48	1-27-49	1a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	95	Quinone	5	0.5	19.9641	0.0087	0.0125	0.0098	0.0168	0.0478	Continuously aerated and agitated. Temperature: 75 $\pm$ 5° F. Metal plates were hand-polished. Corrosion Cycle # 1 Compare this data with series # 2.
		1b	"	"	"	"	"	"	"	"	20.0063	0.0036	0.0122	0.0114	0.0186	0.0458	
		1c	"	"	"	"	"	"	"	"	20.0924	0.0056	0.0126	0.0145	0.0193	0.0520	
		2a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	95	Quinone	5	1.0	20.1878	0.0046	0.0077	0.0081	0.0124	0.0328	
		2b	"	"	"	"	"	"	"	"	19.7684	0.0119	0.0096	0.0108	0.0141	0.0464	
		2c	"	"	"	"	"	"	"	"	19.3950	0.0110	0.0090	0.0090	0.0193	0.0483	
		3a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	95	Quinone	5	2.0	20.1224	0.0038	0.0070	0.0097	0.0112	0.0317	
		3b	"	"	"	"	"	"	"	"	20.1977	0.0054	0.0058	0.0066	0.0077	0.0255	
		3c	"	"	"	"	"	"	"	"	20.1733	0.0063	0.0069	0.0030	0.0098	0.0260	
		4a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	95	Quinhydrone	5	0.5	19.6302	0.0032	0.0093	0.0079	0.0193	0.0397	
		4b	"	"	"	"	"	"	"	"	20.2157	0.0032	0.0106	0.0087	0.0139	0.0364	
		4c	"	"	"	"	"	"	"	"	19.5712	0.0085	0.0101	0.0082	0.0164	0.0432	
		5a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	95	Quinhydrone	5	1.0	19.1235	0.0049	0.0099	0.0060	0.0155	0.0363	
		5b	"	"	"	"	"	"	"	"	19.1411	0.0047	0.0067	0.0145	0.0166	0.0425	
		5c	"	"	"	"	"	"	"	"	20.3206	0.0035	0.0058	0.0076	0.0106	0.0275	
		6a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	95	Quinhydrone	5	2.0	19.6051	0.0047	0.0083	0.0070	0.0108	0.0308	
		6b	"	"	"	"	"	"	"	"	20.5702	0.0036	0.0085	0.0092	0.0148	0.0361	
		6c	"	"	"	"	"	"	"	"	20.0631	0.0024	0.0075	0.0067	0.0107	0.0273	
		7a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Dichromate	95	Hydroquinone	5	0.5	19.9420	0.0046	0.0212	0.0142	0.0109	0.0509	
		7b	"	"	"	"	"	"	"	"	19.6826	0.0044	0.0184	0.0241	0.0181	0.0650	
		7c	"	"	"	"	"	"	"	"	20.1267	0.0027	0.0163	0.0180	0.0191	0.0561	
		8a	3	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Dichromate	95	Hydroquinone	5	1.0	19.5497	0.0027	0.0212	0.0266	0.0270	0.0775	
		8b	"	"	"	"	"	"	"	"	19.7481	0.0047	0.0233	0.0154	0.0217	0.0651	
		8c	"	"	"	"	"	"	"	"	20.0970	0.0041	0.0209	0.0186	0.0239	0.0675	

PH (BECKMAN)

DATE STARTED	TEST SERIES NO.	SPECIMEN NO.	SOLUTION	1 day	4 days	7 days	10 days	13 days	16 days	20 days	23 days
12-29-48	10	1a	8.90	7.38	7.24	7.09	7.41	7.20	7.18	7.10	7.08
		1b	8.90	7.42	7.29	7.39	7.31	7.20	7.20	7.04	7.09
		1c	8.90	7.38	7.25	7.40	7.29	7.15	7.20	7.00	7.00
		2a	8.80	7.58	7.14	7.50	7.48	7.41	7.45	7.30	7.28
		2b	8.80	7.46	7.32	7.45	7.42	7.35	7.38	7.19	7.23
		2c	8.80	7.55	7.45	7.51	7.50	7.40	7.42	7.20	7.24
		3a	9.00	7.58	7.45	7.50	7.51	7.50	7.52	7.43	7.42
		3b	9.00	7.53	7.42	7.49	7.52	7.43	7.49	7.39	7.40
		3c	9.00	7.60	7.48	7.54	7.55	7.47	7.50	7.40	7.40
		4a	9.02	7.55	7.40	7.46	7.45	7.28	7.30	7.10	7.09
		4b	9.02	7.43	7.32	7.43	7.40	7.22	7.28	7.06	7.06
		4c	9.02	7.51	7.39	7.56	7.60	7.25	7.32	7.08	7.11
		5a	9.00	7.52	7.40	7.50	7.48	7.45	7.39	7.22	7.24
		5b	9.00	7.55	7.50	7.55	7.68	7.55	7.51	7.34	7.40
		5c	9.00	7.52	7.45	7.51	7.50	7.44	7.49	7.32	7.41
		6a	8.95	7.56	7.46	7.55	7.55	7.49	7.52	7.49	7.41
		6b	8.95	7.55	7.43	7.51	7.52	7.50	7.52	7.45	7.44
		6c	8.95	7.54	7.41	7.49	7.49	7.41	7.48	7.41	7.42
		7a	8.12	7.23	7.02	7.31	7.20	7.10	7.12	7.00	7.02
		7b	8.12	7.14	7.06	7.32	7.18	7.15	7.16	7.00	7.02
		7c	8.12	7.14	7.03	7.40	7.12	7.14	7.14	7.00	7.00
		8a	8.08	7.13	7.05	7.33	7.31	7.21	7.16	7.01	7.00
		8b	8.08	7.16	7.08	7.35	7.20	7.11	7.18	7.00	7.00
		8c	8.08	7.12	7.01	7.32	7.22	7.16	7.16	7.00	7.00

WEIGHT LOSS DATA - CORROSION TEST SERIES NO. 11

DATE		CORROSIVE SOLUTION			INHIBITOR MIXTURE				LOSS OF WEIGHT (GMS.)					REMARKS			
START	END	ANLYS NO.	TYPE	PARTS BY WT.	MAJOR COMPONENTS	PARTS BY WT.	MINOR COMPONENTS	PARTS BY WT.	CONCENTRATION (% BY WT.)	INITIAL WEIGHT OF METAL PLATE (GMS.)	1ST 7 DAYS	2ND 7 DAYS	3RD 7 DAYS		4TH 7 DAYS	TOTAL	
1-17-49	2-14-49	1a	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	90	Hydroquinone	10	0.1	20.2665	0.2161	0.2406	0.6882	0.2508	1.3957	Continuously aerated and agitated. Temperature: 75 ± 5° F. Metal plates were hand-polished. Corrosion Cycle # 1.	
		1b	"	"	"	"	"	"	"	20.7719	0.2267	0.2750	0.7474	0.2664	1.5155		
		1c	"	"	"	"	"	"	"	20.3615	0.2187	0.2661	0.7179	0.2656	1.4683		
2a	2b	2c	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	90	Hydroquinone	10	0.5	20.8766	0.0482	0.0230	0.3348	0.2829	0.6889	Corrosion Cycle # 1.	
			"	"	"	"	"	"	"	"	19.1582	0.0421	0.1089	0.3781	0.2342		0.7633
			"	"	"	"	"	"	"	"	20.1520	0.0418	0.1930	0.4672	0.2831		0.9851
3a	3b	3c	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	90	Hydroquinone	10	1.0	20.9059	0.0340	0.0215	0.0665	0.0139	0.1359		
			"	"	"	"	"	"	"	"	19.6309	0.0271	0.0186	0.0565	0.0110		0.1132
			"	"	"	"	"	"	"	"	19.1956	0.0224	0.0131	0.0470	0.0138		0.0963
4a	4b	4c	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	90	Hydroquinone	10	1.5	19.7292	0.0200	0.0139	0.0434	0.0078	0.0851		
			"	"	"	"	"	"	"	"	21.5860	0.0249	0.0168	0.0524	0.0115		0.1056
			"	"	"	"	"	"	"	"	20.1781	0.0255	0.0198	0.0468	0.0135		0.0996
5a	5b	5c	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	90	Hydroquinone	10	2.0	19.8900	0.0224	0.0166	0.0493	0.0175	0.1058		
			"	"	"	"	"	"	"	"	19.7166	0.0230	0.0142	0.0490	0.0159		0.1021
			"	"	"	"	"	"	"	"	19.6610	0.0264	0.0164	0.0547	0.0183		0.1158
6a	6b	6c	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	90	Hydroquinone	10	2.5	21.2732	0.0221	0.0151	0.0478	0.0171	0.1021		
			"	"	"	"	"	"	"	"	19.9746	0.0216	0.0112	0.0469	0.0156		0.0953
			"	"	"	"	"	"	"	"	19.0113	0.0262	0.0130	0.0491	0.0116		0.0999
7a	7b	7c	$\text{CaCl}_2 - \text{MgCl}_2$	5	Sodium Chromate	90	Hydroquinone	10	3.0	19.5687	0.0270	0.0212	0.0608	0.0198	0.1288		
			"	"	"	"	"	"	"	"	19.4190	0.0263	0.0169	0.0522	0.0188		0.1142
			"	"	"	"	"	"	"	"	19.6023	0.0237	0.0165	0.0475	0.0197		0.1074

PH (BECKMAN)

DATE
STARTED

TEST
SERIES
NO.

SPECIMEN
NO.

SOLUTION

2 days

6 days

10 days

13 days

17 days

21 days

25 days

28 days

28 days

28 days

28 days

28 days

28 days

28 days

28 days

28 days

28 days

28 days

1-17-49

11

1a

8.21

6.99

6.80

6.78

6.85

6.80

6.72

6.80

6.90

6.85

6.89

6.90

6.84

6.85

6.80

6.80

6.80

6.80

1b

8.21

7.05

6.80

6.80

6.90

6.82

6.80

6.80

6.85

6.80

6.85

6.89

6.90

6.84

6.85

6.80

6.80

6.80

6.80

1c

8.21

7.02

6.80

6.80

6.91

6.86

6.80

6.80

6.85

6.80

6.85

6.89

6.90

6.84

6.85

6.80

6.80

6.80

6.80

2a

8.05

7.61

7.35

7.09

7.18

6.91

6.80

6.80

6.85

6.80

6.85

6.89

6.90

6.84

6.85

6.80

6.80

6.80

6.80

2b

8.05

7.65

7.11

6.99

6.94

6.88

6.80

6.80

6.85

6.80

6.85

6.89

6.90

6.84

6.85

6.80

6.80

6.80

6.80

2c

8.05

7.39

7.08

6.89

6.91

6.85

6.80

6.80

6.85

6.80

6.85

6.89

6.90

6.84

6.85

6.80

6.80

6.80

6.80

3a

8.00

7.50

7.35

7.22

7.18

7.24

7.39

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

3b

8.00

7.59

7.48

7.39

7.45

7.39

7.39

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

3c

8.00

7.52

7.41

7.36

7.45

7.38

7.38

7.30

7.30

7.30

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7.30

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7.30

7.30

7.30

4a

8.05

7.50

7.45

7.40

7.45

7.40

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7.30

7.30

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7.30

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7.30

7.30

7.30

7.30

4b

8.05

7.50

7.42

7.40

7.40

7.40

7.40

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

4c

8.05

7.51

7.48

7.38

7.45

7.40

7.40

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

5a

8.14

7.50

7.41

7.41

7.46

7.40

7.40

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

5b

8.14

7.58

7.42

7.41

7.50

7.48

7.48

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

7.30

5c

PH (BECKMAN)

DATE TEST SPECIMEN
STARTED SERIES NO

2-15-49 12

SOLUTION

3 days

7 days

11 days

14 days

21 days

23 days

25 days

28 days

1a 8.51 6.90 7.02 7.09 6.88 7.45 7.22 7.10

1b 8.51 6.99 7.25 7.22 6.98 7.48 7.40 7.20

1c 8.51 7.01 7.22 7.25 6.00 7.50 7.48 7.29

2a 8.48 7.18 7.21 7.29 7.00 7.48 7.49 7.30

2b 8.48 7.10 7.30 7.40 7.12 7.50 7.52 7.32

2c 8.48 7.09 7.31 7.38 7.01 7.49 7.48 7.29

3a 8.46 7.10 7.40 7.44 7.12 7.44 7.65 7.41

3b 8.46 7.10 7.39 7.42 7.10 7.52 7.58 7.35

3c 8.46 7.09 7.40 7.48 7.09 7.48 7.50 7.25

4a 8.49 7.18 7.49 7.52 7.20 7.69 7.70 7.50

4b 8.49 7.19 7.44 7.50 7.12 7.59 7.61 7.40

4c 8.49 7.10 7.42 7.50 7.15 7.60 7.62 7.50

5a 8.50 7.16 7.58 7.49 7.10 7.60 7.62 7.48

5b 8.50 7.21 7.52 7.61 7.20 7.71 7.69 7.49

5c 8.50 7.49 7.60 7.58 7.30 7.70 7.51 7.51

6a 8.48 7.21 7.49 7.50 7.20 7.61 7.61 7.50

6b 8.48 7.12 7.45 7.44 7.18 7.68 7.68 7.48

6c 8.48 7.11 7.42 7.42 7.18 7.51 7.62 7.42

7a 8.50 7.30 7.54 7.58 7.11 7.72 7.78 7.52

7b 8.50 7.28 7.56 7.58 7.10 7.70 7.80 7.51

7c 8.50 7.18 7.50 7.60 7.09 7.82 7.80 7.49

WEIGHT LOSS DATA - CORROSION TEST SERIES NO. 13

DATE	SPECIMEN NUMBER	CORROSIVE SOLUTION		INHIBITOR MIXTURE				INITIAL WEIGHT OF METAL PLATE (GMS)	LOSS OF WEIGHT (GMS)				REMARKS
		ANVLS NO.	TYPE	PARTS BY WT.	MAJOR COMPONENTS	PARTS BY WT.	MINOR COMPONENTS		1ST 7 DAYS	2ND 7 DAYS	3RD 7 DAYS	4TH 7 DAYS	
3-17-49	3-31-49		Distilled H ₂ O	100				17.2356	0.0923	0.0923	0.0923	0.0923	All specimens in this series were refluxed to remove dissolved O ₂ and kept in sealed jars with no agitation.
	1a		"	"				18.1458	0.0832	0.0832	0.0832	0.0832	
	1b		"	"				18.6278	0.0800	0.0800	0.0800	0.0800	
	2a		CaCl ₂ - MgCl ₂	1				18.3530	0.0757	0.0757	0.0757	0.0757	
	2b		"	"				18.4134	0.0684	0.0684	0.0684	0.0684	
	2c		"	"				17.4103	0.0623	0.0623	0.0623	0.0623	
	3a		CaCl ₂ - MgCl ₂	5				16.4743	0.0344	0.0344	0.0344	0.0344	
	3b		"	"				17.3382	0.0273	0.0273	0.0273	0.0273	
	3c		"	"				18.0703	0.0414	0.0414	0.0414	0.0414	
	4a		CaCl ₂ - MgCl ₂	20				18.2829	0.0135	0.0135	0.0135	0.0135	
	4b		"	"				18.7192	0.0108	0.0108	0.0108	0.0108	
	4c		"	"				17.3853	0.0108	0.0108	0.0108	0.0108	
	5a		CaCl ₂ - MgCl ₂	30				18.3668	0.0067	0.0067	0.0067	0.0067	
	5b		"	"				19.2098	0.0059	0.0059	0.0059	0.0059	
	5c		"	"				18.0557	0.0060	0.0060	0.0060	0.0060	
	6a		Rock Salt	1				18.3643	0.0691	0.0691	0.0691	0.0691	
	6b		"	"				17.3014	0.0668	0.0668	0.0668	0.0668	
	6c		"	"				18.4734	0.0534	0.0534	0.0534	0.0534	
	7a		Rock Salt	5				17.2872	0.0370	0.0370	0.0370	0.0370	
	7b		"	"				17.3278	0.0404	0.0404	0.0404	0.0404	
	7c		"	"				17.1173	0.0259	0.0259	0.0259	0.0259	
	8a		Rock Salt	20				17.9475	0.0155	0.0155	0.0155	0.0155	
	8b		"	"				18.0191	0.0067	0.0067	0.0067	0.0067	
	8c		"	"				18.1411	0.0103	0.0103	0.0103	0.0103	
	9a		Rock Salt	30				17.2454	0.0083	0.0083	0.0083	0.0083	
	9b		"	"				17.7193	0.0084	0.0084	0.0084	0.0084	
	9c		"	"				18.1240	0.0033	0.0033	0.0033	0.0033	

WEIGHT LOSS DATA - CORROSION TEST SERIES NO. 24

DATE		CORROSIVE SOLUTION		INHIBITOR MIXTURE				LOSS OF WEIGHT (GMS)				REMARKS				
START	END	ANVLS. NO	TYPE	PARTS BY WT	COMPOSITION	MAJOR COMPONENTS	PARTS BY WT	CONCENTRATION BY WT	INITIAL WEIGHT OF METAL PLATE (GMS)	1ST 7 DAYS	2ND 7 DAYS		3RD 7 DAYS	4TH 7 DAYS	TOTAL	
4-6-49	4-30-49	1a	Distilled H ₂ O	100					15.8836		.0437				.0437	All specimens in this series were continuously aerated and agitated.
		1b	"	"					17.6432		.0203				.0203	
		1c	"	"					17.9679		.0396				.0396	
		2a	CaCl ₂ - MgCl ₂	1					17.4126		.3623				.3623	All specimens in this series were maintained at a temperature of 35 ± 1° F. Metal plates were sand-blasted. Corrosion Cycle # 1.
		2b	"	"					18.3137		.3484				.3484	
		2c	"	"					17.7918		.3204				.3204	
		3a	CaCl ₂ - MgCl ₂	5					16.8330		.2415				.2415	
		3b	"	"					18.1515		.2961				.2961	
		3c	"	"					16.9379		.2277				.2277	
		4a	CaCl ₂ - MgCl ₂	20					17.4631		.0610				.0610	
		4b	"	"					17.0460		.0520				.0520	
		4c	"	"					18.9494		.0487				.0487	
		5a	CaCl ₂ - MgCl ₂	30					17.6603		.0259				.0259	
		5b	"	"					18.5515		.0357				.0357	
		5c	"	"					18.3229		.0286				.0286	
		6a	Distilled H ₂ O	100					17.6219		.2486				.2486	
		6b	"	"					17.5940		.3368				.3368	
		6c	"	"					17.8290		.3525				.3525	
3-17-49	3-31-49	7a	Rock Salt	1					18.4467		.3870				.3870	
		7b	"	"					18.1816		.4001				.4001	
		7c	"	"					17.6573		.3927				.3927	
		8a	"	5					17.2533		.2591				.2591	
		8b	"	"					19.0033		.3880				.3880	
		8c	"	"					17.5573		.2709				.2709	
		9a	Rock Salt	20					18.6523		.1532				.1532	
		9b	"	"					18.9317		.1680				.1680	
		9c	"	"					17.5945		.1239				.1239	
		10a	Rock Salt	30					18.3107		.0564				.0564	
		10b	"	"					17.7318		.0487				.0487	
		10c	"	"					18.6368		.0478				.0478	

WEIGHT LOSS DATA - CORROSION TEST SERIES NO. 15

DATE		CORROSIVE SOLUTION			INHIBITOR MIXTURE					INITIAL WEIGHT OF METAL PLATE (GMS)	LOSS OF WEIGHT (GMS)				REMARKS
START	END	ANVLS NO.	TYPE	PARTS BY WT	MAJOR COMPONENTS	PARTS BY WT	MINOR COMPONENTS	PARTS BY WT	CONCENTRATION % BY WT	1ST 7 DAYS	2ND 7 DAYS	3RD 7 DAYS	4TH 7 DAYS	TOTAL	
3-24-49	4-6-49	1a	Distilled H ₂ O	100						18.2754	0.6238			0.6238	All specimens in this series were continuously aerated and agitated.
		1b	"	"						0.6721				0.6721	
		1c	"	"	"						0.5325				
		2a	CaCl ₂ - MgCl ₂	1						19.3927	0.3634			0.3634	All specimens in this series were maintained at a temperature of 75 ± 5° P.
		2b	"	"						0.3986				0.3986	
		2c	"	"	"					0.3937					
		3a	CaCl ₂ - MgCl ₂	5						17.5655	0.6083			0.6083	Metal plates were sand-blasted.
		3b	"	"						0.5532				0.5532	
		3c	"	"	"					0.5765					
		4a	CaCl ₂ - MgCl ₂	20						18.1500	0.1613			0.1613	Corrosion Cycle # 3.
		4b	"	"						0.1643				0.1643	
		4c	"	"	"					0.1684					
		5a	CaCl ₂ - MgCl ₂	30						18.6224	0.0546			0.0546	
		5b	"	"						0.0627				0.0627	
		5c	"	"	"					0.0646					
		6a	Distilled H ₂ O	100						13.5559	0.7148			0.7148	
		6b	"	"						0.5214				0.5214	
		6c	"	"	"					0.4822					
		7a	Rock Salt	1						18.0321	0.6876			0.6876	
		7b	"	"						0.7661				0.7661	
		7c	"	"	"					0.7631					
		8a	Rock Salt	5						18.0844	0.4459			0.4459	
		8b	"	"						0.6493				0.6493	
		8c	"	"	"					0.4438					
		9a	Rock Salt	20						18.2175	0.2031			0.2031	
		9b	"	"						0.2248				0.2248	
		9c	"	"	"					0.1807					
		10a	Rock Salt	30						18.0881	0.1063			0.1063	
		10b	"	"						0.0665				0.0665	
		10c	"	"	"					0.0623					

WEIGHT LOSS DATA - CORROSION TEST SERIES NO. 16

DATE	START	END	SPECIMEN NUMBER	CORROSIVE SOLUTION		INHIBITOR MIXTURE			INITIAL WEIGHT OF METAL PLATE (GMS)	LOSS OF WEIGHT (GMS)				REMARKS
				ANVLS NO.	TYPE	PARTS BY WT	MAJOR COMPONENTS	COMPOSITION		1ST 7 DAYS	2ND 7 DAYS	3RD 7 DAYS	4TH 7 DAYS	
4-8-49		4-22-49	1a		Distilled H ₂ O	100			17.1156					All specimens in this series were refluxed to remove dissolved O ₂ and kept in sealed jars with no agitation.
			1b		"	"			19.0250	0.0632				
			1c		"	"			16.8532	0.0622	0.0560			
			2a		CaCl ₂ - MgCl ₂	1			18.6083	0.0743				All specimens in this series were maintained at a temperature of 75 ± 5° F. Metal plates were sand-blasted. Corrosion Cycle # 3.
			2b		"	"			17.4991	0.0663				
			2c		"	"			16.6664	0.0954				
			3a		CaCl ₂ - MgCl ₂	5			17.5746	0.0988				
			3b		"	"			17.5386	0.0551				
			3c		"	"			16.0519	0.0519				
			4a		CaCl ₂ - MgCl ₂	20			17.5505	0.0241				
			4b		"	"			17.7318	0.0169				
			4c		"	"			17.5922	0.0111				
			5a		CaCl ₂ - MgCl ₂	30			17.5041	0.0043				
			5b		"	"			16.0409	0.0146				
			5c		"	"			18.6214	0.0072				
			6a		Distilled H ₂ O	100			16.6584	0.0856				
			6b		"	"			16.6115	0.0660				
			6c		"	"			18.5261	0.0529				
			7a		Rock Salt	1			17.1248	0.0661				
			7b		"	"			15.3864	0.0531				
			7c		"	"			17.3852	0.0502				
			8a		Rock Salt	5			17.6362	0.0164				
			8b		"	"			17.4166	0.0345				
			8c		"	"			17.0414	0.0374				
			9a		Rock Salt	20			17.5045	0.0138				
			9b		"	"			18.6965	0.0151				
			9c		"	"			16.0771	0.0173				
			10a		Rock Salt	30			16.8926	0.0075				
			10b		"	"			17.1162	0.0037				
			10c		"	"			16.8661	0.0054				

TABLE 17

pH (BECKMAN)								
Specimen	Series 13		Series 14		Series 15		Series 16	
No.	Initial	14 days	Initial	14 days	Initial	14 days	Initial	14 days
1a	6.60	7.58	6.62	7.28	7.00	7.05	7.00	7.70
1b	7.00	7.43	7.00	7.30	6.79	7.10	6.80	7.58
1c	6.70	7.35	6.80	7.30	6.62	7.58	6.72	7.52
2a	8.40	7.31	8.40	6.25	8.40	6.90	8.40	8.22
2b	8.40	7.20	8.40	6.79	8.40	6.99	8.40	8.41
2c	8.40	8.04	8.40	6.82	8.40	6.93	8.40	7.00
3a	8.10	8.40	8.10	7.70	8.10	6.20	8.10	7.46
3b	8.10	8.33	8.10	7.72	8.10	5.97	8.10	8.68
3c	8.10	8.15	8.10	7.02	8.10	5.87	8.10	8.59
4a	7.90	7.70	7.90	6.80	7.90	6.44	7.90	8.09
4b	7.90	7.95	7.90	6.48	7.90	6.40	7.90	8.08
4c	7.90	7.90	7.90	7.72	7.90	6.42	7.90	8.09
5a	7.70	7.60	7.70	6.69	7.70	6.18	7.70	7.59
5b	7.70	7.69	7.70	6.68	7.70	6.14	7.70	8.01
5c	7.70	7.66	7.70	6.64	7.70	6.14	7.70	7.80
6a	7.30	8.12	7.10	7.45	7.35	7.18	7.20	8.15
6b	7.30	7.48	7.30	7.50	7.10	7.04	7.10	8.20
6c	7.30	7.30	7.20	7.64	7.15	7.03	7.00	7.99
7a	7.25	7.19	7.30	7.19	7.30	7.03	7.30	9.00
7b	7.25	6.98	7.30	7.32	7.30	7.00	7.30	9.30
7c	7.25	7.00	7.30	7.32	7.30	7.00	7.30	9.10
8a	7.45	6.63	7.25	7.49	7.25	6.72	7.25	8.42
8b	7.45	6.65	7.25	7.30	7.25	6.43	7.25	9.19
8c	7.45	6.50	7.25	7.12	7.25	6.66	7.25	9.32
9a	7.60	6.35	7.45	7.02	7.45	6.04	7.45	9.50
9b	7.60	6.25	7.45	6.90	7.45	6.10	7.45	9.20
9c	7.60	6.98	7.45	6.84	7.45	6.35	7.45	9.32
10a			7.60	7.42	7.60	7.11	7.60	6.98
10b			7.60	7.58	7.60	7.00	7.60	7.58
10c			7.60	7.50	7.60	6.97	7.60	7.98

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