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*Corrosion and Tuberculation  
of Cast Iron, Fourth Report*

BY

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## Current Research on Corrosion and Tuberculation of Cast Iron

—Thurston E. Larson and R. V. Skold—

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THE objective of this research is to study the effects of mineral content on the corrosion and tuberculation of cast iron pipe with specific reference to loss in carrying capacity through tuberculation. Space does not permit a review of the previous research (1-3) reported on this project. This report will present only a brief summary of the more significant findings in the past year.

### Fresh Cast-Iron Surface

The freshly cast, unground, interior surface of cast-iron pipe has been found to have a high resistance to corrosion by water (1). In order to determine the composition of this surface, a specimen was submitted to W. H. Bruckner of the University of Illinois Department of Metallurgy. Figure 1 shows a microphotograph (50 $\times$ ) of an unetched mount. Two layers are present on the surface.

When the surface was scraped off of the interior of the cast iron, the black phase (between the metal surface and the gray phase) was found to be ferromagnetic magnetite ( $\text{Fe}_3\text{O}_4$ ) with a cubical structure. The gray

phase on the internal, exposed surface (adjacent primarily to the magnetite) showed two or more components under polarized light: [1] long, needle-like pyroxenes of monoclinic structure, such as  $\text{CaSiO}_3$ , or  $\text{FeSiO}_3$ ; and [2] polyhedron garnets of cubical structure, such as  $\text{Ca}_3\text{Al}_2(\text{SiO}_4)_2$  or  $\text{Fe}_3\text{Al}_2(\text{SiO}_4)_2$ . This silicate "skin" is apparently responsible for the excellent resistance to corrosion by water. It is, however, quite brittle and therefore only of academic interest.

### Present Studies

One laboratory study, still in progress, is being conducted to show the effect of pH on the corrosion rates of cast iron at a flow rate of 0.1 fps for a particular zero hardness water having an alkalinity of 125 ppm and a chlorine-alkalinity (Cl/alk) ratio of 0.2. Corrosion rates are given in milligrams per square decimeter per day (mdd). The results shown in Fig. 2 are similar to those obtained for steel specimens (1) in that the lowest average corrosion rate occurs at pH 7.0. Severe local pitting was noted at the edge of the paraffin coating over the edges.

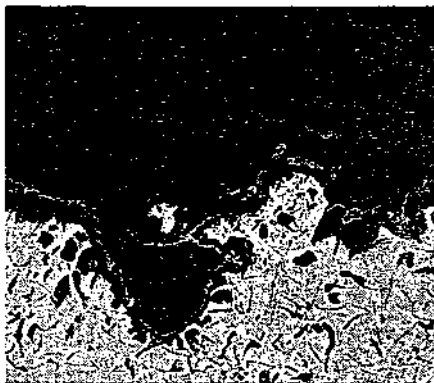


Fig. 1. Microphotograph of an Unetched Mount of Cast Iron

The outer, dark edge of the sample is composed of silicates and aluminosilicates; the intermediate, gray stage is composed of magnetite; and the inner, light-gray stage is the actual ferrite. This microphotograph was taken at 50 $\times$ .

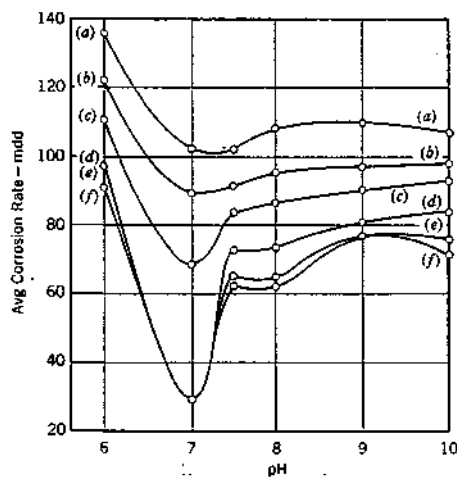


Fig. 2. Relationship of Corrosion Rate to pH

Curves a, b, c, d, e, and f represent corrosion rates at periods of 1, 10, 20, 50, 100, and 150 days, respectively, at the indicated pH.

Tuberculation on the machined cast-iron surface increased with increasing pH in the range 7.5-9. The corrosion products at pH 7 appear to be effectively resistant to the diffusion of dissolved oxygen.

Another test, designed to determine the relative influence of sulfate and chloride ions on tuberculation, showed no significant difference with regard to corrosion rate or tuberculation in concentrations up to 30 ppm sulfate and 3-25 ppm chloride with water of an 85-ppm calcium hardness, a 120-ppm alkalinity, and 0.29 (Cl + SO<sub>4</sub>)/alk ratio at saturation indexes of -0.8, -0.3, and 0.0.

Another study has been made to discover the effect of the Cl/alk ratio on the corrosion of machined cast iron in waters with an alkalinity of 125 ppm at calcium concentrations of 30 ppm and 85 ppm. The pH was regulated

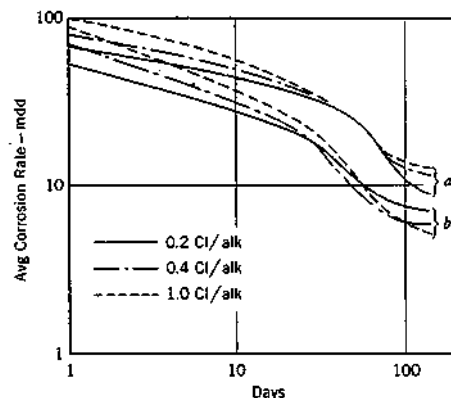


Fig. 3. Decrease in Average Corrosion Rate With Time

The curves of Group a represent runs with 0.6 epm Ca at pH 8.2; those of Group b represent runs with 1.7 epm Ca at pH 7.8. For all runs the saturation index was 0.0, linear velocity was 0.8 fps, and alkalinity was 2.4 epm.

to maintain a zero saturation index. The corrosion rates for this study are shown in Fig. 3. It can be seen that the relationship of increased corrosion rate to increased Cl/alk ratio is minimized within 30 days when the water is stabilized with  $\text{CaCO}_3$ . The beneficial effect of higher calcium hardness is shown even though the pH is lower.

**New Test Chambers**

A newly designed corrosion test chamber, which is being evaluated for

use both as a laboratory and field device, is shown in Fig. 4. This particular chamber has six cast-iron specimens, two in each of the three sections defined by the water flow outlets. The test chamber itself is made of clear lucite and the water flow channel is 0.4 X 1.4 in. in cross section. The calomel and platinum electrodes serve to measure relative corrosion rates (4). The three outlets provide means for testing the effects of water flow velocity. This corrosion test chamber

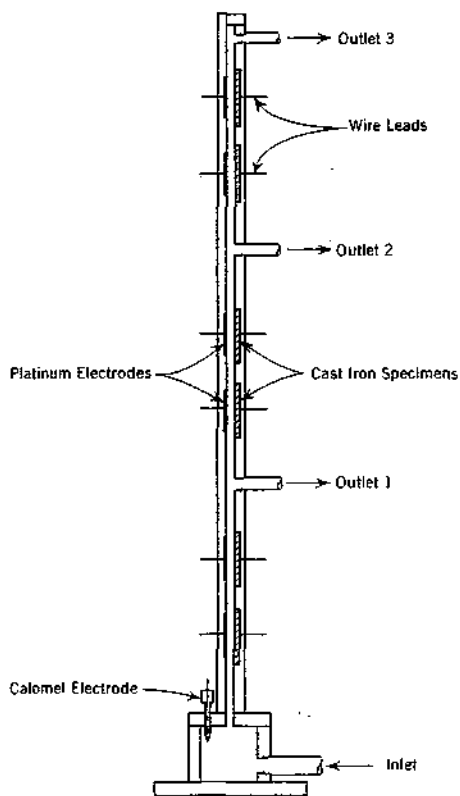


Fig. 4. Corrosion Test Chamber

The calomel and platinum electrodes permit measurements of relative corrosion rates; the outlets provide a means for testing the effect of flow velocity.

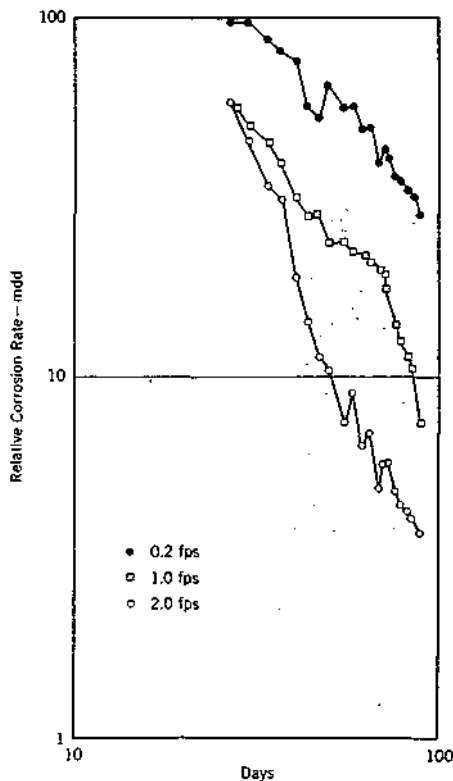


Fig. 5. Effect of Water Flow Velocity on Corrosion Rate

The three curves represent relative corrosion rates with Champaign-Urbana tap water over a period of 85 days at the indicated flow velocities.

may have many applications, particularly at water plants, where a continuous test of the corrosive nature of the water used is desirable. Figure 5 shows the results with Champaign-Urbana tap water for a period of 85 days during which this test chamber was used.

Another project under way is a study of the behavior of particular ions in water at the anode and cathode of a corrosion cell. For this study, a nine-compartment cell (5), which has anode and cathode plates in the two end compartments, is being used. The water being tested flows continuously through the middle cell. A current is impressed between the two electrodes during the test. The results of this study, which is concerned with electrode reactions and ion migration, are promising and will be reported when sufficient data permit a proper evaluation.

### Acknowledgment

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