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HW-21079

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May 10, 1951

To: File

From: R. M. Fryar

TRIP REPORT - ALCOA RESEARCH LABORATORIES

This memorandum outlines the information obtained on a technical consultation trip to the Alcoa Research Laboratories in New Kennsington, Pennsylvania, during the period April 29 to May 4, 1951. The information was gained by personal contact with Mr. R. H. Brown and his staff. The staff members who supplied the majority of information were Messrs. W. W. Binger, J. S. Hamilton and R. Williams. The principle information will be considered by subject matter and discussed separately.

I. THE EFFECT OF pH ON ALUMINUM CORROSION

On the basis of research work done at the Alcoa Laboratory over a two-year period, with a great number of different impurities in water, there appears to be no optimum pH value for aluminum corrosion. However, in general, there does appear to be an optimum range of pH values which will give minimum corrosion for a given type of water. This range of pH values is from about 4.5 to 8.5. The end value may vary slightly for different impurities present in the water. The most noticeable variation from the above rule was observed when fluorine compounds were present in the water. It appears that the pH is relatively unimportant in comparison to the type and amount of foreign ions present in the water.

II. THE EFFECT OF TURBULENCE ON ALUMINUM CORROSION

On the basis of the thesis work done by R. H. Brown at the M.I.T., it was established that a definite relationship exists between the corrosion rate and corrosion distribution for steel and the turbulence of the water.

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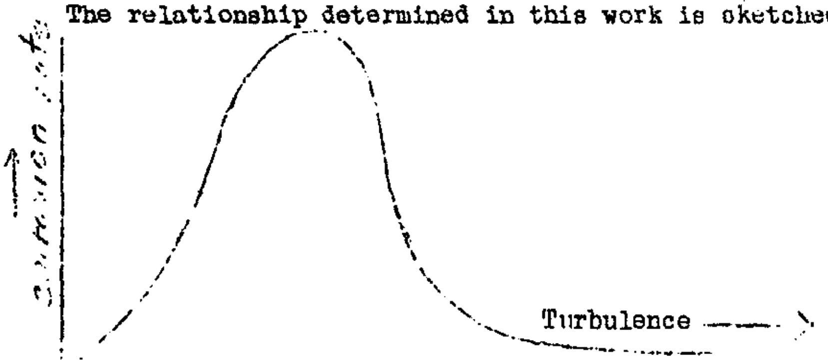
The relationship determined in this work is sketched below:



Note: The shape of the curve for very high turbulence is not known.

The Alcoa Laboratories are now investigating this same relationship for aluminum, and preliminary information indicates that the same type of curve will probably hold for this metal. This may explain, to some extent, the front tube corrosion present in the Hanford Piles, since in the tube entrance, when there is no dummy pattern, the velocity and Reynolds number are low. Thus, since the Reynolds number is a measure of turbulence, this section of the tube could be operating near the peak of the above curve.

III. THE INFLUENCE OF HEAVY METALS ON CORROSION

The metals lead, copper, nickle, cobalt, tin and mercury accelerate the corrosion rate of aluminum. Since chemical analysis of the film which forms on the flow surfaces of the process tubes of the Hanford Piles indicates there is about 3.9 per cent by weight of lead, this element could be contributing to the corrosion rate.

Mercury is extremely capable of corroding aluminum. Even minute traces of colloidal mercury have produced very large aluminum corrosion rates in industrial installations. The mercury can enter the system as unsuspected traces in the process materials or by leakage from mercury instruments.

IV. A NEW INHIBITER FOR ALUMINUM CORROSION

Research work done by the Alcoa Laboratories indicates they have discovered a new inhibiter which appears to be far superior to chromates. Work in both beaker type experiments and in flowing systems under severe corrosion conditions, demonstrates the value of nitrates as a corrosion inhibiter for aluminum.

V. CHROMATES AS ALUMINUM CORROSION INHIBITERS

In general, Alcoa recommends the addition of at least 1/8 of an ounce of dichromates per gallon of water or roughly 1,000 ppm, for effective corrosion inhibition. There is no evidence that chromates can produce a lasting reversal of the polarity relationships between two aluminum allows exposed to a water containing chromates. It is possible that temporary and variable changes in the polarity can occur if chromates are present. This effect is independent of the chromate concentration and can occur at either high or low concentrations. Low chromate concentrations appear to have no effect on the corrosion rate.

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VI. ELECTRICAL POTENTIAL DIFFERENCES DUE TO DIFFERENCE IN SURFACE TEMPERATURES

Normally 72S alloy-clad aluminum has higher electrical potential than 3S alloy aluminum. In a demonstration performed at the Alcoa Laboratories in which two tubes, one of 3S and one of 72S clad were submerged in tap water, it was found that the potential of the 3S was about 70 mv below the 72S clad. When atmospheric steam was introduced into the 3S tube and tap water into the 72S clad tube, the potential of the 3S was about 280 mv above that of the 72S clad. It was further found that as the temperature of the bulk water increased the potential difference increased.

Since 2S and 3S aluminum alloys are quite similar, this demonstration could explain the corrosion rate observed at the active section of the Hanford Process.

VII. THE CORROSION PROBLEM IN THE HANFORD PROCESS TUBES

It is the opinion of the staff of the Alcoa Research Laboratory, that the corrosion problem of the process tubes is a combination of two different corrosion problems. First the problem of front tube corrosion, and second, the problem of the active section slug corrosion.

The front tube corrosion is probably due to the low turbulence of the water, the lack of electrical shielding against the electrical potential differences between the nozzle, slugs and the 72S clad tube, the presence of corrosion-causing compounds, or a combination of these effects. The corrosion-causing compound could very probably be lead chromate, which is insoluble and settles out due to the low turbulence and thus causes a pitting type of attack.

The problem of the active section slug corrosion is probably due to the potential relationship resulting from the differences of surface temperatures of the slugs and tube, the increased bulk water temperature, the presence of corrosion-causing compounds, or a combination of these effects.

IX. THE USE OF MAGNESIUM DUMMIES TO PREVENT FRONT TUBE CORROSION

On the basis of available information, the staff of the Alcoa Laboratories does not recommend the use of magnesium dummies for front tube protection for the following reasons.

1. There is a very narrow range of potential differences between magnesium and aluminum which will give protection to the aluminum. A potential difference above this range causes ionization of the water and the OH ions produce a high rate of caustic attack on the aluminum. However, the potential difference can be influenced by water composition, metal temperatures, and water turbulence. The effects of these factors on the application of magnesium dummies to the Hanford problem can not be readily evaluated and must be determined experimentally.

2. They believe that a more feasible method of protecting the front tubes from corrosion may be to install 72S clad dummies.

X. THE REMOVAL OF CORROSION PRODUCTS FROM THE PROCESS TUBES

The staff of the Alcoa Laboratory recommended that in the event of changing the water quality either by the omission of the dichromate or the addition of other inhibiters, that the present corrosion product be removed by either chemical or mechanical means. They emphasized the importance of removing all the produc since removal of only part of the material may actually accelerate the corrosion rate.

XI. FUTURE EXPERIMENTAL PROGRAM FOR THE HANFORD CORROSION PROBLEMS

Experimental setups for determining the relationship between the corrosion rate and the variables of alloy composition, bulk water temperature, alloy surface temperature difference, shielding effect for the electrical potentials, water turbulence, and the effect of sodium nitrate as a corrosion inhibiter were discussed in detail.

The experimental equipment necessary for this work is of a type which could be fabricated quickly and economically.

CONCLUSIONS

Since the corrosion problem of the process tubes at the Hanford Piles is serious it can be concluded that (1) there is a solution to the problem (2) the information secured from the Alcoa Research Laboratories gives an excellent starting point for finding the solution, and (3) a program for finding the solution should be started immediately.

It may be concluded as a result of the information obtained from the conferences with the Alcoa Laboratory people, that immediate steps should be taken to:

1. Find the source of, and a way to eliminate, the lead present in the process water of the piles.

2. Determine if the dichromate may be removed as a process water additive. The above two steps would eliminate the presence of lead chromate which is suspected of causing the front tube pitting.

3. Determine the electrical potential relationships between magnesium dummies and the alclad process tubes to determine if these dummies may safely be used.

4. Determine the electrical potential relationship between the 2S slugs and the alclad tube due to the temperature difference of those surfaces in the active section in order to find a method of reducing the slug corrosion.

5. Determine the relationships between the corrosion rate and the process tube water turbulence in order to discover a method of eliminating the front tube corrosion.

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6. Test the effectiveness of sodium nitrate as a corrosion inhibitor in the Hanford type process water.

7. Evaluate the present water system and its instrumentation in order to prohibit the addition of mercury to the process water either by accident or as a means of sabotage.

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