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327 BASIN ALUMINUM CORROSION TEST

by

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INTRODUCTION

An investigation of corrosion in the 327 Building's water storage basin was made to determine whether the static storage of aluminum jacketed fuel elements could cause corrosion effects that would interfere with studies of in-pile corrosion. The Coatings and Corrosion Unit suggested that the value of using sodium nitrate as a corrosion inhibitor be determined at the same time.

SUMMARY AND CONCLUSIONS

The amount and type of corrosion which occurs in the 327 Building basin does not interfere with the examination for aluminum corrosion on irradiated slugs. It was, also, determined that the use of sodium nitrate as a corrosion inhibitor was not necessary in the prevention of excess aluminum corrosion on slugs stored in the basin.

DETAILS

The investigation was made using non-irradiated 1100 (2S) aluminum coupons by coupling the coupons with all possible contacts within the basin and by making similar building water tests with and without use of sodium nitrate.

The assumption was made that the corrosion rate of irradiated aluminum would be approximately the same as unirradiated aluminum.

The 327 Building has a ten-foot deep water storage basin for storing radioactive materials. The aluminum jackets on uranium fuel elements are exposed to basin water for extended periods of time. Any large amount of corrosion occurring in the aluminum would interfere with any examinations done to the aluminum jackets. The type and amount of corrosion to 1100 (2S) non-irradiated aluminum from the 327 Buiding basin was evaluated by microscopic and weight loss techniques.

Jacketed fuel elements, fuel elements that have no bare uranium exposed, are usually stored in a galvanized iron rack. Defective fuel elements, with some bare uranium exposed, are stored in thick 24S aluminum cans with screw caps. These 24S aluminum cans are filled with 327 basin water, 100 area basin water, or air.

During the entire testing period of 90 days, 200-300 parts per million of sodium nitrate was maintained in the basin at all times. Oil, dust, and other debris that accumulates on the basin water surface was removed during the working hours by maintaining a water flow of thirty gallons per hour which was added at the bottom and removed out the overflow at the top.

The amount of sodium nitrate to be added for maintaining the recommended concentration was calculated as follows:

$$\int_{x_1}^{x_2} \frac{dx}{x} = -\frac{r}{v} \int_0^t dt$$

$$x_2 = x_1 e^{-rt/v}$$

where: x = grams sodium nitrate
r = rate of water flow
v = volume of water
t = hours of water flow
x_1 = initial amount of sodium nitrate
x_2 = amount of sodium nitrate at time t.

The basin has 2,833 gallons of water; consequently, at an initial concentration of 300 ppm of sodium nitrate, 3,214 grams of sodium nitrate would be present. With a water flow of 30 gallons per hour, the equation can be expressed as:

$$x_2 = 3{,}214\ e^{-30t/2{,}833}$$
$$= 3{,}214\ e^{-t/94.4}$$

The amount of sodium nitrate added at each replenishing period can be represented by:

$$x = 3{,}214\ (1-e^{-t/94.4})$$

Twenty-four corrosion coupons were cut from four eight-inch 1100 (2S) aluminum slug cans. A one-fourth-inch hole was punched in each coupon for supporting the coupon during testing. The coupons had an area of approximately 4.5 square inches. The aluminum jackets on slugs are annealed in their production, so, to have similar conditions the coupons were annealed at 450 C for one hour. A representative coupon is shown in Figure 1.

There are three possible types of locations for the storage of fuel elements in the basin. Three coupons were placed in each of the locations that fuel elements are stored: the storage rack for jacketed fuel elements, in storage cans for defective fuel elements, and resting on the basin bottom, Figure 5. Two slug storage cans were used, three coupons in each; one was filled with tap water, the other with basin water. Three control coupons were suspended in the basin free of any contact except for the tygon tubing which supported them; one was near the bottom, one near the top, and the other half way down. Three control coupons were also placed in stagnant tap water and three in flowing tap water. This made a total of seven different circumstances being tested or 21 coupons under testing conditions.

The corrosion test began on March 10, 1955, and ended 90 days later on June 5, 1955. The coupons were not moved during the testing period.

During the testing period an average of 1,540 gallons of water per week flowed through the basin. During the same period an average of 1,350 grams of sodium nitrate per week was added. Also included in the average water flow and sodium nitrate additions are two basin cleanups and a giant cask introduction, all of which lowered the water level in each case to where water had to be added through the large main valve, and the sodium nitrate concentration brought back to its original value. Remaining in the storage racks during the testing period were approximately 35 jacketed fuel elements and 60 defective fuel elements. Seventeen jacketed fuel elements were placed in the racks and eight removed during the testing period. Fifteen defective fuel elements were placed in the racks and three were removed during the testing period. This makes a total of 36 times that a one ton cask was lowered into the basin during the testing period.

After removing the coupons from the basin and those in tap water, they were rinsed in water and dried for one week in a dessicator containing "Drierite." The coupons were then weighed and any weight gains determined. The calculated weight gains are given in Table I.

The measured weight gains on most samples in the basin were the same as the control samples in stagnant tap water. Those samples on the basin bottom and in the slug storage rack showed more weight gain than the controls from the stagnant tap water and free of basin contact. Those on the basin bottom had 1-1/2 to four times more weight gain than the others; the coupons in running tap water having three times the weight gain of those on the basin bottom. The coupons in running tap water were darkened and had large areas of white corrosion product and barnacles. The only corrosion product visible on the rest of the coupons was small scattered white specks. Figure 2 is a coupon that was in the slug storage rack, and it is representative of the type of corrosion that occurs in the basin.

The coupons were then cleaned in a bath containing 10 per cent by weight of concentrated sulfuric acid and 3 per cent chromic acid at 70 C for five minutes each. Three more control coupons were cleaned with the test coupons to determine the amount of metal removed due to cleaning. The coupons were dried in a dessicator before re-weighing. The weight loss due to cleaning was 0.40 $mg/cm.^2$. The calculated weight losses are given in Table I.

The most amount of weight loss occurred with the coupons that were in the storage can filled with basin water. The coupon on the basin bottom had 0.4 times less weight loss than those in the storage can filled with basin water with those in the slug storage rack and in the storage can filled with tap water only 0.8 times less. The coupons that were free of basin contact and in running tap water were both greater.

The pit depths were measured using the vernier scale on the fine focusing adjustment on a microscope. Magnifications of the order of 200X were used while measuring the pit depths. The microscope was focused on the bottom of a pit, then the top, and the difference in the two vernier settings being the pit depth. The deepest pits only were measured. Five pits on each side of a coupon were measured with three measurements of each pit being made.

The coupons that were in running tap water had the deepest pits. The pits in the basin coupons were all about the same, with the coupons that were free of basin contact having the deepest, and the ones that were on the basin bottom having next to the deepest pits.

A comparison of the magnitude of the pits is shown in Figures 3 and 4. Figure 3 is a deep pit in one of the coupons from the running tap water. Figure 4 represents the deepest pits formed on any of the test pieces, being from a coupon that was resting on the bottom of the basin. The pictures are at 20 magnifications.

The amount of corrosion of all the test coupons was approximately the same, with those in the slug storage can filled with basin water being the least. The control coupons in stagnant tap water had a corrosion rate that was equivalent to or less than that of all the test pieces. The other control coupons, free of basin contact and in running tap water, had higher rates than any of the rest.

The coupons in stagnant tap water had the equivalent or less corrosion than any of the coupons in the basin with the control coupons that were free of basin contact being most. Consequently, the sodium nitrate did not help in decreasing the amount of 2S (1100) aluminum corrosion occurring in the basin. The amount of corrosion that does occur in the basin is so slight that it should not interfere with slug jacket examinations when the slugs have been stored in the basin for a period of less than two years.

ACKNOWLEDGMENT

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TABLE I

Average Corrosion Rates for 1100 (2S) Aluminum in the 327 Building Storage Basin

Location Tested	Weight gain mg/cm²/yr.	Weight loss (corrosion product removed) mg/cm²/yr	Pit Depth inches/year
Basin water in slug storage can	5	0.39	0.0027
Tap water in slug storage can	10	0.30	0.0040
Slug Storage rack	12	0.30	0.0034
Basin bottom	19	0.14	0.0050
Free of basin contact	9	1.00	0.0064
Stagnant tap water	10	0.14	0.0030
Running tap water	55	1.50	0.0330

Figure 1. Aluminum Corrosion Coupon before Testing. 1X

Figure 2. Aluminum Corrosion after Being in the Slug Storage Rack for 90 Days. 1X

Figure 3. A Pit, Representative of What Is Caused by Running Tap Water. 20X

Figure 4. A Pit Representative of Basin Water Corrosion. 20X

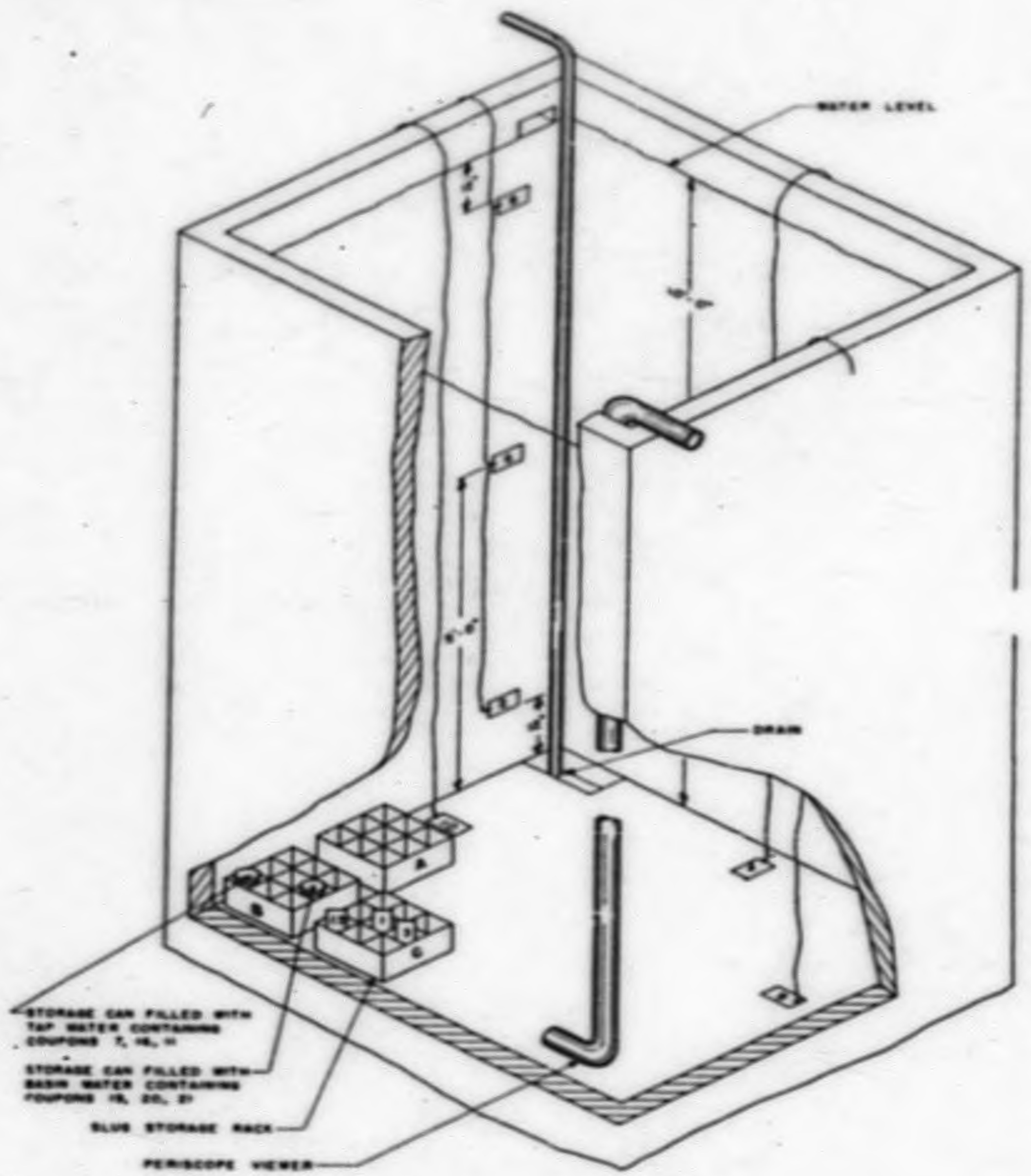

FIGURE 5

SCHEMATIC SHOWING THE RELATIVE LOCATIONS OF THE ALUMINUM CORROSION COUPONS IN THE 327 BUILDING STORAGE BASIN

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