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ALUMINUM FUEL CANISTER CORROSION

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ALUMINUM FUEL CANISTER CORROSION

C. A. Richardson

INTRODUCTION

On June 26, 1977, it was first reported that aluminum fuel canisters stored in the KE Basin were experiencing corrosion to the extent that canister integrity could be jeopardized should the canister remain in storage for an extended period. In an effort to determine the extent of the corrosion, and to monitor its progress, a fuel canister from the KE Basin was examined on July 6, 1977, February 14, 1978, and on August 23, 1979. Two canisters from the N Basin were examined on February 2, 1978. One canister from the KW Basin was examined on August 23, 1979. The purpose of this document is to report the results of the examinations.

SUMMARY

The aluminum fuel canisters stored in the KE Basin are experiencing severe pitting corrosion; however, the examination results to date indicate that the rate of the pitting is diminishing with storage time. After approximately 4½ years storage time, the maximum pit depth reached was 42 mils under a corrosion product tubercle that had been disturbed or cleaned three times versus 34 mils under a tubercle that had not previously been cleaned. Weld bead corrosion is occurring only on the weld bead itself, not at the weld bead-to-canister wall junction, which should not jeopardize the integrity of the canister. To date, examination results indicate that the pitting corrosion being experienced by the aluminum fuel canisters stored in the KE Basin will not jeopardize the integrity of the canisters should they remain stored for several more years.

An examination of several fuel canisters store in the N Basin indicated that no pitting corrosion problem exists on the canisters. The canisters examined were known to have been stored in the N Basin for approximately 6 years. A fuel canister that has been stored in the KW Basin since December, 1978, is experiencing pitting corrosion. Continued examinations will be required, however, before it can be determined whether or not the rate at which the pitting is occurring is increasing or decreasing.

DISCUSSION

A. KE Basin

An aluminum fuel storage canister that has been stored in the KE Fuel Storage Basin since startup was examined for corrosion behavior on July 6, 1977, February 14, 1978, and August 23, 1979, after 2½, 3, and 4½ years exposure to the basin water. This canister was a new, unused canister filled with leak bricks and has been used at the basin for hoist checks. As shown in Figure 1, approximately one-half the outer surface of the canister and essentially all the weld beads were covered with soft blue-white tubercles. The tubercles are corrosion product buildup resulting from localized pitting corrosion. Aluminum corrosion product that is blue-white in color is generally associated with aluminum materials exposed to water containing oxygen, copper, carbonates, iron and chlorides (and other impurities). The water in the KE Basin contains all these elements, see Table I.

At the first examination, a small area of a canister wall was selected at random, and 20-25 tubercles were observed. The tubercles varied in size and shape; however, each deposit had two similarities: each tubercle was very soft (indicating active corrosion) and under each tubercle was an area of general corrosion plus a pit resulting from localized corrosion. After removing the tubercles, underlying pits ranging from 23 to 34 mils deep were measured. After the examination, the canister was returned to

the KE Basin until it was again examined on February 14, 1978. No difference in the size, number or texture of the deposits were noted between the first and second examination. It was, however, noted that tubercles had reformed over those corroded areas that had been cleaned during the previous examination. The deposits were again cleaned, but due to equipment malfunction, no pit depth measurements were taken. It was noted during the second examination that the tubercles were considerably larger and heavier near the top of the canister, see Figure 1. The reason for this noted difference is not known. After the second examination, the canister was returned to the KE Basin until it was again examined for the third time on August 23, 1979 - after approximately 4½ years total storage time. As was noted previously, corrosion continued to be worse near the top of the canister; as noted during the second examination, tubercles had again preformed on the previously cleaned areas. A comparison of the number and location of tubercles noted in 1977 and 1978 with those noted in 1979, revealed that no new areas of corrosion had developed since examinations were first initiated (approximately two years elapsed time). During the two years between the first and third examination, pit depths increased from approximately 23 to 34 mils to 25 to 42 miles in the same cleaned area. A close-up view of the pits in the cleaned area is shown in Figure 2. By comparison, pit depths measured for the first time in 1979 in a previously noncleaned area ranged from 25 to 34 mils. The almost exact similarity between both initial pit depth measurements indicate that the corrosion begins and continues to a certain point, then becomes passive and stops or at least slows considerably. However, softness of corrosion deposits usually indicates active corrosion. Continued examinations, on a periodic schedule, should be conducted to determine whether the corrosion is becoming passive as the previous examinations seem to indicate.

Since the initial examination of the KE Basin canister, corrosion in the weld areas has prompted some concern over the integrity of the welds. During the 1978 examination, it was noted that the corrosion appeared to

be concentrated on the weld bead and that the corrosion deposits were not as bad or as thick as originally thought. As can be seen by photographs taken during the 1979 examination, Figures 3 and 4, both before and after a weld bead had been cleaned, only the thick weld bead is corroding. Therefore, it can be concluded that, to date, corrosion on the weld beads and thinner adjacent areas is not jeopardizing the integrity of the canisters.

Corrosion on the inside-top of the KE Basin canister appears to be somewhat more severe than the corresponding outside-top. The reason for this difference is not known; however, it is concluded that the difference can partly be attributed to "work hardening" of the aluminum material during fabrication of the "flare-top" and partly to the angle of the "flare-top" which allows impurities to accumulate. The contents (lead bricks) of the canister did not permit a good visual check to determine if the severity of corrosion on the inside diminished towards the bottom of the canister as was previously noted on the outside. If this determination is considered necessary, the lead bricks can be removed during the next examination.

B. KW Basin

On August 23, 1979, an empty canister that had been stored in the KW Basin was examined. As can be seen in Figure 5, the canister is experiencing localized corrosion. Even though this canister had only been in the KW Basin for approximately eight months, pits 10 to 14 mils deep were measured. The corrosion deposits on the KW Basin canister were hard and brittle (indicating passive corrosion) whereas the deposits on KE Basin canister were very soft. Since the canister was first placed in the KW Basin, the quality of the water in the KW Basin has improved considerably which may have caused the initially active corrosion to become passive. As previously stated, poor quality water is concluded to be the primary reason for the severe corrosion being experienced in the KE Basin. Continued observation of the KW Basin canister will be required before it

can be determined if aluminum corrosion will also be a problem in the KW Basin.

C. N Basin

On February 2, 1979, two canisters from the N Basin were examined. Figure 6A shows an aluminum fuel canister that is known to have been placed in the N Basin since February-March, 1972. Figure 6B was taken of an aluminum fuel canister for which placement date in the N Basin cannot be verified. The canister shown in Figure 6B is a co-product canister that was last tested in November, 1973 (see date on canister). It is very probable that the canister had not only been stored in the N Basin since November, 1973, but also stored for several years prior to that date (during co-product production years). In either case, exact storage time is not known; however, canister corrosion being experienced in the N Basin is minor and will not jeopardize canister integrity as long as the water in the N Basin is controlled in its present mode.

TABLE I

KE Basin Chemical Analysis

Impurity CONCENTRATION (ppm)	6-30-75	9-23-75	10-28-75	2-9-76	6-14-76	3-15-77	5-22-78	8-21-79
<u>Cations</u>								
Ca	26.5	27.6	30.4	31.0	38.3	23.5	25.5	18
Mg	-----	4.0	4.0	4.0	4.5	4.2	-----	3.8
Na	4.0	3.8	3.8	4.1	10.5	5.2	5.0	5.1
K	4.0	2.8	3.1	2.4	1.0	2.0	-----	1.0
Al	-----	.1	.1	1.0	-----	.02	-----	1.0
Fe	.05	.01	.03	.16	.05	.04	.1	.05
Ni	.1	.1	.1	.05	-----	.01	-----	.05
Cu	.01	.02	.02	-----	.02	.01	-----	.01
<u>Anions</u>								
CO ₃	-----	3.5	3.5	3.5	3.5	-----	.1	3.6
HCO ₃	-----	42.0	38.0	20.6	7.3	7.8	35.0	43.2
SO ₄	-----	27.0	29.0	28.0	24.0	13.5	31.5	45.0
SiO ₂	-----	6.0	5.8	5.1	4.0	3.0	-----	1.5
Cl	-----	20.0	20.0	37.0	75.0	34.5	-----	9.0
pH	7.33	7.50	7.26	7.20	-----	-----	7.55	7.50
Conductivity	230.00	230.00	235.00	220.00	-----	-----	250.00	138.00

FIGURE 1
Aluminum Canister After 4 1/2 - Years Exposure
To KE Basin Water

FIGURE 2

Close-up View Of Pits After Removal of Tubercles

No. 7908401-5CN
8-23-79

No. 7908401-6CN

FIGURE 3

Weld Area Before Removing Corrosion Products

No. 7908401-4CN

FIGURE 4

Weld Area After Removing Corrosion Products

FIGURE 5

Aluminum Canister After Six Months Storage in KW Basin

A. Exposed From March 1972 to February 8, 1978

B. Exposed From Sometime Prior to November 1973 to February 8, 1978

FIGURE 6

Cannisters Exposed to N Fuel Storage Basin Water