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December 3, 1979

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of Commonwealth Edison Company (Zion Station, Units 1 and 2)	)))	Docket Nos. 50-295 50-304

Dear Members of the Board:

In Licensee's submittal on intergranular stress corrosion cracking dated November 16, 1979, two pages were inadvertently omitted from the article attached to Mr. Clarke's affidavit. The missing pages are enclosed.

Also, there is an error in Dean Staehle's affidavit. On page 4, the third line from the bottom, the word "boron" should be substituted for "H_3Bo_4" so that the sentence reads: "The concentration of boron in the TMI spent fuel pool is 2200 to 2300ppm."

I apologize for these errors.

Sincerely,

Philip P. Steptoe

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ment quantitatively ranks this heat near the lowest end of the scale of susceptible mate.ials. According to the A 262, Practice A test, Heat TH6656 ... be expected to be more susceptible to IGSCC than Heats 812292 ...), using only degree of sensitization as a criterion.

... intermediate level of IGSCC susceptibility occurred in a heat of 1-in. ...rged bar (Heat 812292) dynamically tested after the 500 °C/24 h sensitization treatment. A specimen from this heat revealed IGSCC about 2 to 3 grains deep (Fig. 8) and a transgranular region below the IGSCC initiated cracks. The sensitization measurement etch structures for this heat are shown in Fig. 9. The A 262, Practice E, test indicated penetrations of 0.1 to 0.4 mil, which occurred at slip planes (Fig. 9*a*) produced by surface cold work during specimen machining.

The EPR test gave a relatively high value (P_a = 16.8 C/cm^2) for degree of sensitization, and the structure revealed a profusion of precipitated carbides (Fig. 9*b*). The carbides present are very small and difficult to resolve using conventional metallographic techniques. This precipitation mode probably accounts for the lack of grain boundary grooving after A 262, Practice A, testing (Fig. 9*c*), where the chromium carbides are presumably too small for the sensitivity of the oxalic acid test. Thus, an advantage is shown for the EPR test method, particularly for some precipitate morphologies.

Generally, the A 262 tests (Practices A and E) are not sufficiently discerning to distinguish between degrees of sensitization at these low levels of sensitization. One exception is the evaluation of the 66-cm (26-in.) rolled and welded pipe (Heat 834264), which has exhibited inconsistent behavior in other related studies [*6*]. Specimens from this large grained (ASTM 3.5 compared to 5 to 5.5 for the other materials) material are highly susceptible to IGSCC but consistently yield relatively low sensitization values in the EPR test. The A 262, Practice E, test also indicates relatively low levels of sensitization, but the A 262, Practice A, test ranked this heat properly. Although the EPR technique gave a low P_a value for this heat, the post-test appearance did show considerable grooving of the grain boundaries, indicating that post-test examination of the EPR attack should be weighted in the decision process at low P_a values.

Analysis of the remainder of the data in Table 4 indicates the EPR test is more sensitive than either A 262, Practices A or E, in distinguishing and quantifying degree of sensitization at these lower levels of sensitization. It is significant that the high IGSCC susceptibility of Heat M7616 can be eliminated by solution annealing, even when the material is subsequently given the low-temperature sensitization treatment. It was difficult to solution anneal this material adequately, however, as even rapid air cooling after the 1038 °C/h anneal resulted in a sensitized structure similar to the mill-annealed condition given in Table 4. Complete solution annealing was accomplished in this heat only after water quenching in the cooling chamber

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FIG. 8—*IGSCC in sensitized (500°C/24 h) Type 304 stainless steel (Heat 812292) tested by dynamic strain in 289°C water with 8-ppm O_2 at extension rate of 0.0008 mm/min.*

of the heat-treat furnace. Apparently, the precipitation of chromium carbides occurs extremely fast during cooling from the solution-annealing temperature, such that a "seeding" effect results which enhances sensitization during subsequent thermal treatments in the sensitization range [*1*].

Additional work was conducted to assess the three measurement methods after more severe sensitization heat treatments. Measurements were performed on a heat of 2.5-cm (1-in.) plate (Heat X14902) which was sensitized 1, 4, 20, and 40 h at 620°C and furnace cooled. These results are given in Table 5, where all three methods indicate a saturation effect for this heat after sensitizing for 20 h or greater. All three methods reveal the lack of sensitization in the as-received condition (mill annealed). The EPR and A 262, Practice A, tests indicate a lower degree for specimens sensitized 4 h compared to 1 h, but this trend could be due to specimen variability, since the A 262, Practice E, tests were conducted on separate specimens while the A 262, Practice A, and EPR tests were conducted on the same specimens. All these sensitized specimens were susceptible to IGSCC after constant load testing in the severe environment of 289°C water with 8-ppm dissolved oxygen [*6*].

Six of the seamless pipe heats were evaluated further after sensitizing for 40 h at 620°C and furnace cooled. This sensitization treatment caused extensive IGSCC susceptibility in all the Type 304 stainless steel pipe spec-

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