Commonwealth Edison
One First National Plaza, Chicago, Illinois
Address Reply to: Post Office Box 767
Chicago, Illinois 60690

May 21, 1975

Mr. D. L. Ziemann, Chief
Operating Reactors - Branch 2
Division of Reactor Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Dresden and Quad-Cities Stations
Reactor Water Recirculation 4-Inch
Diameter Piping Crack Investigation
Program, NRC Dkts. 50-237, 50-249,
50-254, and 50-265

Dear Mr. Ziemann:

In a letter to Mr. Case dated February 10, 1975, one of the Further Investigations identified was additional strain rate testings of the piping material by Battelle Columbus Laboratories. The tests have been completed, and a report describing the results is attached for your information. These results in conjunction with the results in the Battelle Columbus Laboratories report dated November 26, 1974 attached to the February 10, 1975 letter to Mr. Case, completes the strain rate studies. The constant strain rate studies indicate that "lightly and heavily sensitized specimens from Dresden II (Unit 2) and Quad-Cities II (Unit 2) piping are more susceptible to stress-corrosion cracking in oxygenated high temperature water than are similarly treated specimens from a heat of Type 304 stainless steel used in previous Battelle studies". The Dresden Unit 2 and Quad-Cities Unit 2 specimens were obtained from portions of the Reactor Water 4-Inch Diameter Piping which was removed for repairs during September and October 1974.

As committed in a letter to Mr. Case dated December 27, 1974, all 4-inch diameter recirculation system piping has been replaced or in the case of Dresden Unit 3, is being replaced during the current refueling outage. The heat of piping material represented by the Dresden Unit 2 and Quad-Cities Unit 2 specimens in the Battelle tests is no longer in service at any of the four subject units.

One signed original and 39 copies of the report are provided for your use.

Very truly yours,

50-237 249
254/265 5752
Incident

J. S. Abel
Nuclear Licensing Administrator
Boiling Water Reactors

COPY SENT REGION III

Battelle
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151
Telex 24-5454

February 28, 1975

Mr. D. D. Galle
Engineering Department
Commonwealth Edison Company
P.O. Box 767
Chicago, Illinois 60690

Dear Mr. Galle:

We have completed the three additional constant-strain-rate tests as discussed in our January meeting. The initial results of the study, together with the procedures, were detailed in my letter to you dated November 26, 1974.

The additional tests have been made on lightly sensitized specimens from the Dresden II and Quad Cities II piping and the Battelle heat of Type 304 stainless steel. The tensile-type specimens were sensitized 7 hr at 1150 F to produce intermittent chromium carbide precipitation at grain boundaries. (This structure appears similar to that obtained in the heat-affected zone when welding Type 304 stainless steel.) The specimens were then pulled to tensile rupture at a constant strain rate of 3×10^{-6} in./in.-sec in 550 F deionized water containing 100 ppm dissolved oxygen at start-up. The procedures and theory for this test procedure also were described in my letter to you dated November 26, 1974.

The results of these tests are included in Table 1 together with the results from the previous study. Note that the time-to-failure and reduction in area were less for the Dresden II and Quad Cities II specimens than for the Battelle specimen given the same 7 hr/1150 F sensitization treatment. Thus, the results continue to suggest that the material used in the Dresden II and Quad Cities II piping is more susceptible to stress-corrosion cracking than the Battelle heat of material. This might be related to the quality of the original mill-annealed microstructure, although the constant-strain-rate tests with mill-annealed material revealed no difference among the three specimens. (No specimen exhibited stress-corrosion cracking and all had about the same time-to-failure and reduction in area--see Table 1.)

The appearance of the lightly sensitized specimens after test tends to support the data presented in Table 1. Photographs of the two halves of the broken tensile specimens are presented in Figures 1 and 2. These photographs suggest severe cracking. However, the metallographic examination of longitudinal cross sections through these specimens revealed many

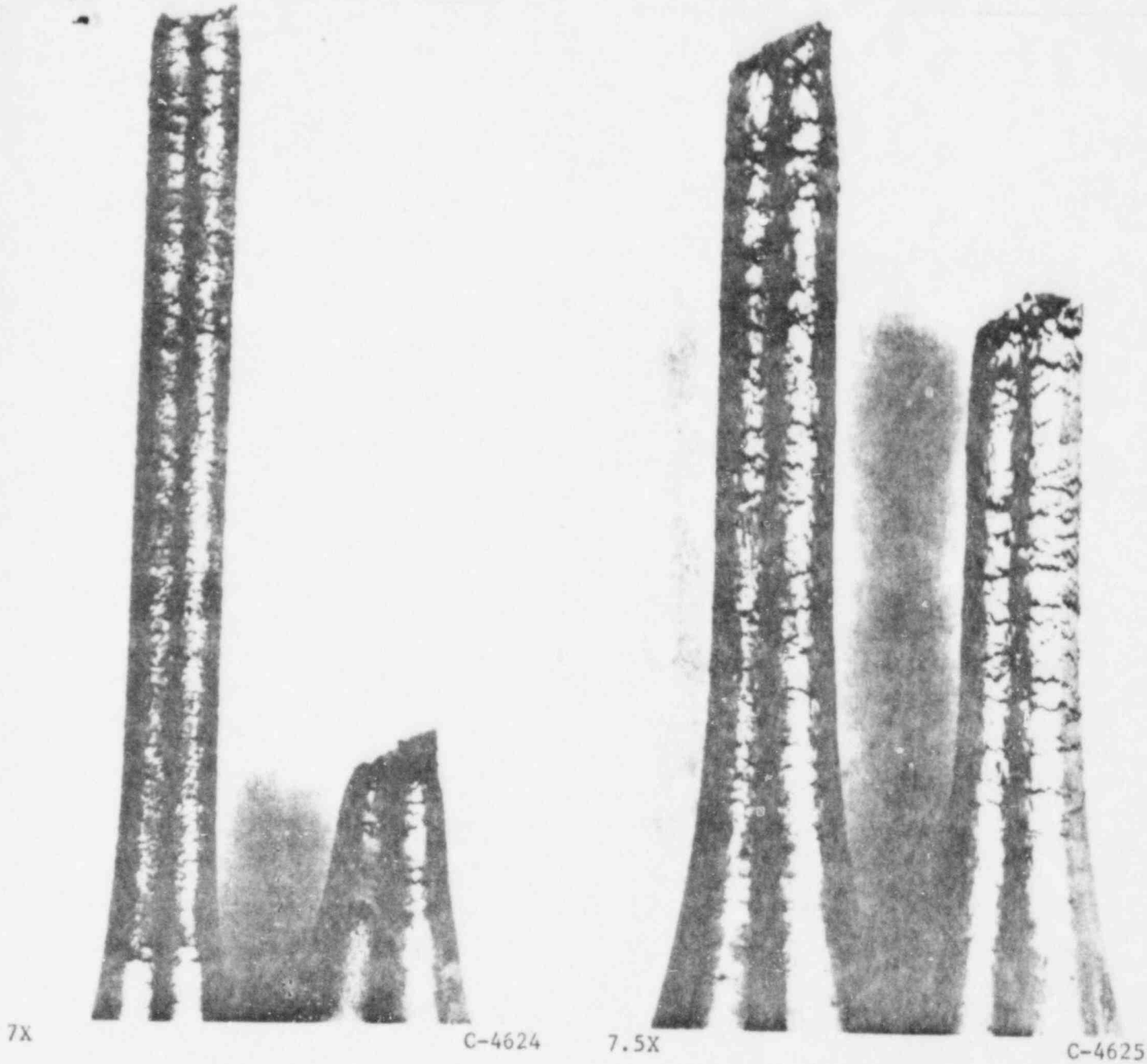
TABLE 1. SUMMARY OF RESULTS FROM THE CONSTANT-STRAIN-RATE TESTS

(3×10^{-6} In./In.-Sec in 550 F Water Containing 100 Ppm Dissolved Oxygen)

Metallurgical Condition	Material[(a)]	Time to Failure, hr	Elongation, in.	Reduction in Area, percent
As-received (mill-annealed)	Battelle	53.1	0.287	54
	Battelle	62.4	0.337	61
	Dresden II	54.1	0.280	67
	Quad Cities II	55.9	0.320	72
Sensitized 4 hr/1250 F	Battelle	26.4	0.141	15
	Dresden II	9.2	0.059	9.7
	Quad Cities II	9.4	0.052	14
Sensitized 7 hr/1150 F	Battelle	56.3	0.315	60
	Dresden II	45.4	0.254	37
	Quad Cities II	45.7	0.258	38

(a) Dresden II and Quad Cities II specimens cut from as-removed piping. Battelle specimens obtained from bar stock with following composition and properties:

0.07 C	35,000 psi YS
20.0 Cr	98,000 psi UTS
8.5 Ni	100% elongation in 2 in.
1.85 Mn	84% reduction in area
0.20 Cu	

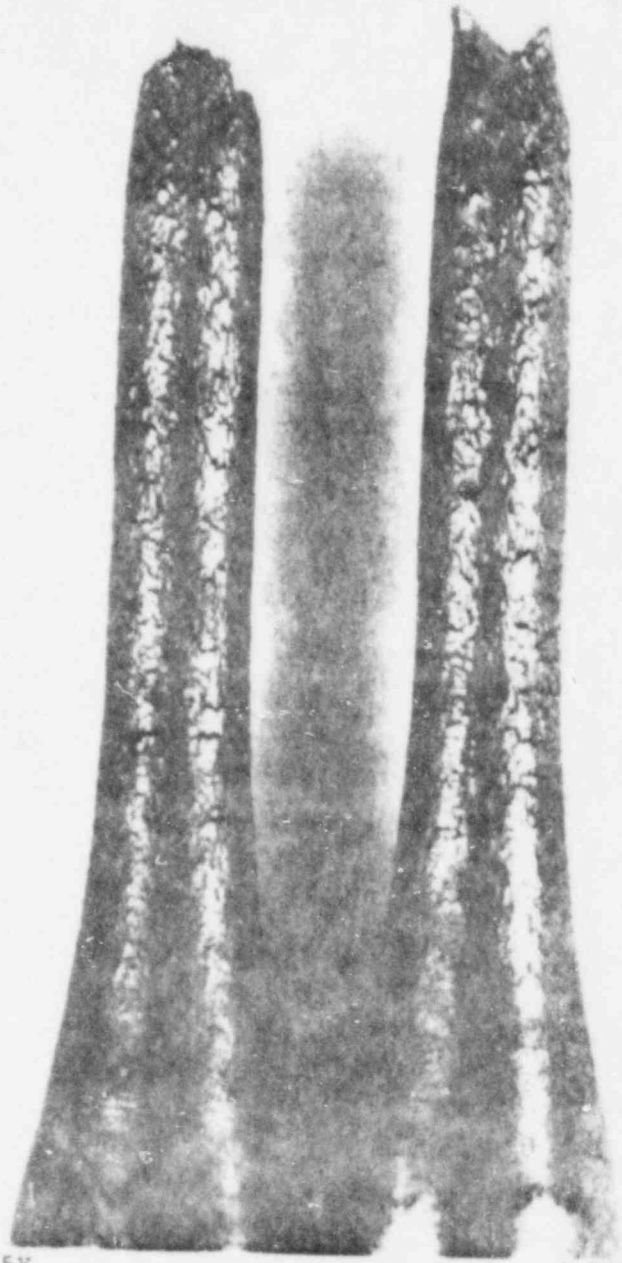


a. Dresden II

b. Quad Cities II

FIGURE 1. APPEARANCE OF LIGHTLY SENSITIZED TENSILE SPECIMENS FROM DRESDEN II AND QUAD CITIES II PIPING AFTER PULLED TO FAILURE AT 3×10^{-6} IN./IN.-SEC STRAIN RATE IN 550 F WATER CONTAINING 100 PPM DISSOLVED OXYGEN

Note the many secondary cracks. Compare with Figure 2.



7.5X C-4626

FIGURE 2. APPEARANCE OF LIGHTLY SENSITIZED TENSILE SPECIMEN FROM A BATTELLE HEAT OF TYPE 304 STAINLESS STEEL AFTER PULLED TO FAILURE AT 3 x 10^{-6} IN./IN.-SEC STRAIN RATE IN 550 F WATER CONTAINING 100 PPM DISSOLVED OXYGEN

Note secondary cracks and ductile necking at the fracture. Compare with Figure 1.

shallow secondary intergranular cracks with an occasional transgranular wedge. (The latter are often found on crack-resistant mill-annealed material after test.) The Dresden II and Quad Cities II specimens appeared to have more and slightly deeper secondary cracks than the Battelle specimen. Photomicrographs of typical areas are shown in Figure 3.

In summary, the results of the constant-strain-rate studies indicate that lightly and heavily sensitized specimens from the Dresden II and Quad Cities II piping are more susceptible to stress-corrosion cracking in oxygenated high-temperature water than are similarly treated specimens from a heat of Type 304 stainless steel used in previous Battelle studies. However, constant-strain-rate tests on as-received material show no difference in susceptibility to stress-corrosion cracking that can be related to the behavior of these materials when subsequently sensitized.

Please contact me if you have any questions or comments.

Best regards,

Warren E. Berry

Warren E. Berry
Associate Manager
Corrosion and Electrochemical
Technology Section

WEB:nkd

In quintuplicate

Airmail

100X C-4627

a. Battelle Heat

100X C-4628

b. Quad Cities II Piping

Etchant: Electrolytic 10 Percent Oxalic Acid

FIGURE 3. PHOTOMICROGRAPHS OF SECONDARY CRACKS SHOWN IN FIGURES 1 AND 2 (LONGITUDINAL SECTIONS)

Note shallow depth of penetration.