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FROM: NIAGARA MOHAWK POWER CORP SYRACUSE, NY G K RHODE

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DESCRIPTION

LTR TRANS THE FOLLOWING.......

PLANT NAME: NINE MILE POINT #1

ENCLOSURE

LABORATORY EXAMINATION OF CRACKED 6" TYPE 304 PIPE FROM NINE MILE POINT CLEANUP SYSTEM W/PHOTOS..........

ACKNOWLEDGED DO NOT REMOVE

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NIAGARA MOHAWK POWER CORPORATION

NIAGARA MOHAWK

300 ERIE BOULEVARD WEST
SYRACUSE, N. Y. 13202

April 2, 1976

Director of Nuclear Reactor Regulation
Attn: Mr. George Lear, Chief
Branch #3
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Re: Nine Mile Point Unit 1
Docket 50-220
DPR-63

Dear Mr. Lear:

Enclosed are forty (40) copies of a Laboratory Examination of Cracked 6-inch type 304 stainless steel pipe from the Nine Mile Point Unit 1 cleanup system. These reports were requested by Mr. Guibert of your staff. However, only one copy of the report contains a set of original photographs, the other thirty-Nine (39) have Xerox copies. Should any further information be needed, please contact us.

Very truly yours,

NIAGARA MOHAWK POWER CORPORATION

Gerald K. Rhode
Vice President - Engineering

MGM/amv

3473

Laboratory Examination of Cracked 6" Type 304 Pipe From Nine Mile Point Cleanup System.

Introduction

During a pre-startup inspection at the end of the refueling outage in November, 1975, a leak was discovered in a 6" Type 304 pipe in the cleanup system. The pipe is the high pressure supply from the reactor, outside the drywell, to the regenerative heat exchanger. A section of the pipe, and some insulation, was sent to Vallecitos Nuclear Center for examination. This pipe operates in an environment of reacter water, at 546°F and with .2 ppm oxygen.

Background

The pipe section was fabricated from 6" schedule 80 pipe, to A.S.T.M. A-376, Type 304. The fabrication consisted of making a 45° cold bend on a 30" radius. The fabricator, M.W. Kellogg Company, has indicated that the pipe was not annealed after cold bending.

Prior to service, the pipe received two coats of "Thurmalox No. 70", a silicone based material. The coated pipe was then covered with pre-formed asbestos insulation.

Conclusions

1) The cracking initiated in the severely cold worked inside surface.

2) The cracking initiated in a transgranular mode, and changed to intergranular after it had propagated through the cold worked surface.

3) The base material was sensitized.

4) Cracking mechanism was stress corrosion.

Examination Procedures

The pipe was examined visually, by visible dye penetrant, metallography and scanning electron microscopy.

The insulation was analyzed for leachable chlorides.

Results

Visual

The outside of the pipe, as received, is shown in Figure 1. The crack appears to be longitudinal, on the outside surface of a 45° bend. A small area of the crack had been cleaned and polished by the customer prior to shipping the pipe. Radiation readings on the pipe were 5R at contact. In order to minimize personnel exposure, the section containing the crack was removed by sawing, and the remaining pieces were stored. The inside surface of the pipe is shown in Figure 2. The inside surface appears to have been severely deformed. This most probably occurred during removal of the mandrel used in the cold bending operation. The visible crack was longer on the inside surface than on the outside surface.

Visible Dye Penetrant

Figures 3 and 4 show the outer and inner surfaces after penetrant examination. The cracking appears much more severe on the inside surface, indicating that the cracks initiated on the inside of the pipe. Sections were cut for metallographic examination from the locations marked on Figure 4. The main crack was about 3" long on the outside and 4" long on the inside.

Metallography

Section 1

This section was prepared to examine what appeared to be short circumferential cracks, visible in Figure 4. A closer view is shown in Figure 5. The section, as polished, is shown in Figure 6, and numerous cracks can be seen. The deepest of these cracks in the plane examined was 1/8". The cracks initiated in the heavily cold worked surface in a transgranular mode. Propagation changed to an intergranular mode below the cold worked surface. Figures 7 and 8 illustrate a typical crack from this section. The cracks were filled with oxides over most of their lengths.

The microstructure (except for the cold worked surface) consisted of equiaxed grains of austenite with an A.S.T.M. grain size of 5 to 6. There was significant carbide precipitation around grain boundaries, as shown in Figure 9.

The combination of a cold-worked sensitized material is known to be susceptible to stress corrosion cracking, and this is considered to be the most probable mechanicsm. The reason for carbide precipitation is not known. The A.S.T.M. specification requires all Type 304 pipe to be solution annealed.

Metallography

Section 1 Contd.

Fabrication was by cold bending. No annealing was performed after bending, according to the supplier. This is confirmed by the high surface hardness, and the absence of recrystallized grains at the cold worked inside surface of the pipe.

Microhardness readings, converted to Rockwell scales, ranged up to Rc22 on the outside surface and to Rc38 on the inside surface. These hardnesses reflect the results of the cold bending operation, and subsequent removal of the mandrel. Hardness in the mid-wall portions was R_B 95.

Structure and hardness were similar on all sections examined.

Section 2

This section was examined for comparison purposes with Section 1. Only one crack was found, shown in Figure 10. It is clearly transgranular in the cold worked surface area, and has started to propagate in an intergranular mode.

Section 3

This section was taken for scanning electron microscopy and will be discussed later.

Section 4

This section was taken to examine the longitudinal crack. Figures 11 and 12 show the inside surface before and after penetrant examination. This section of the crack also started in a transgranular mode, but propagated through the wall in an intergranular mode.

Section 5

The inside surface before and after penetrant examination is shown in Figures 13 and 14. The polished section is shown in Figure 15. In this plane, one crack had almost penetrated the wall. The microstructure and crack morphology were similar to the other sections.

One shallow crack was found on the outside surface of this section, which does not appear to be associated with the pipe leak. This is shown in Figure 16. It is less than .010" in depth, and is primarily transgranular. While the exact mechanism of this crack can not be determined, similar cracks in the past have been attributed to chloride contamination stress corrosion. This would most likely have occurred during the fabrication or construction period.

Scanning Electron Microscopy

Section 3

This section of the crack was broken open, and the fracture surfaces were examined. Heavy oxide deposits hampered the examination, especially at the crack initiation area. From a depth of about .010" on, the fracture was clearly intergranular. The depth of .010" corresponds to the cold worked depth found on the other sections.

Insulation

A 5.5 gram sample was leached with water in a Soxhlet extraction apparatus for 6 hours. The water leach was filtered, and the chloride content was determined by $Hg(NO_3)_2$ titration. The chloride content was 24 ppm. The insulation specification permits a maximum of 200 ppm. leachable chloride and halide.

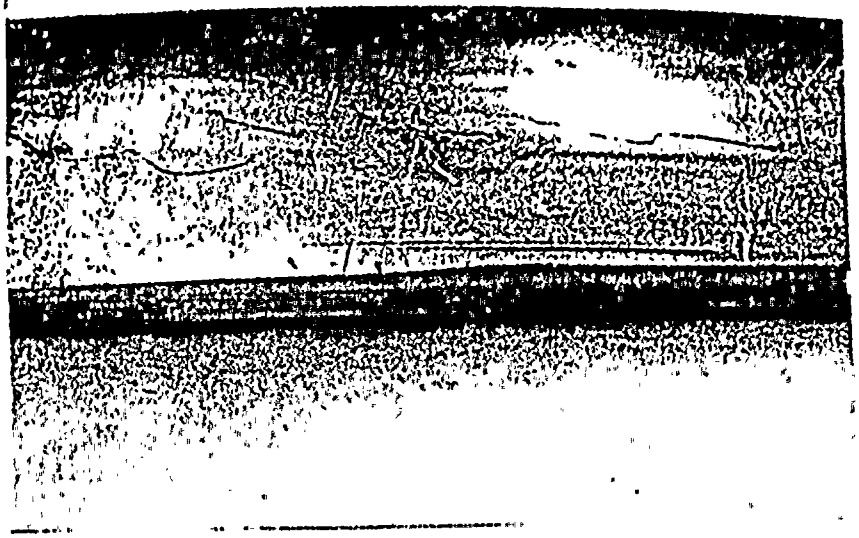


Figure 1. - Pipe Outside Surface, As Received.

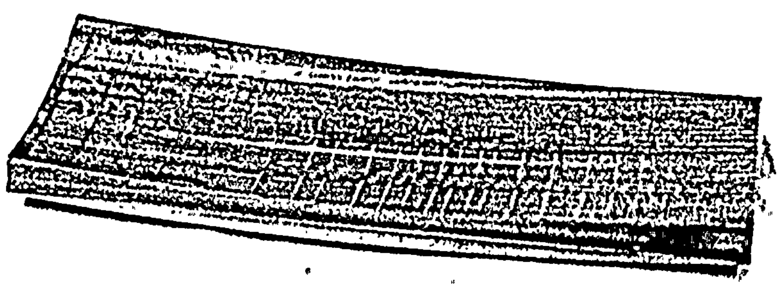


Figure 2. - Pipe Inside Surface

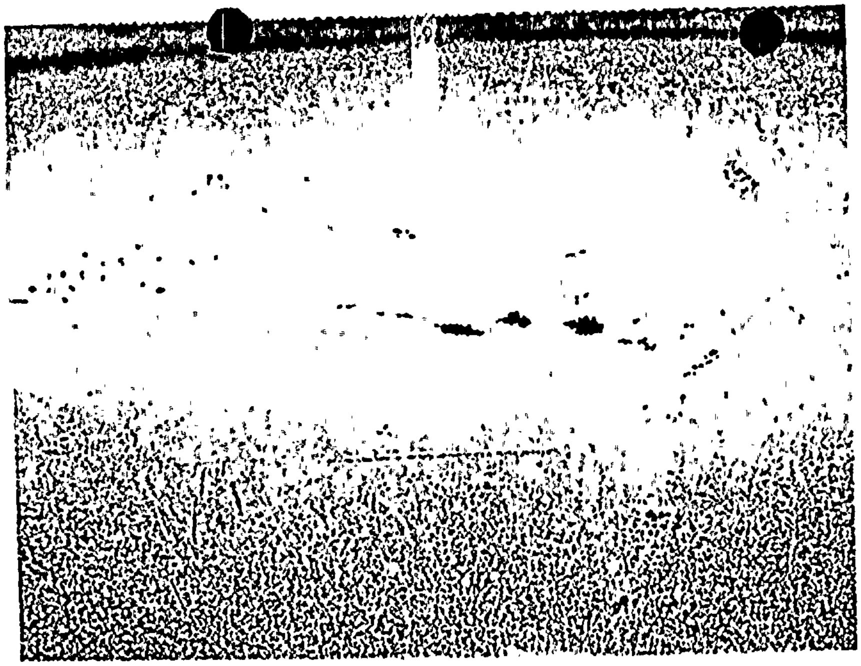


Figure 3. - Pipe Outside, Penetrant Examined.

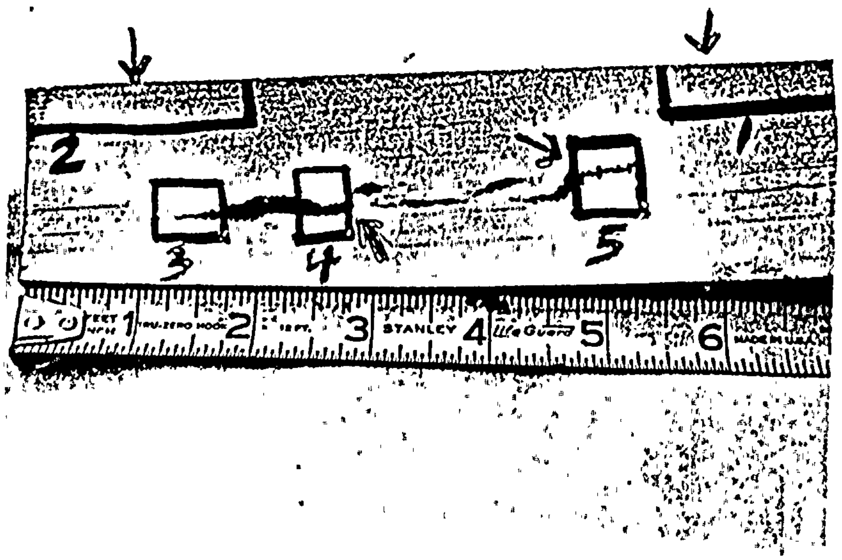


Figure 4. - Pipe Inside, Penetrant Examined and Section Locations.

Figure 5. - Section 1, Penetrant Indications.

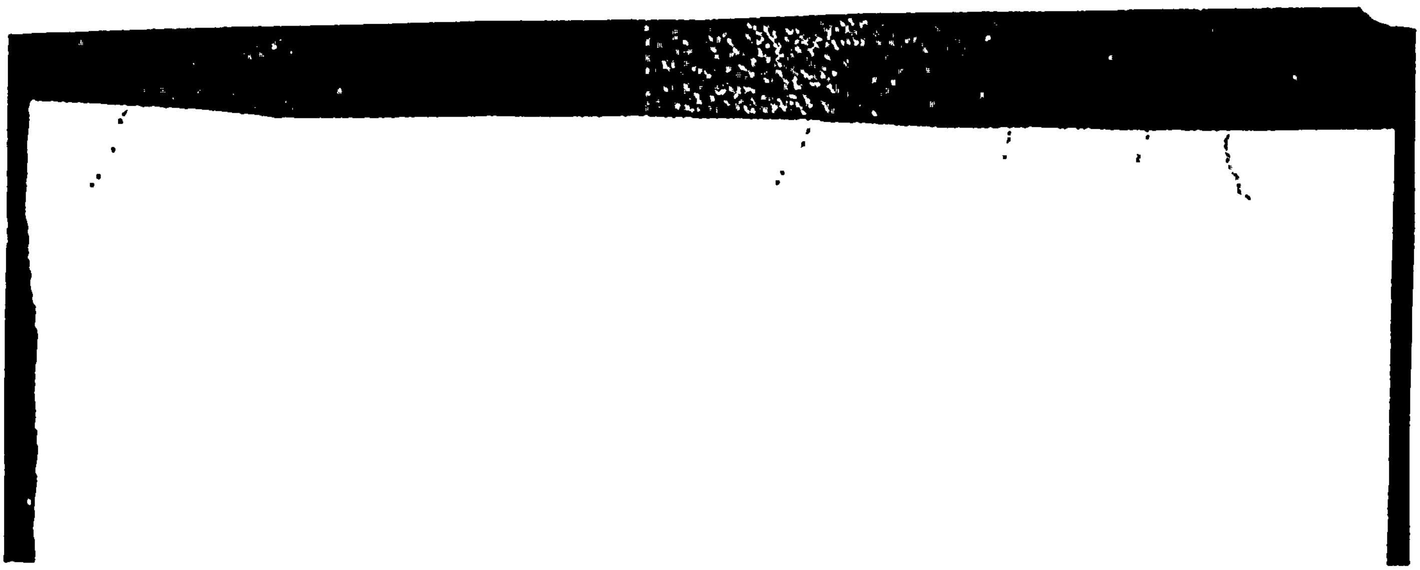


Figure 6. - Section 1, As-Polished. 8X

Figure 7. - As Polished 100X
Typical Crack, Section 1

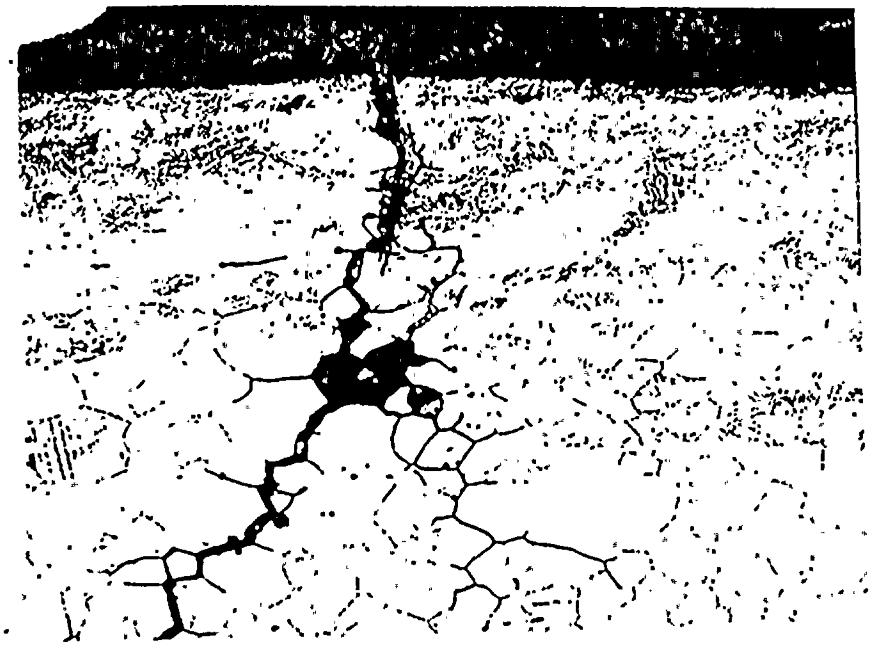


Figure 8. - Etched, Electrolytic Oxalic Acid 100X
Typical Crack, Section 1.

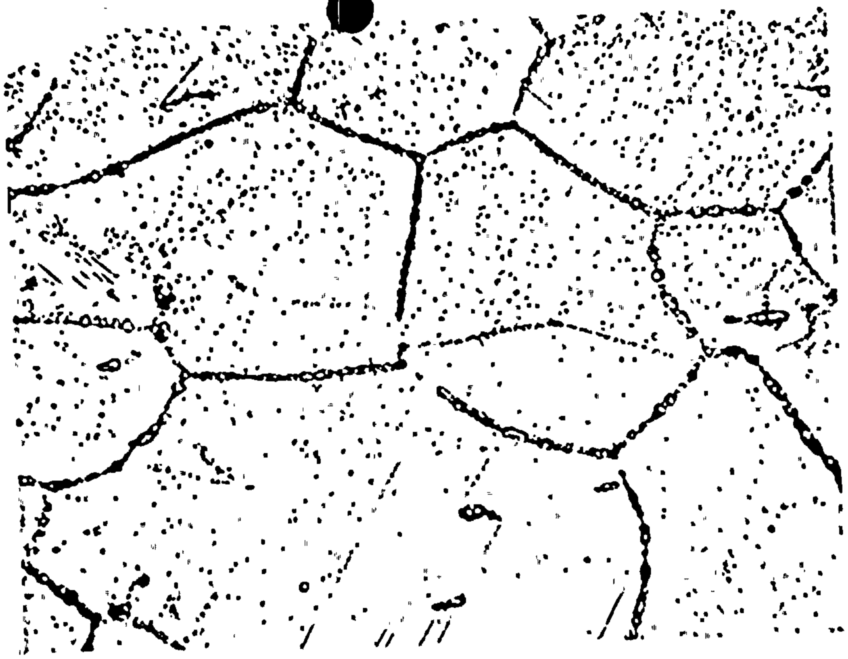


Figure 9. - Section 1 500X

Grain Boundary Carbide Precipitates

Figure 10. - Etched, Electrolytic Oxalic Acid. 100X

Typical Crack, Section 2

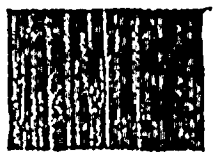


Figure 11. - Section 4, Inside Surface

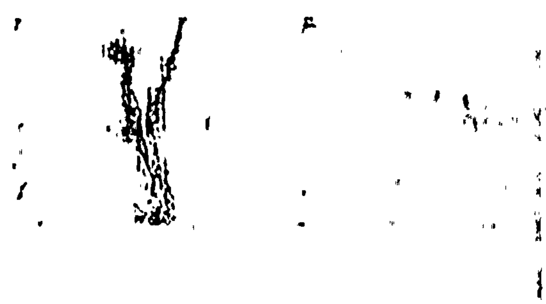


Figure 12. - Section 4, Inside Surface Penetrant Examined.

Figure 13. - Section 5, Inside Surface.

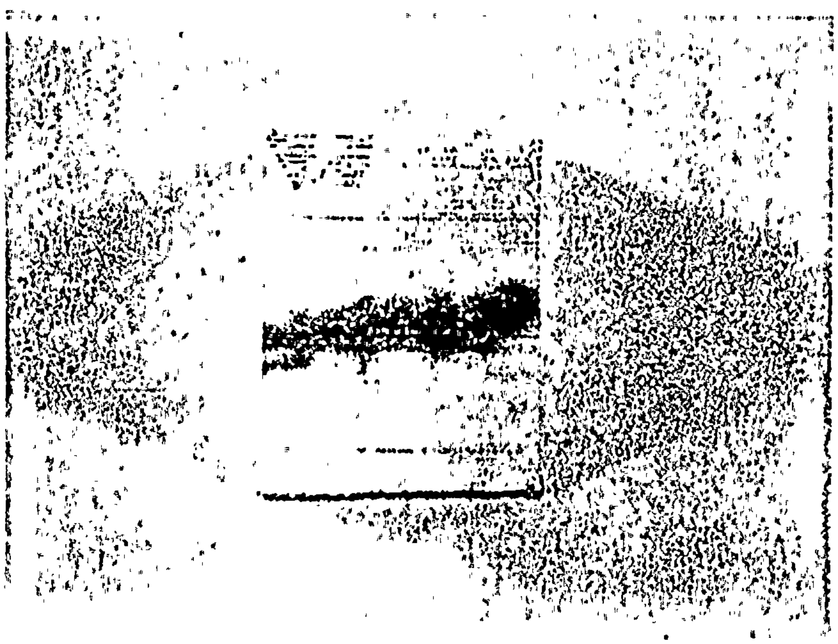
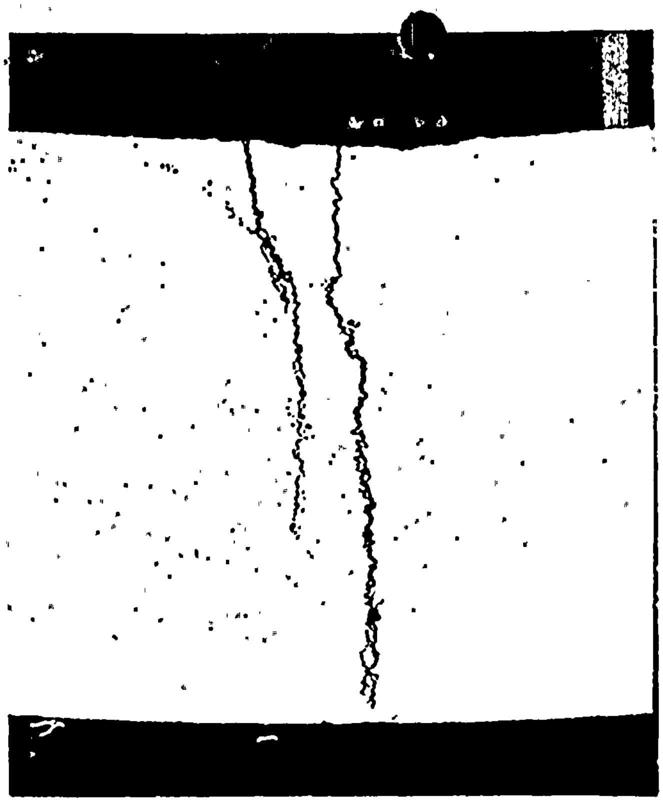


Figure 14. - Section 5, Inside Surface Penetrant Examined.



Inside Surface

Outside Surface

Figure 15. - As Polished 8X
Section 5 Cracks

Figure 16. - Etched, Electrolytic Oxalic Acid 100X

Section 5, Crack on Outside Surface.