CENTRAL FILES

RG&E

ROCHESTER GAS AND ELECTRIC CORPORATION • 89 EAST AVENUE, ROCHESTER, N.Y. 14649

LEON D. WHITE, JR.
VICE PRESIDENT

TELEPHONE
AREA CODE 716 546-2700

July 27, 1979

Mr. Boyce H. Grier, Director
U.S. Nuclear Regulatory Commission
Office of Inspection and Enforcement
Region I
631 Park Avenue
King of Prussia, PA 19496

Subject: IE Bulletin No. 79-13 - Cracking in Feedwater Piping
Thirty (30) Day Report on the Examination, Evaluation and Corrective Action at R.E. Ginna Nuclear Power Plant
Docket No. 50-244

Dear Mr. Grier:

In accordance with IE Bulletin 79-13 and request from Nuclear Regulatory Commission DOR Staff during a meeting on July 24, 1979 we are submitting with this letter a report of the examination, evaluation and corrective actions associated with the examination of R.E. Ginna Nuclear Power Plant's steam generator feedwater nozzle weld examinations. This transmittal is to be considered a thirty (30) day report and documentation of the presentations made at the July 24, 1979 meeting in Bethesda, Maryland.

Very truly yours,

L D White, Jr.

L. D. White, Jr.

Enclosure
xc: U.S. Nuclear Regulatory Commission
Office of Inspection and Enforcement
Division of Reactor Operations Inspection
Washington, D.C. 20555

A002
CCB

7908230093

Response to IE Bulletin No. 79-13 - Cracking in Feedwater Piping and Request by DOR Staff During a July 24, 1979 Meeting Bethesda, Maryland
Thirty (30) Day Report on Examination, Evaluation, and Corrective Action at R. E. Ginna Nuclear Power Plant
Docket No. 50-244
July 27, 1979

In accordance with the requirements of I.E. Bulletin 79-13, Rochester Gas and Electric examined the feedwater nozzle-to-elbow welds of Ginna Station's two steam generators on July 9 and 10, 1979. These examinations consisted of both radiographic and ultrasonic inspections. Both the ultrasonic and radiographic examination data revealed small linear inside diameter indications in the elbows consistent with those reported in Bulletin 79-13 for the plants listed. After confirming the feedwater nozzle cracking problem, the examination scope was expanded as required by the Bulletin to include other feedwater piping welds inside containment upstream from the nozzle-to-elbow welds. These examinations consisted of both visual and radiographic inspection of 18 additional welds. This includes the welds between the steam generator nozzles and one weld past the first support. Included also was the containment feedwater penetration piping welds, which represents the other terminal ends inside containment. These examinations did not reveal any linear indications and confirmed the continued structural integrity of these additional 18 welds. Information on design, materials, fabrication and operation requested by Mr. Victor Stello, Jr. in his May 25, 1979 letter was submitted by our Mr. L. D. White, Jr.'s letter of June 18, 1979.

After removal of the elbows from the feedwater system, liquid penetrant and magnetic particle examinations were performed which revealed some pitting type and cracking indications in the nozzle bore and thermal sleeve machined taper and counterbore. These indications were found in both nozzles with those in the A nozzle being more pronounced than those in the B nozzle.

The cracks in the A and B elbows were determined to be adjacent to the feedwater nozzle-to-elbow welds, in the elbow base material counterbore-taper intersection approximately 1/2 and 3/4 of an inch, respectively from the center line of the weld. Interpretations of the UT and RT data were made as follows:

A Steam Generator - maximum depth of approximately 1/16 inch wall penetration, 300° around the circumference of the elbow.

B Steam Generator - maximum depth of approximately 3/32 inch wall penetration, 360° around the circumference of the elbow.

The preliminary metallurgical analysis has confirmed that these cracks are a result of a corrosion fatigue mechanism with maximum depth in the areas investigated to date as follows:

A Steam Generator - two cracks noted of 0.065 inch and 0.043 inch in depth.

B Steam Generator - one crack noted of 0.107 inch in depth.

This analysis corresponds very well with the ultrasonic examination flaw sizing data. Also noted were multiple cracks along the area of the weld prep counterbore and taper approximately 0.015 inch in depth. Most of these cracks originated in the groove of deep machine situations, approximately 0.010 inch deep.

Due to the appearance of the cracks with the blunt crack tip ends and the fact that they are completely filled with corrosion products, it is postulated that these cracks are old and have not grown recently. Attachments A and B cover the results of preliminary metallurgical analyses of the A and B steam generator elbows, respectively. The A steam generator elbow was analyzed by RG&E materials laboratory personnel while the B steam generator elbow was analyzed by Westinghouse R and D personnel. When a final report on the metallurgical analysis of these cracks is available, the Nuclear Regulatory Commission will be sent a copy.

Based on these analyses, the cause of the base material cracking cannot be definitively known at this time. Potential causes include feedwater chemistry, original heat treatment, thermal fatigue, and synergistic effects of these with normal operating stresses. Feedwater chemistry control has been reviewed and we do not believe that it has contributed to the cracking. Although corrosion pitting was found in the nozzle bore along with the cracking, oxygen control at Ginna has been very good. During normal power operation, oxygen concentrations are less than 1.0 ppb while during hot standby conditions, the feedwater oxygen concentration is controlled to approximately 100-300 ppb.

Other mechanisms are being evaluated. A report on the normal operating stresses is provided at Attachment C. As part of our evaluation to defemine the factors involved in the cracking phenomenon, we are participating in a pipe cracking owners group to study and analyze the cause. This work will be performed by Westinghouse guided by a technical advisory committee from the utilities involved and will consist of both analytical and experimental approaches. Recommendations for permanent corrective actions will be developed as part of the owners group effort.

The corrective actions taken at Ginna have been to build up the nozzle end preps from schedule 60 to schedule 80 and to replace the carbon steel (P1) elbows with schedule 80 chrome-moly (P4) elbows. The replacement has been performed utilizing qualified repair procedures and very precise preheat and post-weld heat

treatment procedures. All pitting, cracks and surface checking inside the nozzle bore were removed by mechanical means. Any areas where minimum wall was encroached were repaired by repair welding in accordance with qualified procedures. These corrective actions are considered a repair and not a modification to the existing configuration of the plant. The replacement chrome-moly (P4) elbows are manufactured to the same Standard Specification, ASTM A-234, and provide greater assurance for the continued structural integrity of the steam generator feedwater nozzle to elbow connection. Therefore, the repair of the cracks found in the nozzles and replacement of the P1 elbows with a P4 material does not represent an unreviewed safety question and does not require a change in technical specifications.

After completing the repair program on the replacement of the feedwater piping to steam generator elbows we will do a final radiographic and ultrasonic baseline examination. This baseline examination data will be used when an inservice examination is made on both nozzle-to-elbow welds and base metal adjacent to the welds at our next refueling outage.

As part of a longer-term effort, we have installed thermocouples on both the A and B steam generator replacement elbows to monitor both feedwater temperature and elbow material temperatures. These thermocouples are installed as shown on Attachments D and E. Four are located on the ID and OD of the A steam generator elbow in the area of the weld prep counterbore and taper transition. The B steam generator has thermocouples located in the same position as the A steam generator but in addition has twelve (12) thermocouples located upstream of the nozzle to elbow weld at strategic locations. Temperature data will be given to Westinghouse to contribute more information to the owners group effort. These data will be utilized to complement data from other units that also have similar instrumentation. We understand that Westinghouse will be providing these data to the NRC on a regular basis.

On July 24, 1979 we met with members of the Nuclear Regulatory Commission DOR and IE Staff in Bethesda, Maryland. During this meeting we discussed Ginna's feedwater system background, the nondestructive examinations performed, the preliminary metallurgical analysis to date, our repair program and the cause investigation into the cracking mechanism. This Report documents the information provided by our personnel during the meeting as requested by NRC staff personnel. Attachment F shows the agenda for this meeting as well as the visual aids that were used during the presentations.

Attachment A

Rochester Gas and Electric Corporation

Inter-Office Correspondence

Ginna Station
July 15, 1979

SUBJECT: Materials Laboratory Analysis of "A" Steam Generator Feedwater Piping Cracks

TO: B.A. Snow

Contained in this report are the initial metallographic observations of a specimen taken from the "A" Steam Generator Feedwater Nozzle to the elbow weld area following the detection of linear indications by ultrasonic and radiographic non-destructive examination methods.

Figure 1 is a composite photograph of a macrosection taken from the Feedwater System elbow and a drawing representation of the nozzle and weld configuration. The two cracks shown on the elbow side of the weld are located from the point of the weld prep counterbore and the transition to the nominal wall thickness of the elbow.

Figure 2, taken looking down on the inside surface of the elbow, is a photograph of the counterbore transitioning to the elbow nominal thickness. Near the bottom of the photo a distinct line can be seen. It is at this point that the cracks begin. The roughness of the machined transition surface should also be noted.

Figures 3 and 4 are forty magnification cross-sectional views of the two detected cracks. Note the roughness of the machined surface and the existence of the cracks at the bottom of the machined cuts where maximum stress can be expected. The depth of the deeper crack measured approximately .065 inches. Note also in Figure 3 the presence of a very small crack (approximately .015 inches) in the upper right corner.

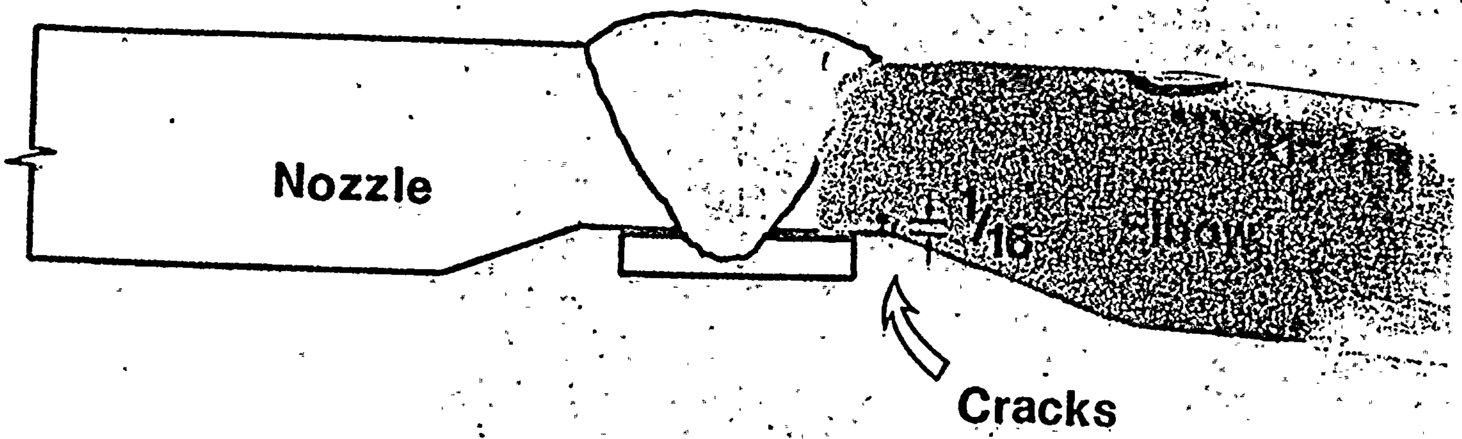
Figure 5 is a 500 magnification photomicrograph of the larger crack's tip. This photo clearly shows the mechanism behind these cracks to be corrosion.

Figure 6 is a view of the internal surface of the crack after the specimen was separated. Note the layered appearance which indicates the gradual progression of the crack.

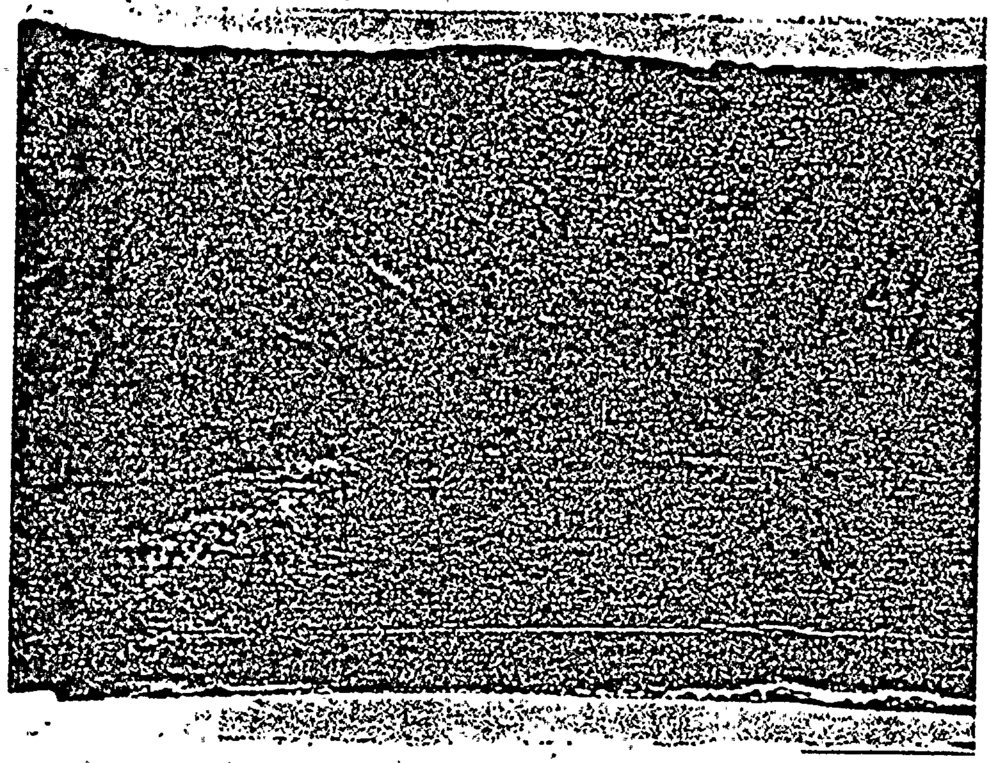
M.J. Saporito
Welding and NDE Specialist

xc: L.D. White, Jr.
J.E. Arthur
T.R. Schuler

Approved:
Albert E. Curtis III
Welding and NDE Engineer

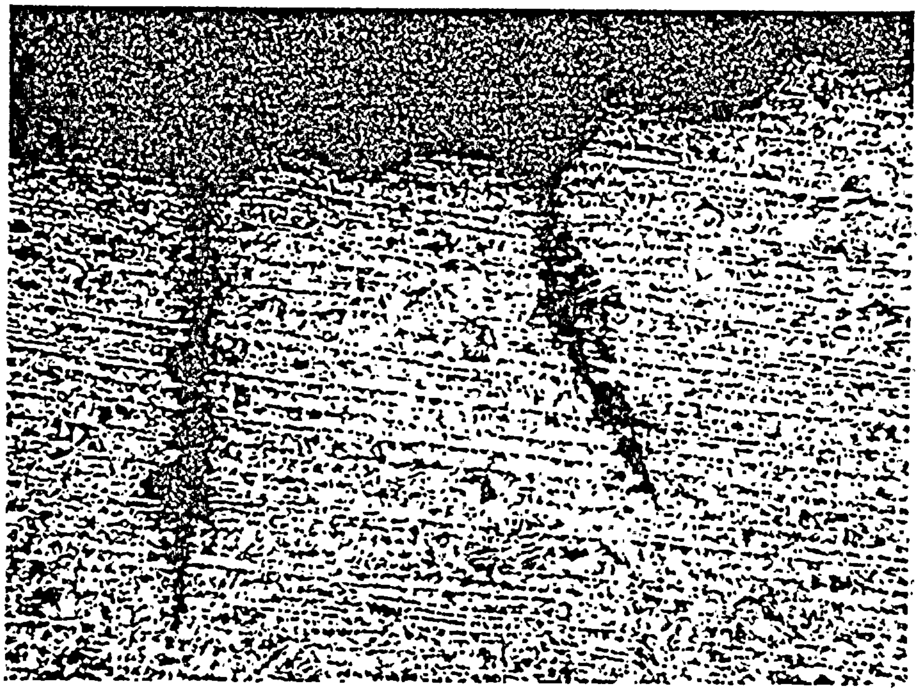


Ginna Sta S/G Feedwater
Elbow Cracks



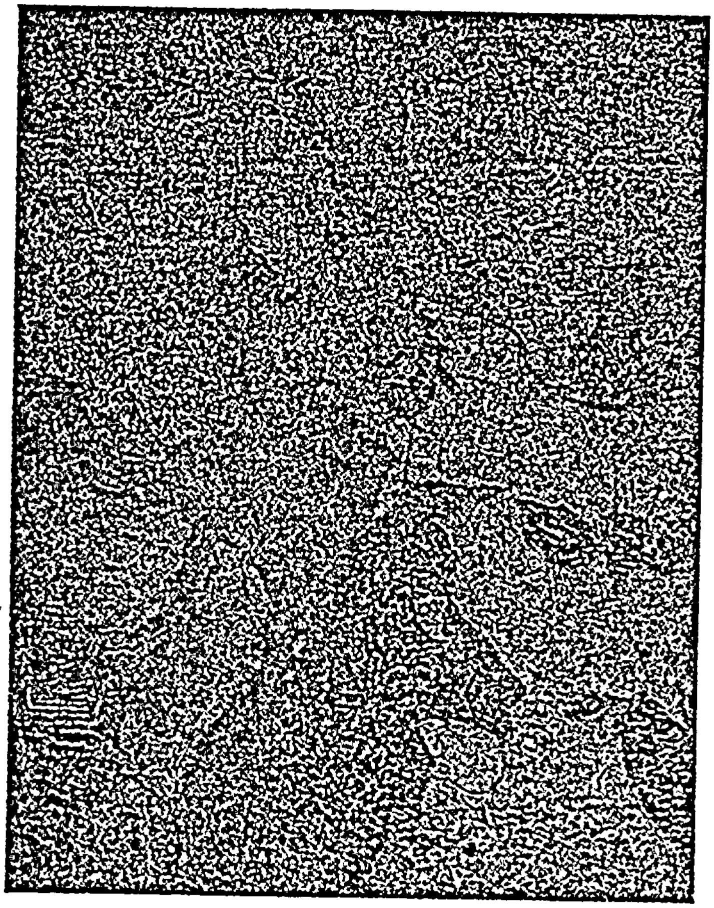
Inside Surface of Elbow .5X
Figure 2

As Polished 40X
Figure 3



5% Niatl Etch 40X.

Figure 4



5% Nital Etch. 500X

Figure 5

Cracks
Internal Surface

Figure 6 30X

Robert Emmett Ginna, Loop B –
Summary of Metallurgical Evaluations

We have examined the cracked elbow section of the Loop B feedwater pipe of the Robert Emmett Ginna Nuclear Station of the Rochester Gas and Electric Corporation using nondestructive inspection techniques, metallography and fractography. We also checked the material for chemistry, strength, and ductile-brittle transition behavior. Following are some of the results obtained:

1. The chemistry of the steel conforms to ASTM specification A 106 Grade B with carbon being 0.28% and Mn 0.86%.
2. The tensile strength was 72 ksi at room temperature and 67 ksi at 440°F with corresponding yield strengths of 39 ksi and 34 ksi.
3. The ductile-brittle transition temperature was near 0°F. Typical Charpy impact values were 7 ft-lbs at -50°F, 174 ft-lbs at room temperature and 179-ft-lbs at 440°F.
4. Multiple cracks were found at a machined section change of the elbow near the elbow-to-nozzle weld joint. Cracks started from deep machining marks and progressed to various depths in the elbow.
5. Maximum crack depth occurred at the 'knee' of the tapered elbow section at the 8:35 o'clock position. The depth here was 0.107 inches.
6. The cracks were filled with oxide scale, were transgranular in nature, and showed horizontal branching along pearlite bands.
7. Opened cracks showed a dark, banded oxide structure.
8. Energy dispersion analysis of X-ray showed some surface deposits containing Cl, Na, K and Cu.
9. Cleaned fracture surfaces showed a multitude of arrest lines (beach marks) corresponding to cracks running at 90° to the fracture surface.
10. Fractographic examination using the scanning electron and transmission electron microscopes showed a relatively flat, corroded topography with microstructural features formed by pearlite.

We conclude that cracking was due to stress concentrations in the form of a section change and deep machining grooves. A nearby weld most likely added to the stress concentration effect by introducing a residual stress in the notches. Progressive cracking then started by stress corrosion or corrosion fatigue.

L. Albertin
Application Metallurgy

July 23, 1979

Attachment C

RG&E NOZZLE STRESS EVALUATION
(Nozzle/Elbow Juncture) (Ksi)

	Dead	Pressure	Norm Op	Hot Shut
Old Arrangement				
Loop 1A	.195	4.898	4.555	4.890
Loop 1B	.190	4.898	5.290	4.181
New Arrangement				
Loop 1A	.262	4.432	6.225	6.699
Loop 1B	.256	4.432	7.19	5.693

HOT STANDBY
THERMAL TRANSIENT DEFINITION

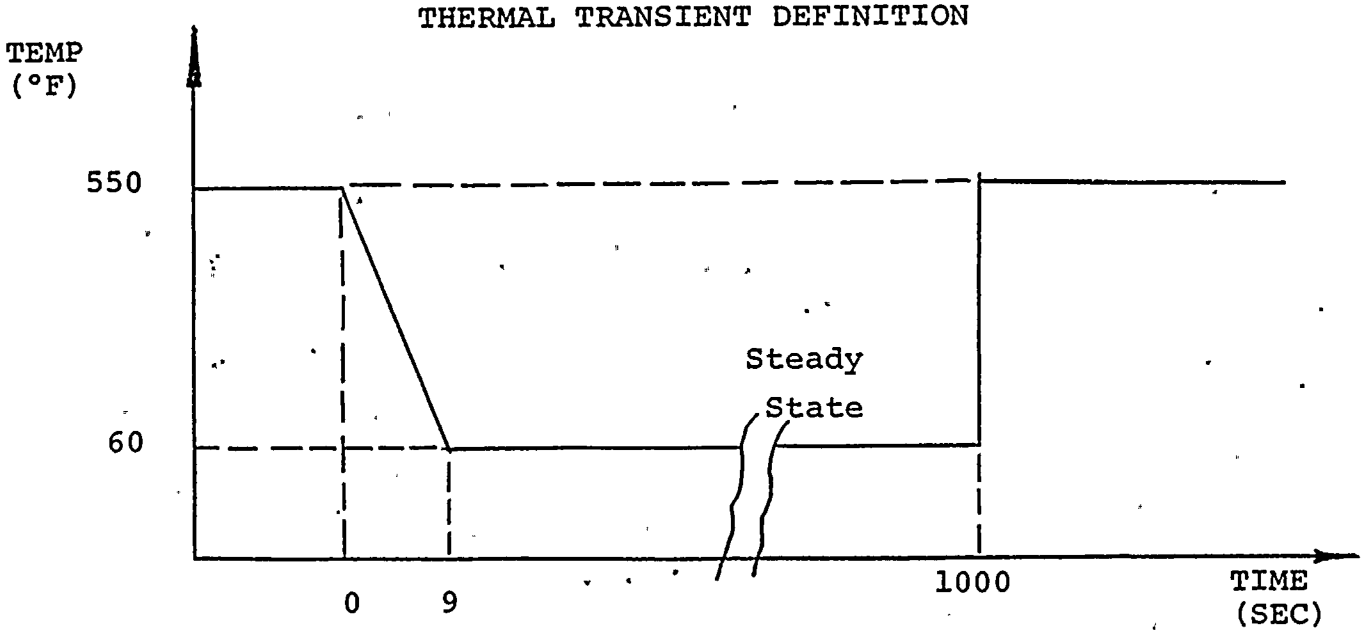
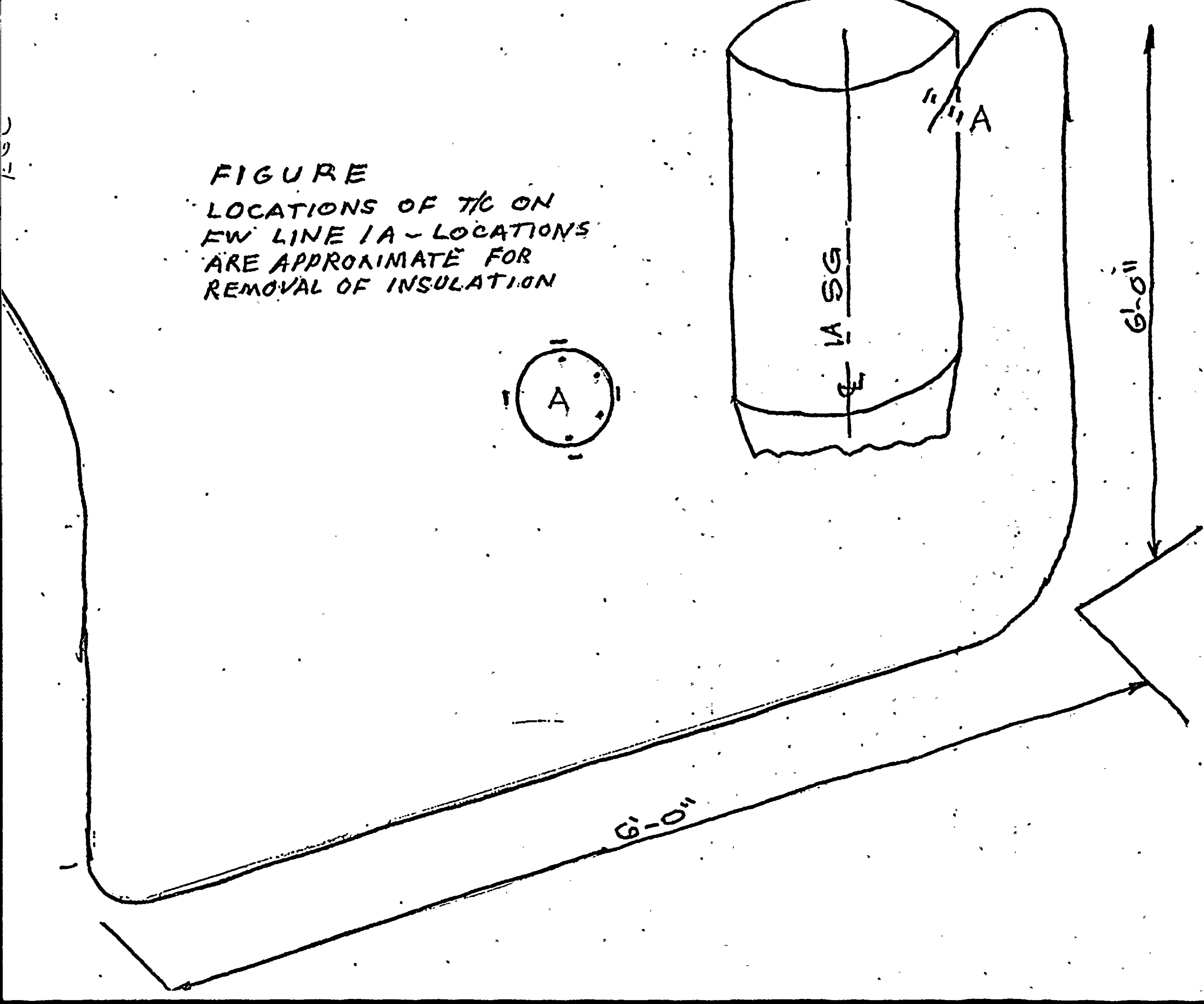


FIGURE
LOCATIONS OF T/C ON FW LINE 1A - LOCATIONS ARE APPROXIMATE FOR REMOVAL OF INSULATION

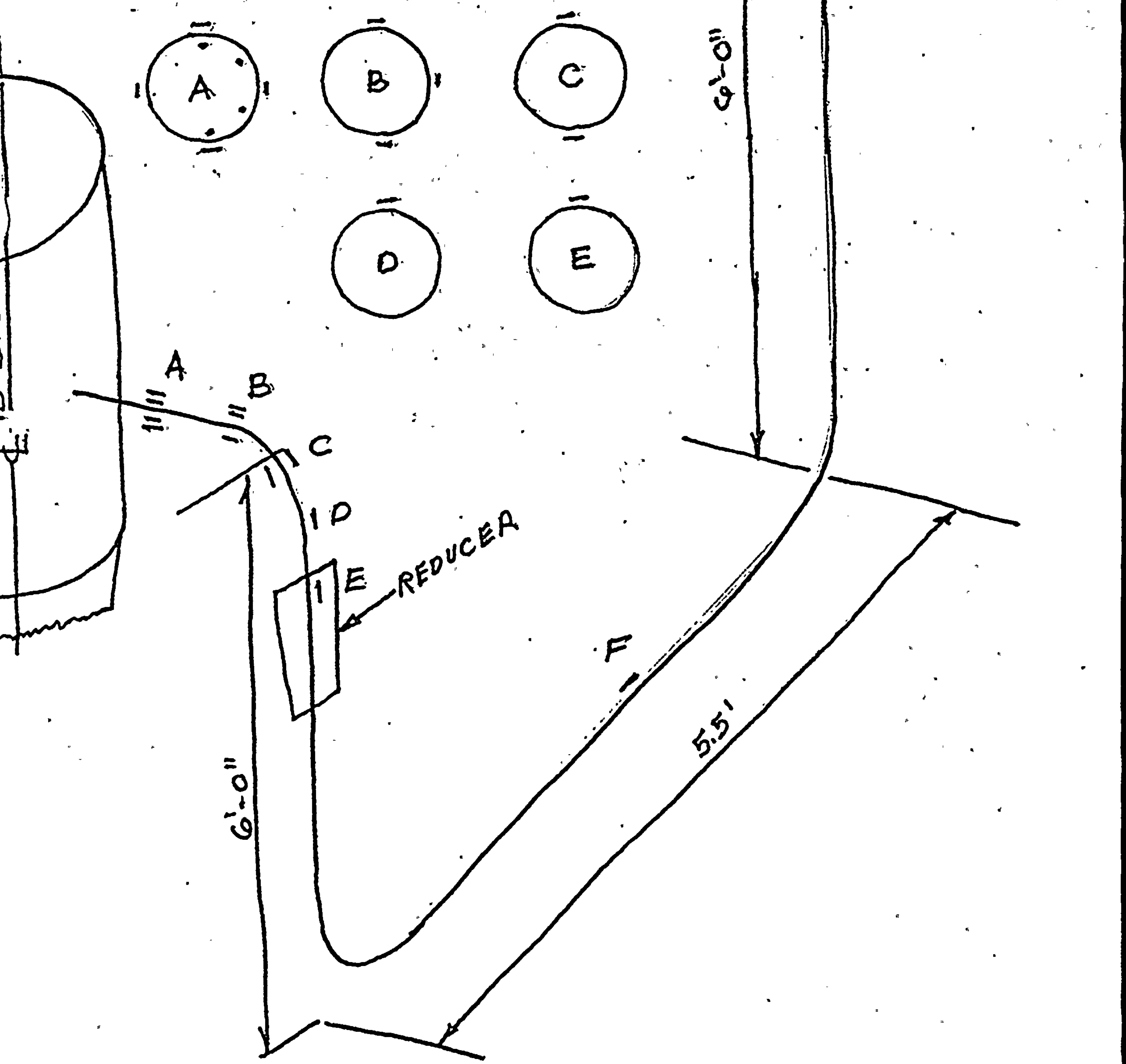


Attachment D

RGE

FIGURE

LOCATIONS OF T/C OF FW LINE 1B - LOCATIONS ARE APPROXIMATE FOR INSULATION REMOVAL



CRACKING IN FEEDWATER SYSTEM PIPING

RG&E/NRC MEETING

BETHESDA, MD

JULY 24, 1979

A. Introduction — J. C. Hutton

- D.C. Cook
- Stello letter
- Westinghouse recommendation
- IE 79-13

B. System Background — J. C. Hutton

- design
- materials
- fabrication
- operation
- stress analysis

C. Nondestructive Examination — A. E. Curtis

- nozzle welds
- piping welds
- nozzle ID

D. Metallurgical Evaluation — A. E. Curtis

- S/G 1A
- S/G 1B
- characterization

E. Repair — A. E. Curtis

- design
- materials
- fabrication
- examination

F. Cause Investigation — A. E. Curtis

- owners group
- instrumentation
- analytical
- experimental

Revision 0
J. Hutton
7/23/79

I. Reason for Feedwater System Inspection

A. NRC IE Bulletin 79-13

B. Westinghouse Recommendation.

II. Feedwater Design Information

A. Configuration - Loop A - Figure B-12
- Loop B - Figure B-13

B. Materials

1. The feedwater ring and thermal sleeve material in ASTM A 106 Grade B.

2. Steam Generator nozzles are SA 336 Code Case 1332, Para. 5a - 5d later incorporated in SA - 508, Class 2.

3. The feedwater piping is ASTM A-106, Grade C, seamless pipe with ASTM A-234, Grade WPB fillings.

C. Welding

1. Nozzle to elbow J-groove, 1/16" land with backing ring GTAW 1st pass fill with SMAW E7018.

2. Piping welds 37-1/2° + 10° Compound bevel 1/16" land K insert GTAW fill with SMAW E7018.

3. Heat treatment 1150 $\pm$ 25° F

III. Nondestructive Examination

A. Nozzle to Elbow VT, RT, UT

B. Bulletin Extention Welds VT, RT

C. Nozzle bore -, PT, MT

D. Under thermal sleeve - RT

IV. Feedwater Chemistry

A. Chemistry History

1. Phosphate type control 12/69 - 10/74

a. pH Control only emphasis

b. Marcy/Halstead Ratio 2.8 - 6.0 Range

2. 71 - 72 M/H Ratio <2.6

3. 73 M/H Ratio ~ 2.1

4. Late 73 M/H Ratio 2.3 - 2.6
a. pH 8.5 - 10.6
b. PO_4 10 - 80 ppm
c. Free OH^--0
d. Cl^- <75ppm

5. 10/74 - 12/77 AVT

6. 12/77 AVT with Condensate Polishers (Deep Bed)
a. Excellent Chemistry
b. Cat. Cond. 0.2 - 0.3 m mhos

B. Oxygen Control

1. Normal Operation <5 ppb

2. Maximum Excursion <40ppb 1 week

3. 7/78 - present <1 ppb

V. Corrective Actions

A. Fitting Replacement

1. Cr - Mo (P4) Material SA-234, WP-11

2. Schedule 80 Welding Ends on Nozzle

3. Repair Procedures

VI. Longterm Actions

A. PWR Feedwater Pipe Cracking Owners Group

B. Refueling Outage Inservice Inspections of Areas