UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

(26)

AUG 2 1983

MEMORANDUM FOR: Robert Baer, Engineering & Technical Support Branch
Division of Engineering & Quality Assurance, IE

THRU: Robert A. Clark, Chief
Operating Reactors Branch #3
Division of Licensing

FROM: Dominic C. DiIanni, Project Manager
Operating Reactors Branch #3
Division of Licensing

SUBJECT: CONCENTRATED BORIC ACID THIN WALL PIPE CRACKS AT PRAIRIE ISLAND UNIT NO. 1 (TIA 83-14)

On January 28, 1983, Northern States Power Company (the licensee) manually shut down Prairie Island Unit No. 1 after declaring the concentrated boric acid line connecting the storage tanks to the safety injection system inoperable. The licensee subsequently met with the NRC staff to describe this problem and his corrective action. The attached meeting minutes provide a summary of that meeting.

A memorandum dated February 4, 1983 from C. E. Norelius to D. G. Eisenhut (copy attached) transferred the responsibility for the resolution of this issue to NRR. The TIA 83-14 dated February 17, 1983 was prepared for this issue and indicates that I&E will consider the generic aspect of this problem. The purpose of this memorandum is to provide material regarding the potential generic aspects of this issue.

We suggest this issue be considered generic for only those PWRs that require the concentrated boric acid system be operable to limit the return to power of the reactor during rapid heat removal from the reactor coolant system during a large steam line break. We attempted, via informal discussions with the licensee, to have industry (Westinghouse & INPO) notify those licensees having plants that fall into this category. As yet industry has not acted on this matter. Although the nature of this problem does not require immediate action, the issue should not be closed out until the plants vulnerable to this problem are notified. It may also be appropriate to forward the attached meeting minutes describing the corrective action taken by NSP that was found acceptable by the staff.

Dominic C. DiIanni

Dominic C. DiIanni, Project Manager
Operating Reactors Branch #3
Division of Licensing

cc: C. Norelius, Reg. III
W. J. Collins, IE
W. Hazelton, NRR
D. Danielson, Reg. III
C. Y. Cheng, NRR
D. Wessman, NRR

8305090321/XA

DATE: FEBRUARY [illegible] 1983
TAC #: Unit 1 - 49571
Unit 2 - 49572

83-14

# TASK INTERFACE AGREEMENT

PROBLEM: Prairie Island 1/2 - Cracking in Boric Acid Piping

LEAD OFFICE: [ ] I&E [X] NRR [ ] REGION [ ] JOINT

NOTIFICATION: Memo to D. Eisenhut fm C. Norelius, 02/04/83, subject: Transfer of Responsibility - Cracking in Boric Acid System Piping

REFERENCES:

ACTION PLAN:

NRR: 1. Review technical & safety aspects of Boric Acid System Piping cracking at Prairie Island. (MTEB lead, CHEB assist)

2. Provide Safety Evaluation to PM (MTEB lead, CHEB assist).

NRR responsible for decision regarding plant restart, scheduled 02/10/83.

Region III: 1. Monitor/inspect licensee's program for repair/modification of boric acid system.

I&E: 1. Review generic aspects of this problem. Initiate appropriate correspondence. (Bulletin, Circular, Notice) if required.

NRR: Designate Lead Project Manager to assign TACS and coordinate correspondence, meetings, and reports (ORB# 3 / LB# - D. DiAnni).

OFFICE COORDINATORS:

T. Ippolito (X27415)

R. Vollmer 2/9/83 (X 27207)

G. Lainas (X 27317)

( X )

( X )

F. Miraglia 2/10/83 (X27492)

NRR

APPROVED:

R. Baer per telecon 2/17/83
I&E

C. Norelius
Region III

cc: V. Stello, ROGR
Regional Admin.
J. Taylor, I&E
E. Jordan, I&E
R. Baer, I&E
W. Mills, I&E
D. Danielson, R-III
J. Collins, IE
J. Sniezek, I&E
R. DeYoung, I&E
C. Michelson, AEOD
H. Denton, NRR
E. Case, NRR
R. Mattson, NRR
H. Thompson, NRR
T. Speis, , NRR
D. Eisenhut, NRR
R. Vollmer, NRR
G. Lainas, NRR
T. Novak, NRR
F. Miraglia, NRR
G. Holahan, NRR
Lead Project Manager
R. Purple, NRR
[redacted]
[illegible] Hazelton, NRR
R. Bosnak, NRR
C. McCracken, NRR

TASK NO.
DATE;
TAC #:

(8)

# TASK INTERFACE AGREEMENT

PROBLEM: Prairie Island 2 - Cracking in Boric Acid Piping

LEAD OFFICE: ☐ I&E ☒ NRR ☐ REGION ☐ JOINT

NOTIFICATION: Memo to DE director from CNorelius dated 2/6/93 subject Transfer of Responsibility - Cracking in Boric Acid System Piping

REFERENCES:

ACTION PLAN:

NRR 1. Review technical and safety aspects of Boric Acid System piping cracking at Prairie Island. (NTEB lead, assist)
2. Provide Safety Evaluation to PM (NTEB lead, assist)
responsibility for — NRR has a decision regarding plant restart, scheduled for 2/10/93.

IE 1. Review generic aspects of this problem. Initiate appropriate correspondence (Bulletin, Circular, Notice) if required

Region II: 1. Monitor/inspect licensees program for repair/modification of boric acid system.

NRR: Designate Lead Project Manager to assign TACS and coordinate correspondence, meetings, and reports (ORB#3 - D. Diani ).

OFFICE COORDINATORS:

T. Ippolito (X27415)

APPROVED:

R. Baer
I&E

C. Norelius
Region- II

R. Vollmer (X27207)

( X )

( X )

G. Lainas (X27849)

F. J. Miraglia (X27492)
NRR

cc: V. Stello, ROGR
Regional Admin.
J. Taylor, I&E
E. Jordan, I&E
R. Baer, I&E
W. Mills, I&E
D. Douglas RII
J. Sniezek, I&E
R. DeYoung, I&E
C. Michelson, AEOD
H. Denton, NRR
E. Case, NRR
R. Mattson, NRR
H. Thompson, NRR
F. Schroeder, NRR
D. Eisenhut, NRR
R. Vollmer, NRR
G. Lainas, NRR
T. Novak, NRR
F. Miraglia, NRR
J Collins IE
G. Holahan, NRR
Lead Project Manager
R. Purple, NRR
R. Wessman, NRR
W Hazelton
R Bernero

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

AUG 2 1983

MEMORANDUM FOR: Robert Baer, Engineering & Technical Support Branch
Division of Engineering & Quality Assurance, IE

THRU: Robert A. Clark, Chief
Operating Reactors Branch #3
Division of Licensing

FROM: Dominic C. DiIanni, Project Manager
Operating Reactors Branch #3
Division of Licensing

SUBJECT: CONCENTRATED BORIC ACID THIN WALL PIPE CRACKS AT PRAIRIE ISLAND UNIT NO. 1 (TIA 83-14)

On January 28, 1983, Northern States Power Company (the licensee) manually shut down Prairie Island Unit No. 1 after declaring the concentrated boric acid line connecting the storage tanks to the safety injection system inoperable. The licensee subsequently met with the NRC staff to describe this problem and his corrective action. The attached meeting minutes provide a summary of that meeting.

A memorandum dated February 4, 1983 from C. E. Norelius to D. G. Eisenhut (copy attached) transferred the responsibility for the resolution of this issue to NRR. The TIA 83-14 dated February 17, 1983 was prepared for this issue and indicates that I&E will consider the generic aspect of this problem. The purpose of this memorandum is to provide material regarding the potential generic aspects of this issue.

We suggest this issue be considered generic for only those PWRs that require the concentrated boric acid system be operable to limit the return to power of the reactor during rapid heat removal from the reactor coolant system during a large steam line break. We attempted, via informal discussions with the licensee, to have industry (Westinghouse & INPO) notify those licensees having plants that fall into this category. As yet industry has not acted on this matter. Although the nature of this problem does not require immediate action, the issue should not be closed out until the plants vulnerable to this problem are notified. It may also be appropriate to forward the attached meeting minutes describing the corrective action taken by NSP that was found acceptable by the staff.

Dominic C. DiIanni

Dominic C. DiIanni, Project Manager
Operating Reactors Branch #3
Division of Licensing

cc: C. Norelius, Reg. III
W. J. Collins, IE
W. Hazelton, NRR
D. Danielson, Reg. III
C. Y. Cheng, NRR
D. Wessman, NRR

TAC #: Unit 1 - 49571
Unit 2 - 49572

# TASK INTERFACE AGREEMENT

83-14

PROBLEM: Prairie Island 1/2 - Cracking in Boric Acid Piping

LEAD OFFICE: [ ] I&E [X] NRR [ ] REGION [ ] JOINT

NOTIFICATION: Memo to D. Eisenhut fm C. Norelius, 02/04/83, subject: Transfer of Responsibility - Cracking in Boric Acid System Piping

REFERENCES:

ACTION PLAN:

NRR: 1. Review technical & safety aspects of Boric Acid System Piping cracking at Prairie Island. (MTEB lead, CHEB assist)

2. Provide Safety Evaluation to PM (MTEB lead, CHEB assist).

NRR responsible for decision regarding plant restart, scheduled 02/10/83.

Region III: 1. Monitor/inspect licensee's program for repair/modification of boric acid system.

I&E: 1. Review generic aspects of this problem. Initiate appropriate correspondence. (Bulletin, Circular, Notice) if required.

NRR: Designate Lead Project Manager to assign TACS and coordinate correspondence, meetings, and reports (ORB# 3 LB# - D. DiAnni).

OFFICE COORDINATORS:

T. Ippolito (X27415)

APPROVED:

R. Baer per telecon 2/9/83

I&E

W.A. C. Norelius

Region- III

R. Vollmer 2/9/83 (X 27207)

G. Lainas (X 27017)

( X )

( X )

F. J. Miraglia 2/10/83 (X27492)

NRR

cc: V. Stello, ROGR
Regional Admin.
J. Taylor, I&E
E. Jordan, I&E
R. Baer, I&E
W. Mills, I&E
D. Danielson, R-III
J. Collins, IE
J. Sniezek, I&E
R. DeYoung, I&E
C. Michelson, AEOD
H. Denton, NRR
E. Case, NRR
R. Mattson, NRR
H. Thompson, NRR
T. Speis, , NRR
D. Eisenhut, NRR
R. Vollmer, NRR
G. Lainas, NRR
T. Novak, NRR
F. Miraglia, NRR
G. Holahan, NRR
Lead Project Manager
R. Purple, NRR
[redacted]
R. Hazelton, NRR
R. Bosnak, NRR
C. McCracken, NRR

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

APR 1 8 1983

D Eisenhut
Lee 4/20

Docket Nos. 50-282
and 50-306

LICENSEE: Northern States Power Company

FACILITY: Prairie Island Unit Nos. 1&2

On February 8, 1983, the NRC staff met with Northern States Power Company (the licensee) in Bethesda, Maryland to resolve the issue of the crack indications found in the concentrated boric acid line connecting the boric acid storage tanks to the safety injection system (SIS) of Prairie Island Nuclear Generating Plant Unit No. 1. The licensee on Friday, January 28, 1983, declared the safety injection system inoperable because of these crack indications and Unit No. 1 was manually shut down. The purpose of this meeting was to show the basis for declaring the concentrate boric acid line operable and thus permit the restart of the Prairie Island Unit 1. A list of attendees is attached (Attachment 1).

The meeting opened with presentation of the agenda (Attachment 2). The following areas were discussed:

1. Plant Condition, System Function & Component Failure
2. Examination of the Defective Pipe
3. Fracture Mechanics
4. Analysis of Pipe Sample
5. Repairs
6. Evaluation for Operability

1. Plant Condition, System function & Component Failure

Several crack indications were found in the weld areas of the concentrated boric acid supply line that connects the 600 gallon storage tanks to the safety injection system. During normal plant operations this line contained 12% stagnant boric acid. The boric acid line is approximately 214 ft long, 8 inches in diameter, schedule 10 (~0.148 in. thick), 304SS and contains 77 welds. This line is normally under low pressure (~ 10PSI) and is heat traced to 180°F.

Unit No. 1 was manually shut down on January 28, 1983 when the line was declared inoperable. The concentrated boric acid system is used only to limit the return to power of the reactor during the rapid heat removal from the reactor cooling system during a large steam line break. Such an accident requiring the concentrated boric acid also assumes that the most active shut off rod has not entered the core, the accident occurs near the end of core life and one of the safety injection pumps is inoperable.

8304270188

A tiny through wall crack was found in a weld area of the line that was reported to the staff in LER 82-029/0IT-0. Subsequent investigations led to the discovery of other leaks and crack indication when all of the weld areas were examined by ultrasonic testing. The cracks were located in the annealed base metal of the heat affected zone that did not show a significant degree of sensitization.

The licensee observed crack indications only in stagnant lines. However the licensee found no crack indications in the boric acid storage tank or in other lines having more frequent circulation. Nominal amounts of contaminants can be concentrated in stagnant lines by evaporation due to excessive heating and settling effects. In addition, air bubbles can collect in these oxygenated lines. This suggests that stagnation is a major factor in this cracking.

2. Examination of Pipe Welds.

The licensee examined all of the welds (total of 77) in the 8 inch boric acid line utilizing ultrasonic techniques. The basic pulse-echo procedures were used in accordance with Appendix III of ASME Section XI 1974 Edition thru the summer 1976 addenda. The inspection team consisted of personnel certified in accordance with ANSI-TC-1A levels I & II. The results of this examination revealed that 16 welds (20.8% of total weld) had intermittent circumferential indications and 3 welds (3.9% of total) contained spot/axial indications. The licensee stated the ultrasonic techniques employed provided conservative and adequate capabilities for detecting stress corrosion cracks in this system. Based on the presentation given by the licensee and our review of the licensee's submittal on this matter, we agree that the use of ultrasonic techniques as described by the licensee provides reasonable assurance that all stress corrosion cracks in the weld areas have been identified.

3. Fracture Mechanics

The licensee performed a flaw evaluation to determine the maximum crack size in the weld areas that would reduce the margin of safety below the code allowable stress levels. The pipe conditions and loads that were used in the analysis consisted of the following:

Temperature $\leq 250^{o}F$

pressure $\sim$ 10 PSI

pipe loads $\sim$ 1/3 of allowable

The analysis presumed thru wall circumferential cracks in locations where there would be the worst case membrane or bending stresses. The results of the analysis performed in two locations showed allowable flaw lengths of 10 and 12 inches when subjected to stress levels of 6900 and 5000 PSI respectively. Based on this analysis the licensee concluded that the observed cracks in the weld area do not reduce the load carrying margins of safety below the Code Allowable stress levels. The staff agrees with this assessment.

4. Analysis of the Pipe Sample

The licensee removed a section of pipe and requested Westinghouse to perform a metallurgical examination of the crack indications. The scope of work consisted of surface, metallographic and fractographic examinations and a chemistry evaluation. This examination revealed the nature of the leak and crack indications to be transgranular stress corrosion cracking (TGSCC). TGSCC is caused by synergistic effects of contaminants (i.e., chlorides, sulfates and flourides), operating stress and residual tensile stresses introduced by welding and grinding. The chemistry evaluation showed the contaminants as 79 to 110 PPM chlorides, 114 to 204 PPM sulfates and 10 to 84 PPM flourides. The sulfates levels and to some degree the chlorides levels are high enough to attack the 304SS when combined with high residual stress levels and the tensile stress caused by cold work and grinding at the weld areas. Two possible sources of these contaminants are: contaminated batch of boric acid or the concentration of contaminants due to resin intrusion in the recycling system. The metallographic surface examinations indicated grinding and deformation adjacent to the welds which,in the presence of the contaminants, provides initiation sites and creates stress slip bands which are preferentially attacked by the stress corrosion cracking mechanism.

The major stresses in this system are the welding residual stresses. This, combined with the cold work introduced during installation and grinding at welds, suggests that piping adjacent to welds is the first area to be attacked. Therefore, piping adjacent to welds is likely to be the only area attacked by TGSCC that approaches an extent which could reduce the design safety factor of the line.

5. Repairs

All nineteen weld joints showing crack indications (as identified by ultrasonic examinations) were reinforced with reinforcing pads or sleeves. The design of the pads or sleeves is similar to reinforcement required for fabricated branch connections in ANSI B.31.1 Power Piping. The reinforcement sleeves and pads were installed around the pipe covering the crack indication areas and were fillet welded to the pipe. In addition sections of pipe removed for analysis are replaced with sections designed in accordance with ANSI B.31.1 code. The repairs and welding were conducted in accordance with ASME Code Section XI 1980 Edition with addenda thru the Summer 1982. The completed fillet welds were inspected by liquid penetrant techniques. Butt welds were inspected by radiographic and liquid penetrant techniques. Inspection methods and criteria were in accordance with the ASME Code Section XI 1974 Edition with addenda thru the summer of 1976. Finally the repaired system was hydrostatically tested to 1.5 times the design pressure.

6. Evaluation for Operability

The staff concurs with the licensee's finding that the concentrated boric acid line has been restored to an operable status. The basis for this conclusion is as follows:

1. The licensee has demonstrated with a reasonable degree of confidence that all crack indications have been identified.

2. The pipe repairs at 19 locations, as described by the licensee, assure that the pipe line is restored to its original design strength.

3. Flushing operations prior to returning the line to service, showed a decrease in the dissolved contaminants in the water samples after several flushes.

4. To ensure that the line will not be subject to future stress corrosion cracking the licensee committed to the following;

   (a) The boric acid will normally be recirculated (90% of the time) thus preventing contaminants from concentrating in an otherwise stagnant line.

   (b) Contaminants (i.e., chlorides, sulfates) will be more closely monitored with the addition of a new analytical chemistry technique (ion-exchange chromatography) having a 10 PPB detection limit.

5. The licensee has committed to replace the line on Unit 1 prior to the start up of cycle 10 (January 1985). In the interim the licensee committed to conduct monthly visual inspections of the line and to ultrasonically examine 10 welds every six months.

6. The ultrasonic examination of the concentrated boric acid line servicing Unit 2 revealed no crack indications. However, the licensee committed to the provisions of item 4 above and to conduct monthly visual inspections.

The licensee has demonstrated the operability of the concentrated boric acid system. Therefore the Prairie Island Nuclear Generating Plant Unit No. 1 can safely resume power operation.

Dominic C. DiIanni
Project Manager
Operating Reactors Branch #3
Division of Licensing

MEETING SUMMARY DISTRIBUTION

Licensee: Northern States Power Company

*Copies also sent to those people on service (cc) list for subject plant(s).

Docket File
NRC PDR
L PDR
NSIC
ORB#3 Rdg
ORB#3 Summary File
JHeltemes
BGrimes
RAClark
Project Manager
PMKreutzer
OELD
ELJordan
JMTaylor
ACRS-10
NRC Participants

PRAIRIE ISLAND UNIT NO. 1

BORIC ACID LINE CRACK INDICATION

FEBRUARY 8, 1983 MEETING

Attendees

Dominic DiIanni - PM NRR

| | | | |
|---|---|---|---|
| C. Y. Cheng | MTEB/NRR | P. C. Riccardella | NUTECH |
| W. J. Collins | IE/NRR | Gary Miller | NSP |
| W. S. Hazelton | MTEB/NRR | Barry L. Dickerson | Fluor Eng., Inc |
| B. D. Liaw | MTEB/DE/NRR | Greg Krause | NSP |
| W. J. Shack | Argonne National Lab. | Michael T. Anderson | NSP |
| Conrad McCracken | CMEB/DE/NRR | Paul Wu | CMEB/NRR |
| Tom Parker | NSP | Ed Watel | NSP |
| R. A. Clark | ORB#3/NRR | C. W. Rowland | Westinghouse |
| W. J. Key | Reg. III-NRC Reactor Inspector | Lee Spessard | Reg. III |
| D. H. Danielson | Reg. III | J. T. Crane | Westinghouse |
| Gutti Rao | Westinghouse | | |

PRAIRIE ISLAND - NRC MEETING

FEBRUARY 8, 1983

BORIC ACID LINE CRACKING

I. INTRODUCTION

ED WATZL - NSP - PRAIRIE ISLAND PLANT MANAGER
TOM PARKER - NSP - LICENSING ENGINEER

A. DESCRIPTION AND FUNCTION OF SYSTEM
B. HISTORY

II. EXAMINATION OF PIPE

MIKE ANDERSON - NSP - MATERIAL AND SPECIAL PROCESS ENGINEER

A. TECHNIQUE
B. RESULTS
C. CONCLUSIONS

III. FRACTURE MECHANICS

DR. PETE RICCARDELLA - NUTECH - SR. ENGINEERING DIRECTOR
DAVE PITCAIRN - NUTECH - ENGINEERING DIRECTOR, MATERIALS

A. METHOD
B. CRITICAL CRACK SIZE

IV. ANALYSIS OF PIPE SAMPLE

DR. GUTTI RAO - WESTINGHOUSE - SENIOR ENGINEER
JOHN CRANE - WESTINGHOUSE - SENIOR ENGINEER
CHUCK ROLAND - WESTINGHOUSE - PROJECT ENGINEER

A. TYPE OF CRACKING
B. EXTENT OF CRACKING
C. CONTAINMENT

V. REPAIRS

GARY MILLER - NSP - PRAIRIE ISLAND SUPERINTENDENT
OPERATIONAL ENGINEERING

GREG KRAUSE - NSP - MATERIALS AND SPECIAL PROCESSES ENGINEER
BARRY DICKERSON - FLUOR - PRINCIPLE MECHANICAL ENGINEER

A. DESIGN
B. SPECIFIC APPLICATIONS
C. MATERIAL, PROCEDURES, ETC.

VI. OPERABILITY

ED WATZL - NSP - PRAIRIE ISLAND PLANT MANAGER

A. SUMMARY
B. SURVEILLANCE