NRC FORM 173
(2-78)

U.S. NUCLEAR REGULATORY COMMISSION

ORDER NUMBER
20-82-283

DATE APR 0 8 1982

STANDARD ORDER FOR DOE WORK

ISSUED TO: (DOE Office)	ISSUED BY: (NRC Office)
Richland Operations Office	Office of Nuclear Reactor Regulation, DE

PERFORMING ORGANIZATION AND LOCATION
Battelle Pacific Northwest Laboratory
Richland, WA

FIN TITLE
Evaluation of Three Mile Island, Unit No. 1 Steam Generator Corrosion

ACCOUNTING CITATION

APPROPRIATION SYMBOL
31X0200.202

B&R NUMBER
20-19-10-11-2

FIN NUMBER
B2506-2

WORK PERIOD - THIS ORDER

FIXED ☐	ESTIMATED ☒
FROM 1/25/82	TO 5/31/82

OBLIGATION AVAILABILITY PROVIDED BY:

A. THIS ORDER	$ 0
B. TOTAL OF ORDERS PLACED PRIOR TO THIS DATE WITH THE PERFORMING ORGANIZATION UNDER THE SAME "APPROPRIATION SYMBOL" AND THE FIRST FOUR DIGITS OF THE "B&R NUMBER" CITED ABOVE	$ 3,396,000
C. TOTAL ORDERS TO DATE (TOTAL A & B)	$ 3,396,000
D. AMOUNT INCLUDED IN "C" APPLICABLE TO THE "FIN NUMBER" CITED IN THIS ORDER	$ 20,000

FINANCIAL FLEXIBILITY:

☐ FUNDS WILL NOT BE REPROGRAMMED BETWEEN FINS. LINE D CONSTITUTES A LIMITATION ON OBLIGATIONS AUTHORIZED.

☒ FUNDS MAY BE REPROGRAMMED NOT TO EXCEED ± 10% OF FIN LEVEL UP TO $50K. LINE C CONSTITUTES A LIMITATION ON OBLIGATIONS AUTHORIZED 1/ SEE BELOW

STANDARD TERMS AND CONDITIONS PROVIDED DOE ARE CONSIDERED PART OF THIS ORDER UNLESS OTHERWISE NOTED.

ATTACHMENTS:
THE FOLLOWING ATTACHMENTS ARE HEREBY MADE A PART OF THIS ORDER:
- ☐ STATEMENT OF WORK
- ☐ ADDITIONAL TERMS AND CONDITIONS
- ☐ OTHER

SECURITY:
- ☐ WORK ON THIS ORDER IS NOT CLASSIFIED.
- ☐ WORK ON THIS ORDER INVOLVES CLASSIFIED INFORMATION. NRC FORM 187 IS ATTACHED.

REMARKS:
This order approves Dr. Digby McDonald as a subcontractor to PNL on this work and changes the period of performance at no additional cost to the NRC.

After acceptance, please send to the NRC Office of the Controller, ATTN: D. Dandois, and provide a copy to the Office of Nuclear Reactor Regulation, ATTN: D. Corley.

ISSUING AUTHORITY	ACCEPTING ORGANIZATION
SIGNATURE Richard H. Vollmer, Director 4/8/82	SIGNATURE
TITLE Division of Engineering, NRR	TITLE
	DATE

NRC FORM 173 (2-78) 1/ Reprogramming limited to changes on FINs within the same B&R Number and the same Appropriation Symbol. In order for this reallocation to be effective, this office must be notified within 5 days so that an appropriate NRC Form 173 can be issued and counter-signed to complete the action prior to receipt of any bills.

(13) XA 8204200442

J. Gray
OELD

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

APRIL 16 1982

Docket No. 50-289

FACILITY: Three Mile Island, Unit No. 1 (TMI-1)

LICENSEE: GPU Nuclear Corporation (GPU)

SUBJECT: SUMMARY OF MEETING WITH GPU ON APRIL 7, 1982 CONCERNING STEAM GENERATOR TUBE PROBLEMS ON TMI-1

Background

In late November 1981, while the plant was in a cold shutdown condition, primary to secondary leakage was detected in the Once Through Steam Generators (OTSGs). GPU's investigation of this problem has revealed that there are 8-10,000 tubes with defects as determined by eddy current testing (ECT). GPU has conducted a comprehensive program in the areas of ECT, tube failure analysis, and tube repair techniques. The purpose of this meeting was to update the staff on the results of GPU's program since the last meeting on January 25, 1982 and to brief the staff on the proposed repair technique. Copies of GPU's presentation and a list of attendees are enclosed.

Discussion

GPU has completed the majority of the effort related to determining the extent and cause of the tube failures. The extent of the attack within the OTSGs has been almost entirely limited to the top 2-3 inches of the tubes within the 24 inch tubesheet near the roll transition area. Only about 2% of the total defects fall below the 3 inch level as measured from the top face of the upper tubesheet (UTS). The majority of the defects are located near the outer periphery of the tube bundle although there is an assymmetry in the defect locations between the "A" and "B" OTSGs in the radial direction which cannot presently be explained.

With regard to the failure mechanism, GPU's failure analysis effort concluded that the "right" conditions of sensitized material subjected to relatively high stress (residual plus operational) and exposed to an aggressive chemical environment were needed to cause the corrosion. The failures were caused by stress assisted intergranular corrosion initiated from the ID surface resulting in circumferential intergranular cracks. The aggressive chemical species was sulfur in a reduced form although carbon and chloride were also present as contaminants on the tube surfaces. GPU's failure analysis effort has been a very comprehensive program involving: 1) an extensive metallographic and chemical laboratory analysis of portions of 19 removed tubes; 2) an OTSG fabrication history review including heat treatments and stress history; 3) an operational history review of the past 3 years to determine how sulfur entered the Reactor Coolant System (RCS) and other operational indicators which may have contributed to the problem; and 4) review of industry experience with intergranular stress corrosion cracking of Inconel 600. Other important con-

A186

8204260329
PDR ADOCK

clusions from the failure analysis effort indicate that: 1) the eddy current examination is a reliable indicator of crack location; 2) uncracked tubing still exceeds minimum tube specifications and 3) corrosion tests in actual primary coolant indicate that the coolant is currently innocuous.

GPU formulated the following proposed failure scenario which is consistent with their investigation results. Sulfate and thiosulfate[1] were inadvertently added to the RCS during the shutdown period. Reduced sulfur species formed during hot functional testing in August and September 1981. Following plant cooldown when the RCS water level was lowered, a high concentration of aggressive sulfur species formed in the dryout region and cracking occurred in this region. The cracking then terminated due to a reduction in concentration.

With respect to the steam generator repair method, GPU intends to expand the tubes below the present roll area in order to close the existing crevice area and then establish a new leak limiting/load carrying hard roll at the 8-10 inch level in the tubesheet. By this method, the vast majority of the defects would be above the new primary to secondary seal. Any tubes with defects below this rolled area would be plugged. This procedure has the benefits of allowing use of remotely operated tooling resulting in lower man rem exposure, allow continued NDE of repaired tubes, and permit sleeve installation if that is later determined to be necessary. Using this repair procedure, GPU perdicts that the repairs could be completed and the plant ready for operation by October 1982. Prior to commencing repairs, a comprehensive qualification program will be undertaken. Since the repair method involves mechanical joints, some amount of primary to secondary leakage is possible, but leakage must remain within the Appendix I and other Technical Specification limits. Even if it is assumed that large numbers of tubes fail within the UTS, the cumulative failure would remain within the design basis tube rupture accident envelope.

GPU intends to perform a complete internal review under the provisions of 10 CFR 50.59 and will have the internal safety review reassessed by GPU's General Office Review Board (GORB) as well as an external independent review group.

With respect to the potential that the corrosion attack may have affected other RCS materials, GPU outlined their intended inspection program. To date, they have classified all RCS materials as to their corrosion susceptibility and have developed an inspection plan which calls for use of various NDE techniques as well as some destructive laboratory testing.

---

[1] Sulfuric acid, which provides sulfate, may have entered the RCS during an event in 1979. Thiosulfate entered the RCS from valve leakage from the sodium thiosulfate tank associated with the Reactor Building Spray System and then subsequent system cross connection.

The inspection of the reactor vessel internals is scheduled to begin this week.

Richard H. Jacobs, Project Manager
Operating Reactors Branch #4
Division of Licensing

Enclosures:
1. List of Attendees
2. GPU Presentation
cc w/enclosures:
See next page

ORB#4:DL

MEETING SUMMARY DISTRIBUTION

Licensee: GPU Nuclear Corporation

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

Docket File
NRC PDR
L PDR
ORB#4 Rdg
TNovak
JStolz
Project Manager-RJacobs
Licensing Assistant-RIngram
OELD
Heltemes, AEOD
IE-3
SShowe (PWR)
Meeting Summary File-ORB#4
RFraley, ACRS-10
Program Support Branch

ORAB, Rm. 542
BGrimes, DEP
SSchwartz, DEP
SRamos, EPDB
FPagano, EPLB

FCombs	HOrnstein
KWichman	EBrown
RVollmer	ABates
WJohnston	BLiaw
CMcCracken	JGray
PMatthews	JCutchin
EIgne	PWu
PGrant	WCollins
CSellers	EMurphy
DHaverkamp	FYoung

Enclosure 1

LIST OF ATTENDEES - MEETING WITH GPU NUCLEAR

APRIL 7, 1982

STEAM GENERATOR TUBE PROBLEMS AT TMI-1

NRC

D. Eisenhut
R. Vollmer*
T. Novak
W. Johnston
J. Stolz
C. McCracken
R. Jacobs
P. Matthews
E. Igne
H. Ornstein
E. Brown
A. Bates
B. Liaw
J. Gray
J. Cutchin
P. Wu
W. Collins
E. Murphy
P. Grant
C. Sellers
D. Haverkamp
F. Young

*part time

GPU

P. Clark
H. Hukill
R. Wilson
R. Long
D. Slear
E. Wallace
J. Colitz
M. Graham
D. Cowfer
R. Barley
S. Giacobbe
F. Trowbridge, Counsel
T. Baxter, Counsel

Other Attendees

W. Dornsife, Commonwealth of Pa.
S. Maingi, Commonwealth of Pa.
C. Gardner, GAO
D. Leighton, Leighton Ass., Inc.
P. Hinsburg, Inside NRC
L. Connor, Doc. Search, Ass.
J. Reisland, EPRI
R. Borsum, B&W

NRC Consultants

C. Dodd, ORNL
R. Dillon, PNL
D. MacDonald, Ohio State

GPU Consultants

J. Pearson, B&W
R. Kosciba, B&W
S. Weems, MPR
R. Jones, EPRI