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October 21, 1988
JAFP-88-0965

United States Nuclear Regulatory Commission
Mail Station PI-137
Washington, DC 20555

Attention: Document Control Desk

Dear Sirs:

Subject: Additional Information on Internal Vessel Core Spray Pipe Crack

On Tuesday, October 11, 1988, the Authority briefed the NRC staff on a crack in an internal vessel core spray pipe. The crack was detected while performing a visual examination during FitzPatrick's refueling outage in accordance with IEB 80-13. The briefing described FitzPatrick core spray system, details of the crack, the repair program, and the safety implications in both the as-found and future condition. To assist in the discussion, a notebook entitled "J. A. FitzPatrick Core Spray In-Vessel Pipe Crack Briefing" was provided to the NRC staff members. As a result of this meeting, the Authority agreed to provide original and repair design stress values to the NRC and to visually inspect the shroud plate manway covers and to U.T. the other side of the cracked weld.

On Thursday, October 13, 1988, during a phone conversation between the Authority and NRC personnel (Abelson, Koo, LaBarge, et. al.), the NRC staff was provided new information regarding the crack and repair program. In particular, the crack is actually located in a slightly different location than originally discussed.

This letter formally transmits the originally requested stress information and the revised information concerning this crack. Attachment 1 is a revised drawing which shows the actual location of the crack based on the initial visual exam. Attachment 2 provides a drawing which shows the actual crack orientation based on ultrasonic inspection performed October 16, 1988, prior to repair. Attachment 3 summarizes how the original identification error was made. Attachment 4 provides a summary of the revised repair program. Attachment 5 provides a drawing of the revised repair. Attachment 6 provides a summary of the results of other inspections performed in-vessel. Attachment 7 provides the stress information on the original and repaired piping. Attachment 8 provides a copy of the repair safety evaluation.

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Since the cracked weld is unique and an ultrasonic examination of the pipe-to-elbow weld located above the cracked weld revealed no indications, no further in-vessel ultrasonic examinations were considered necessary. For this reason and due to ALARA considerations, no additional exams were performed. Future in-vessel visual inspections will continue during refueling outages as presented during the October 11, 1988 meeting.

If there are any questions, please contact Tom Moskalyk at (315-349-6505).

R. Converse

RADFORD J. CONVERSE

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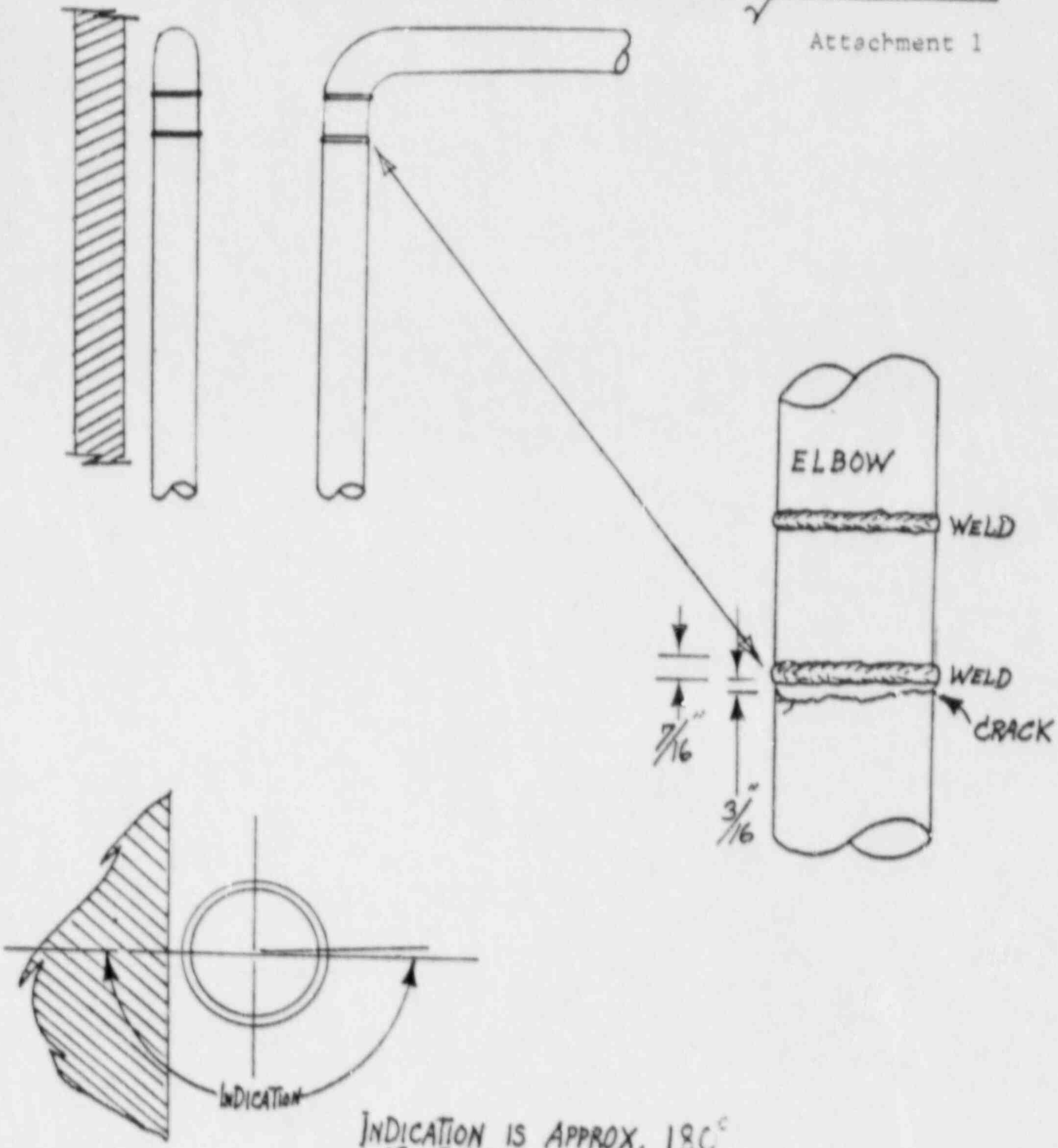
190° AZIMUTH CORE SPRAY RISER

Attachment 1

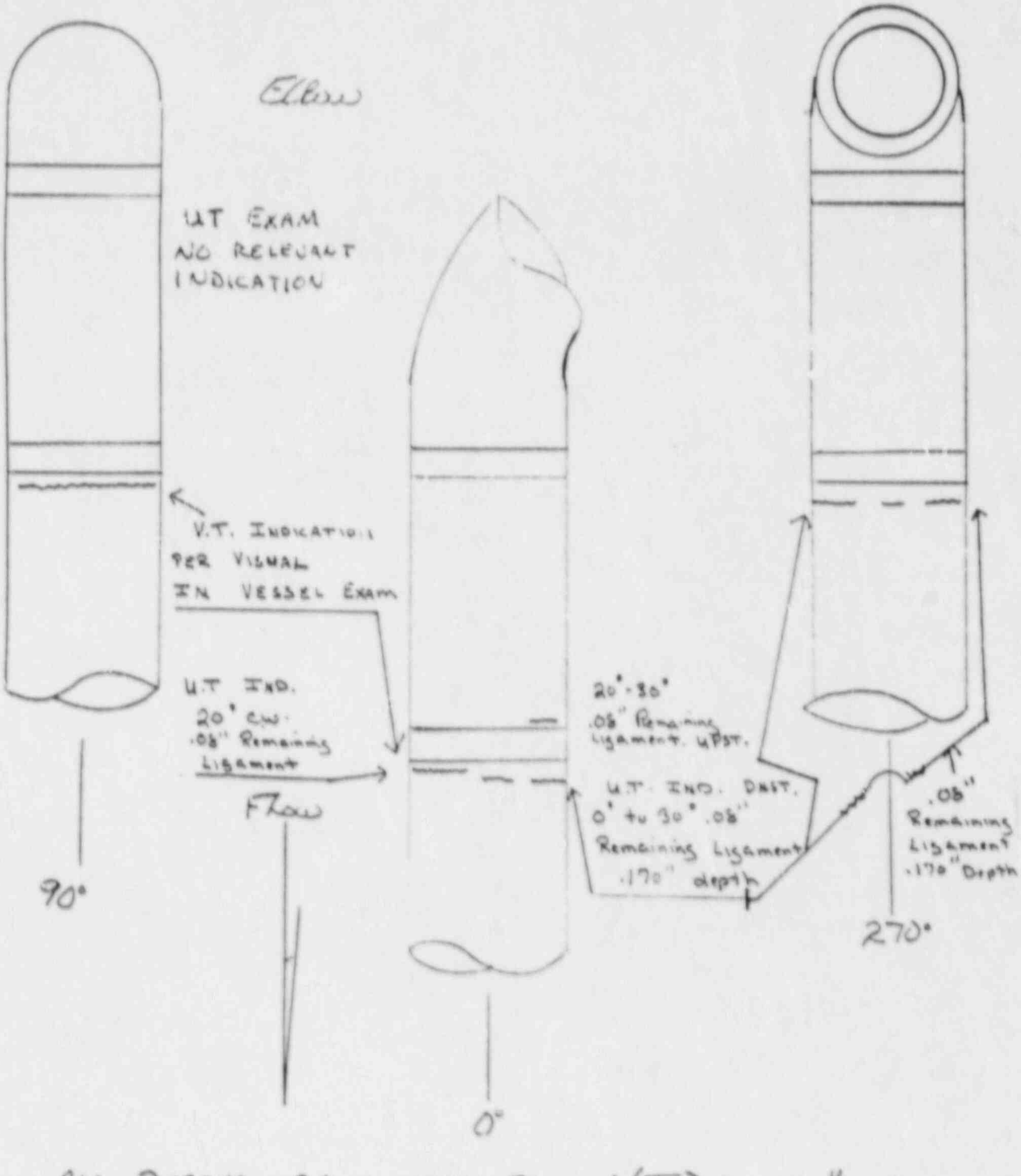


INDICATION IS APPROX. 180°
OF CIRCUMFERENCE

NOT TO SCALE

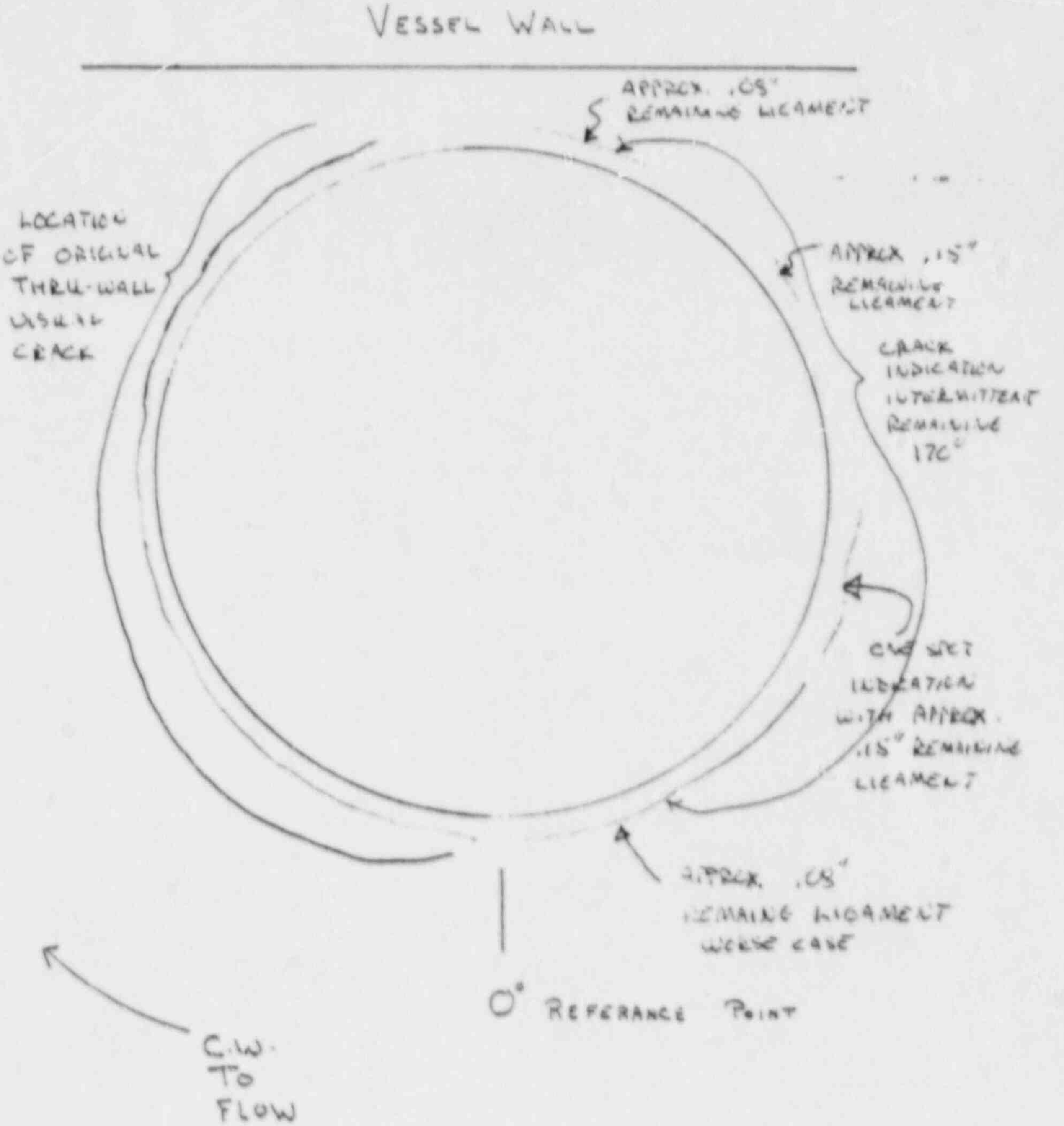
ATTACHMENT 2

JAF Core Spray 190° - Azimuth
of the Reactor Vessel



ALL DEPTHS CALCULATED FROM : (T) = .250"

ATTACHMENT 2 (Cont'd.)



ATTACHMENT 3

A. <u>Reason for Additional Weld</u>

The internal core spray rise pipe has, as shown below, a 5° bend in the pipe to allow for proper installation between the shroud and vessel wall. The shop fabricated pipe, when originally delivered on site, had 3 lengths with elbows in one direction and 1 length with an elbow in the other direction rather than 2 of each. As a result, a General Electric Disposition Instruction was issued which directed the cutting of one of the 3 pipes a minimum of 2 inches below the elbow to pipe weld, reversing the elbow direction and rewelding of the pipe. Thus an additional field weld approximately 6 inches below the elbow to pipe weld was created. This is different than the standard GE installation and may be unique in the industry. Of note, this additional field weld is the only pipe-to-pipe field weld and does provide a reason for the crack being located on the one pipe section.

B. <u>Reason for Misidentification</u>

During the 1988 Refuel Outage visual examination, the inspection team examined all welds on the core spray pipe and initially recognized that an additional weld was present on the affected pipe segment. Once the crack was located, upon further detailed inspections, the inspection team referred to the location as the 190° azimuth pipe to elbow weld. The repeated use of this reference and subsequent video camera concentration on only the crack introduced an error carried over into drawing preparation. Since this configuration is unique and no detailed plant drawings showed this weld, the mistake was carried throughout engineering and the NRC presentation. Subsequent review of the video tapes to finalize engineering and work planning revealed the error.

C. Review of Earlier Inspections

In conjunction with the revision of the repair program, a detailed drawing of the internal vessel core spray piping was produced and a review of prior IEB 80-13 inspection video tapes was conducted. Knowing the exact location of the crack, the review of the 1987 outage video tape revealed an indication. This was originally thought to be the "toe" of the weld. A detailed comparison of the 1987 indication and 1988 crack identified that the indication was in fact an earlier stage of the crack. Of note, a full flow test of core spray system injection was satisfactorily performed at the beginning of the 1988 Refuel Outage. Review of earlier exams revealed that no inspections were performed on this particular weld.

ATTACHMENT 4

SUMMARY OF IN-VESSEL CORE SPRAY PIPE REPAIR

Following the completion of refueling operations, the activities for the repair of the "B" core spray header pipe commenced. A summary of the details is provided.

Plant Conditions

Beginning with the vessel water level below the top flange, a hydrolasing rig was used to decontaminate the wall of the vessel. Water level was reduced as the circular rig was lowered into the vessel by the Reactor Building crane. The activity continued until the water level was lowered to approximately 72 inches above top of active fuel.

A temporary operating procedure (TOP-98) was written specifically to maintain level control in the vessel. The other train of core spray was available for auto-injection at a setpoint of 48 inches above top of active fuel.

Work Platform and Rigging

A shielded work bucket was obtained for this work. This work bucket measures approximately 4'-0" x 4'-0" x 7'-0" high and weighs approximately 10,000# loaded. This structure was designed by GE in accordance with NUREG 0612 requirements for a similar in-vessel piping activity at another facility.

The work bucket was rigged for a four point lift for stability and is a suspended type of work platform. This work bucket accommodated one or two workers and was lowered and lifted by the Reactor Building crane auxiliary hook with 20-ton capacity. The work bucket has a 23" x 24" opening located 6" above the floor. This opening provided sufficient clearance to perform the repair activity to the vertically oriented 5-inch diameter Core Spray pipe.

Modifications were made to the bucket to provide an optimum standoff from the reactor vessel wall for repair access. Additional shielding was provided on the sides and top of the opening to reduce the dose from the Feedwater Sparger line that is located about 24 inches above the work area. When in position, the work bucket was approximately 6 inches above the water surface.

An umbilical line for services including breathing air, compressed air, weld lead, and exhaust air was provided and left in place during the duration of the repair activity.

An aluminum frame protective net composed of lightweight wire mesh and covered with Herculite and welding cloth material was suspended and positioned below the work area at the water surface for the purpose of catching any debris or tools that could have dropped from the work area. The catch net covered an area of approximately 100 square feet and conformed to the vessel inside diameter.

Repair Details

The crack in the pipe was visually noted to be approximately 180°-190° circumferential in the heat affected zone on the lower side of the pipe-to-pipe weld located approximately 6 inches below the elbow-to-pipe weld on the 190° azimuth riser. Subsequent ultrasonic examination revealed that the crack intermittently extended the remaining 180° on the I.D. with worse case remaining ligaments of .08"-.15" (refer to Attachment 2). Ultrasonic examination on the other side of the weld revealed a 20-30 degree internal crack with .08" remaining ligament. In both cases, the cracks revealed IGSCC ultrasonic signal characteristics.

The repair consisted of a "clamshell" arrangement composed of 6 inch, schedule 80 pipe (0.432 inch wall), 4 inches long. The material is ASTM A-312, Type 316L. The clamshell was cut in two, approximately 180° halves, and was positioned on the existing 5 inch, schedule 40 pipe with the affected weld in the middle of the 4 inch long clamshell. Both cracks were completely covered by the clamshell. The inside diameter of the clamshell was approximately 0.2 inches larger than the outside diameter of the 5 inch Schedule 40 pipe, thus providing sufficient clearance for fit-up.

At the location of the crack, the Core Spray line has a clearance with the reactor vessel wall of approximately 1.25 inch, thus providing limited access for welding. ER 308L weld electrode was used for the stainless steel piping welds. The welds consisted of a circumferential fillet weld tying into the existing 5 inch pipe at the upper end, a circumferential fillet weld to the pipe at the lower end, and two full-penetration longitudinal groove welds along the sides. Due to restricted accessibility, the circumferential welds were approximately 300°. By design, this was adequate to provide sufficient structural integrity.

Liquid penetrant exams were not performed prior to welding on the pipe surface due to concern of materials entering into the crack with no means of removal. This could aggravate future stress corrosion cracking. Ultrasonic testing was performed on the crack to better define the dimension and to better characterize the crack as being caused by IGSCC. In addition, the heat affected zone below the pipe-to-elbow weld and the piping where the new circumferential welds were to be located were ultrasonically inspected for integrity. Upon completion of the welding, a visual inspection meeting the requirements of ASME Section III, Subsection NG-5000 was conducted.

Welders were qualified in a full-scale mock-up to replicate the restricted conditions.

Radiological Impact

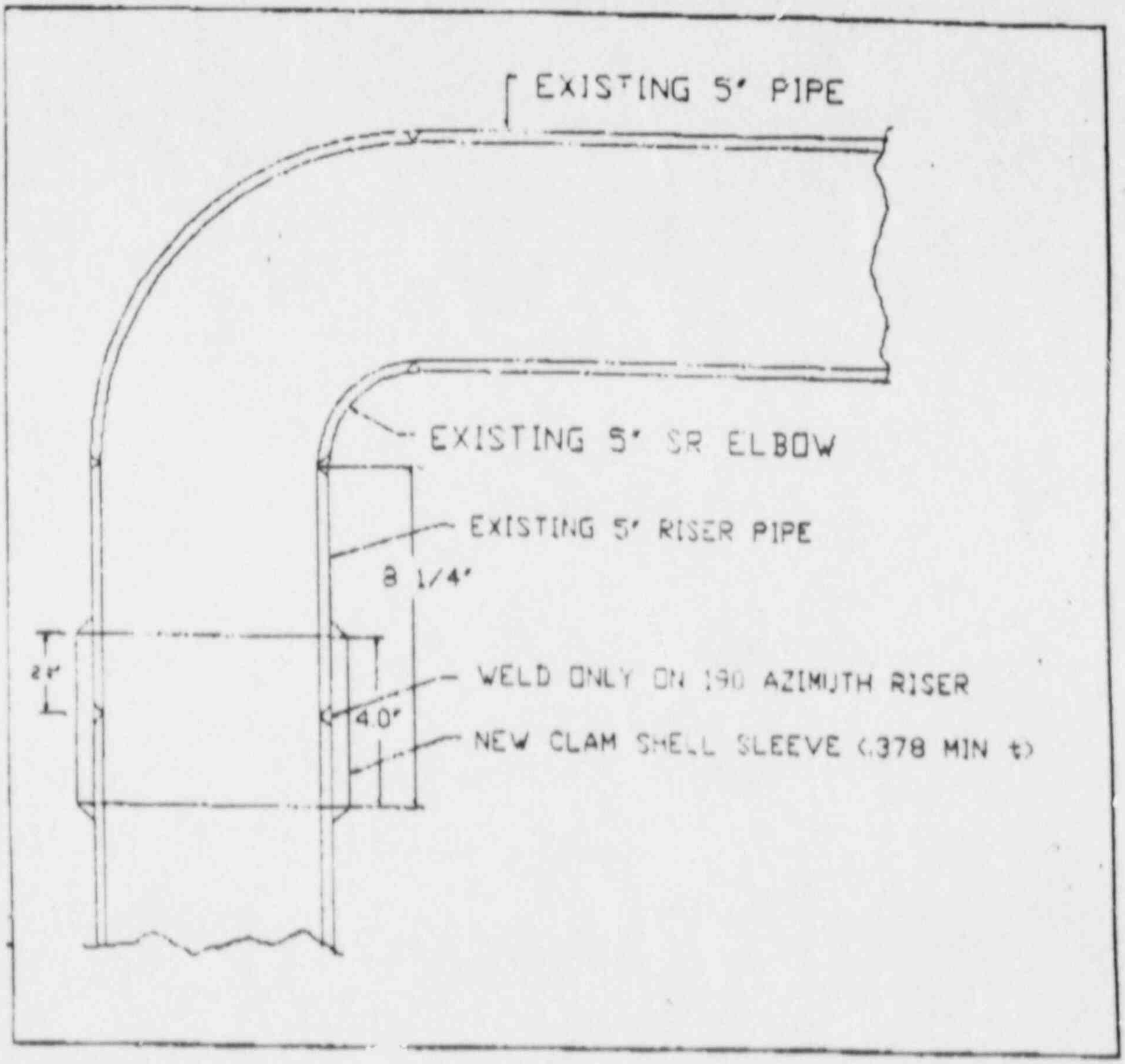
Radiation exposure estimates were developed using data from in-vessel work at Peach Bottom, Brunswick, Duane Arnold, and the Feedwater sparger replacement at FitzPatrick in 1978.

Specific actions to maintain personnel exposures ALARA included the decontamination of the RPV wall and the use of the shielded box, modified with additional shielding to minimize doses from the Feedwater sparger. Other ALARA measures included the use of tele-dosimetry to provide continuous monitoring of personnel doses, closed circuit TV monitoring, the use of local ventilation to control airborne radioactivity, wireless headset communications, local shielding on core spray header and elbow, and the use the suspended lead blankets.

NEW YORK POWER AUTHORITY
JAMES A. FITZPATRICK NUCLEAR POWER PLANT

Attachment 5

Repair of Core Spray Pipe with Clamshell Sleeve



ATTACHMENT 6

SUMMARY OF 1988 IN-VESSEL INSPECTIONS

A. Visual

1. Core Spray Spargers (all) - acceptable

2. Core Spray Support Brackets (all) - acceptable

3. Core Spray Header Supports (all) - acceptable

4. *Core Spray Headers other 3 - acceptable

5. Top Guide Hold Down Bolts (all) - acceptable

6. Top Guide Cell 26-27 & 22-27 - acceptable

7. CRD Nozzle Inner Radius - acceptable

8. Jet Pumps 1, 10, 11, 20 Riser Brace to Vessel Weld and Instrumentation - acceptable

9. **Shroud Plate Manway Covers (both) - acceptable

10. ***Final Visual of Clamshell Repair - acceptable

B. UT

1. Jet Pump Beams (all) - acceptable

2. ****Core Spray "B" 190 Azimuth Header Pipe-to-Pipe Weld at Crack Location - 360° ID crack of which about 190° through wall

3. ****Core Spray "B" 190 Azimuth Header Pipe-to Pipe Weld Above Crack - inside crack approximately 2 inches long

4. ****Core Spray "B" 190 Azimuth Pipe-to-Elbow Weld - acceptable

Notes

* Core spray headers reinspected following discovery of additional weld.

** Shroud plate manway covers inspected following meeting with NRC on October 11, 1988.

*** Final visual exam of clamshell repair performed after repair on October 17, 1988.

**** Core spray header piping ultrasonic inspection performed October 16, 1988 prior to clamshell weld repair.

ATTACHMENT 7

2.0 CORE SPRAY PIPE STRUCTURAL INTEGRITY

The structural integrity of the core spray piping and repair were reviewed to assess: a) the probable crack mechanism, and b) the structural integrity of the core spray piping with clam shell repair applied. Structural analyses were performed to determine the stresses due to various sources and the stress results were compared with the ASME Section III allowables.

The preponderance of information indicates that the most likely mode of cracking was due to an IGSCC mechanism. The results of the assessment and structural evaluation are provided in the following section.

2.1 Potential Cause for Cracking

Cracking in piping can be either due to fatigue or intergranular stress corrosion cracking (IGSCC). The internal core spray piping is not subjected to any significant fatigue cycling. However, the weld location where cracking was observed is subjected to the sustained weld residual stress, is sensitized due to the thermal cycling caused by welding, and is exposed to the oxidizing environment similar to that of the reactor core. Since the three necessary contributors for IGSCC are present at the crack location and fatigue loading is minimal, the likely cause for cracking is IGSCC.

The applied stress is almost entirely due to the weld residual stress. Weld sensitization and surface grinding if any, could produce material susceptibility. Finally, the environmental condition inside the core spray internal piping is more severe than that in the recirculation piping due to the presence of stagnant water that contains non-condensable gases that escape through the vent hole at the top. Once initiated on the inside surface, crack extension can occur under IGSCC aided by accelerated water chemistry conditions in the pipe.

In addition, review of the video tape indicates that the crack behavior around the vicinity of the pipe is similar to IGSCC behavior.

The cracking appeared to propagate similar to an IGSCC and unlike a straight transgranular crack due to fatigue loading.

2.2 STRUCTURAL INTEGRITY

2.2.1 Summary

The internal core spray piping is not a pressure boundary component and was designed using the ASME code as a guide. The original design basis for the core spray piping was to meet the primary stress limits of the ASME Section III, 1965 Edition with addendum to Winter 1966. The analysis presented here confirms that the clam shell repair meets the original requirements conservatively.

With the exception of weld residual stress, all identified stresses expected during normal reactor operation and core spray operation were found to be well within ASME Code allowable limits. Based upon a review of these stresses, it is concluded that the structural integrity of the piping with the clam shell repair, will be maintained during core spray injection. The stresses considered include those due to downcomer flow impingement loads, seismic loads, pressure, deadweight and thermally induced loads.

Although the normal operating loads alone do not result in stresses which are sufficient to cause IGSCC initiation, the addition of the weld residual stresses coupled with local cold work could result in exceeding the initiation threshold. Once initiated the weld residual stresses provide the driving force for throughwall cracking.

2.2.2 Structural Evaluation of Clam Shell Fix

To determine the integrity of the clam shell fix an evaluation was performed considering stresses during a potential SSE event with core spray operation and stresses during normal plant operation. In addition, thermal stresses due to differential expansion of the vessel and shroud were determined. Stresses in the core spray piping arise due to pressure, downcomer flow impingement, core spray flow operation, deadweight, expansion differences between the vessel and shroud, and limiting seismic event stresses.

Stresses in the core spray piping due to bracket restraint are governed by the applied displacement and the compliance of the pipe.

2.2.2.1 Analysis and Results

To determine the structural integrity of the core spray line with the clam shell fix several evaluations were performed. Two different finite element models were used for the evaluation. One model was used to determine the seismic, deadweight, downcomer flow impingement stresses, and stress due to thermal and pressure expansion differences between the vessel and shroud. The second was to determine the pressure and core spray flow induced stresses. The analyses and results are discussed in the following sections.

Beam Finite Element Model

The beam finite element model was used to determine the seismic, deadweight, downcomer flow impingement, and thermal and pressure expansion stresses. The ANSYS finite element program was used for the evaluation (Reference 1). The finite element model is shown in Figure 1. It should be noted that at the clam shell section no credit was taken for the original pipe. As demonstrated in the figure, appropriate boundary conditions were applied at the core spray bracket locations, core spray nozzle to safe end junction, and core spray piping/sparger/shroud connection. The lam shell was simulated by applying the appropriate cross sectional properties to the beam at the clam shell location in the finite element model.

Loads due to the weight of the pipe (including captured water in the pipe) were applied to the model along with vertical and horizontal seismic loads. The stresses at the location in the finite element model where the clam shell was simulated was obtained for combination with other stresses.

Th ose cases corresponding to the limiting core spray service conditions were run to determine the different stress contributions. These are summarized below:

1) Downcomer flow impingement + seismic + deadweight
2) Downcomer flow impingement + deadweight
3) Stress due to vessel/shroud thermal and pressure expansion differences

To determine the expansion stress (case 3), two conditions were evaluated. The first assumes normal plant operation. The second considered core spray operation. The assumed conditions are shown below for the two cases:

1) Vessel Temperature = 550 degrees F
   Shroud Temperature = 550 degrees F
   Core Spray Pipe Temperature = 526 degrees F
   Pressure = 1050 psi

2) Vessel Temperature = 550 degrees F
   Shroud Temperature = 550 degrees F
   Core Spray Pipe Temperature = 40 degrees F
   Pressure = 265 psi

These conditions were applied to the beam model shown in Figure 1.

Axisymmetric Finite Element Model

The axisymmetric finite element model was used to determine the pressure and core spray flow operation induced stresses. Figure 2 shows the finite element model. Note that no credit is taken for any of the original core spray line pipe. The original pipe is removed and the entire load is assumed to be taken by the clam shell and the weld of clam shell to original pipe. Although the actual thickness of the clam shell is higher, the repair specification allowed a minimum thickness of 0.318 in. near the weld location. Furthermore, it was conservatively assumed that because of access limitations only 5/6th of the circumference would be welded. With this correction, the equivalent thickness for the clam shell was calculated as (0.318x5/6) or 0.265 inch.

The expected pressure difference during core spray operation was applied to all internal surfaces. In addition the injection load due to core spray flow was also applied as shown in Figure 2.

Stress Results

The summary of the stress results is shown in Table 1. See Figure 3 for locations referenced in Table 1.

Table 2
Stress In Repaired Pipe (With Clam Shell Repair)

	Stress (ksi)			
	Location 1 Original Pipe		Location 2 Clam Shell	
Source	Memb	Bend	Memb	Bend
Pressure + Core Spray Flow				
Axial Stress	1.41	2.5	1.21	2.5
Hoop Stress	1.97	0.8	0.97	0.78
Seismic + Downcomer Flow (Axial) Impingement + Deadweight	-.07	0.59	-.05	0.36
Downcomer Flow Impingement (Axial) + Deadweight	-.061	0.51	-.04	0.31
Thermal stress (Axial)				
Normal Operation	-1.52	14.03	-1.09	8.42
Core Spray Operation	-0.18	1.51	-.13	0.91

2.2.4 Design Criteria

The existing in vessel piping was fabricated in accordance with the requirements of General Electric Purchase Specification 21A1056. Since the core spray piping in the reactor vessel is classified as a non-code component, the design was not required to meet code requirements. Nevertheless, the 1965 edition with winter 1966 addendum of Section III of the ASME code was used as a guide for the internal core spray piping design.

The repair components are classified as non-code components. However, the design and analysis process has used ASME Section III sub-section NB as a guide.

The stresses were evaluated at two locations as shown in Figure 3. Location 1 is in the original pipe material. Location 2 represents the weld between the original pipe and the clam shell. Since this weld is subjected to visual examination only, a conservative weld quality factor of 0.35 was used based on Table NG-3352-1 of the code. Use of this weld quality factor from Sub-section NG of Section III is conservative since the internal core spray line is not a core support structure. Thus, at location 2 the allowable values of Section III sub-section NB were multiplied by the weld quality factor.

2.2.5 Comparison with Allowables

In this section the stresses obtained from the various analyses are compared with ASME Code allowables. In addition, the stresses for the original pipe design are compared with those for the clam shell fix design. This demonstrates that both the original and repair design meet the intent of Section III of the ASME Code.

Per ASME Code Section III Subsection NB, the stress limitations are:

$P_m < S_m$ $\qquad$ $P_m + P_b < 1.5S_m$ $\qquad$ $P + Q < 3S_m$

where, P_m = primary membrane stress intensity,
P_b = primary bending stress intensity,
Q = secondary stress intensity,
S_m = ASME code design stress intensity

Applying the weld quality factor to this criteria gives (for clam shell material)

$P_m < .35S_m$ $\qquad$ $P_m + P_b < .525S_m$ $\qquad$ $P + Q < 1.05S_m$

The values for S_m from the Winter 1966, and 1986 ASME Code are given below (at 550° F):

Original material, 304 stainless (Winter 1966): S_m = 16000psi
(1986): S_m = 16950psi
Clam Shell material 316L stainless steel (1986): S_m = 13950psi

The allowables are therefore:

Location 1, original material (Winter 1966 limiting)

P_m < 16000psi $P_m + P_b$ < 24000psi $P + Q$ < 48000psi

Location 2, clam Shell material (1986)

P_m < 4883psi $P_m + P_b$ < 7324psi $P + Q$ < 14648psi

Note that the use of the Winter 1966 allowable is limiting for the original Type 304 stainless steel material.

The primary and secondary stresses are summarized in Table 3 below.

Table 3
Stress Results and Allowables

Stress Category	Stress Value(ksi)	Allowable(ksi)
Primary Membrane		
Location 1	1.97	16.0
Location 2	1.16	4.88
Primary Membrane + Bending		
Location 1	4.43	24.0
Location 2	4.02	7.32
Primary + Secondary		
Location 1	16.1	48.0
Location 2	9.86	14.68

As can be seen from Table 3, all stress values are well below the allowable even with the weld quality factor applied to the allowables.

Fatigue loading on the core spray line is not a concern and was not specifically addressed. The expected fatigue loading is not significant and the addition of the clam shell will not impact fatigue loading. Therefore, fatigue usage is expected to be the same with and without the clam shell repair.

2.3 SUMMARY AND [illegible]

The pote[illegible] pore [illegible] piping resulting from normal pla[illegible] and Loss of [illegible]lant Accident were reviewed. [illegible] fatigue and IGSCC were also e[illegible] the crack was caused by IGSCC due to weld res[illegible]ible cold working of the material.

Results of the evaluatio[illegible]s that the expected stresses at the clam shell repair [illegible]re well within the ASME code allowables. Therefore, the [illegible] satisfies the intent of ASME code Section III with consideration [illegible] weld quality factors from Section NG of the Code.

2.4 REFERENCES

1) ANSYS Engineering Analysis System, Gabriel J. DeSalvo, John A Swanson, Swanson Analysis Systems Inc, Houston Pennsylvania, March 1983

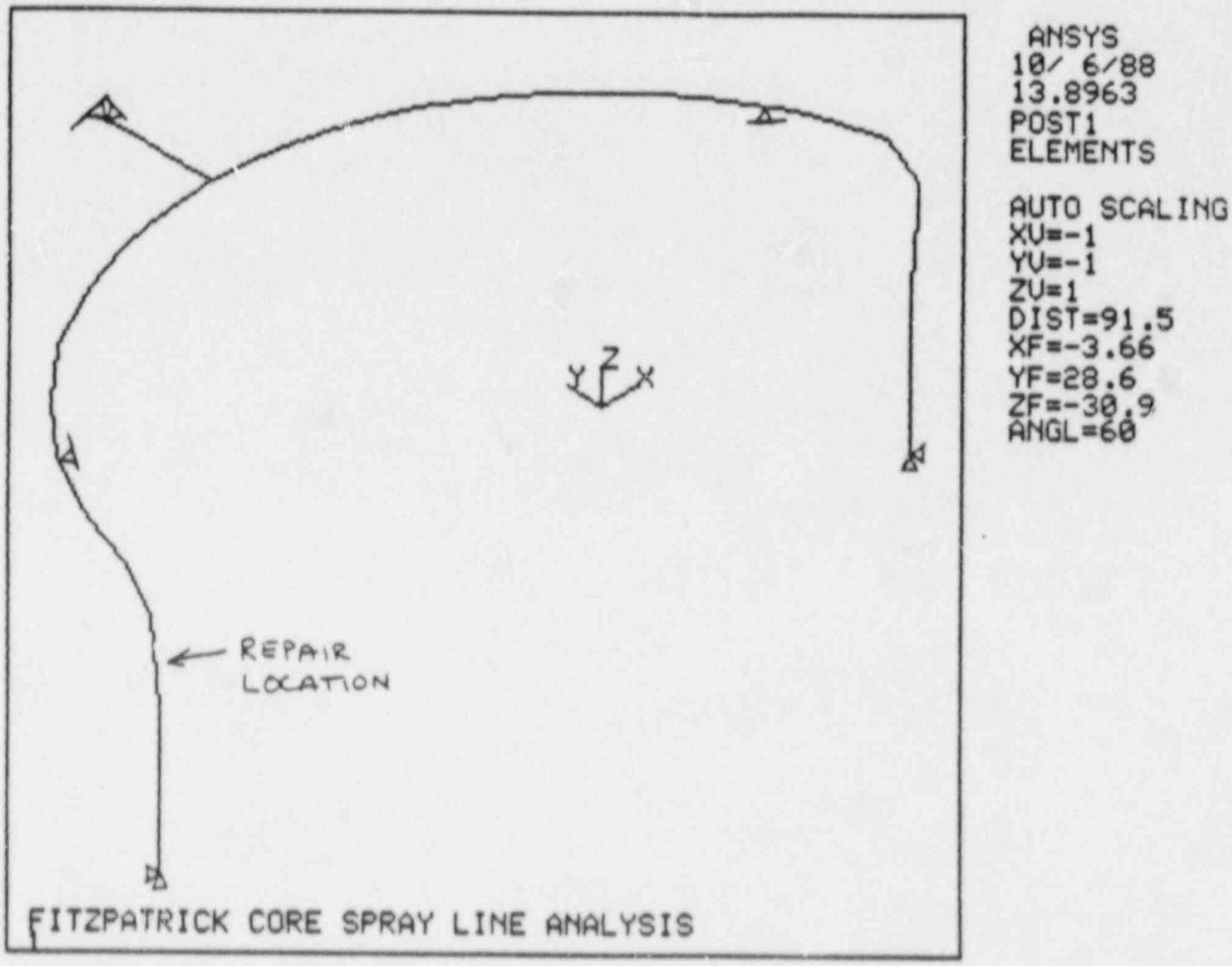


FIGURE 1 BEAM FINITE ELEMENT MODEL

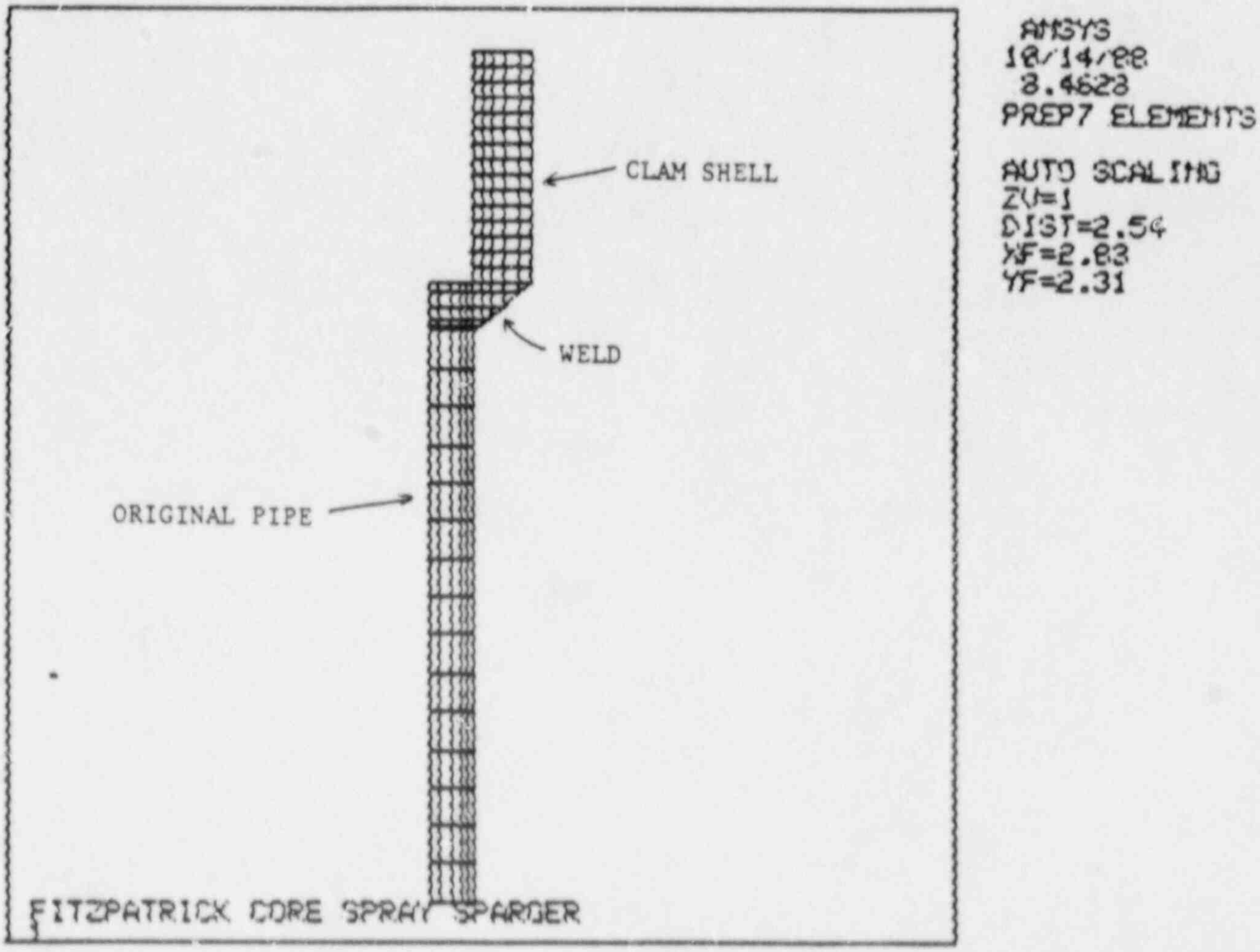


FIGURE 2 AXISYMMETRIC MODEL

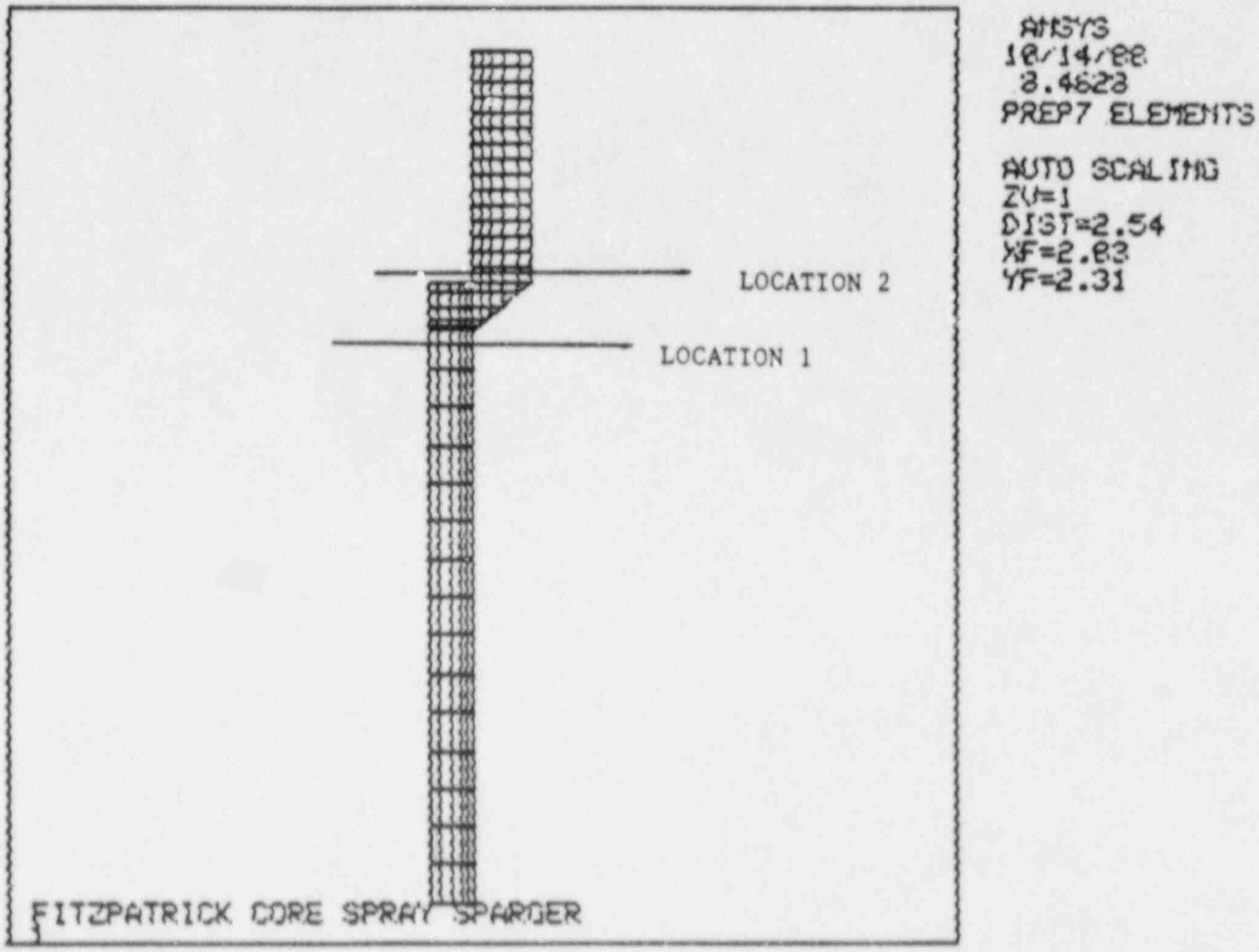


FIGURE 3 LOCATIONS OF STRESS EVALUATION

ATTACHMENT 8
NEW YORK POWER AUTHORITY
JAMES A. FITZPATRICK NUCLEAR POWER PLANT

NUCLEAR SAFETY EVALUATION
NO. JAF-SE-88-190

TITLE: REPAIR OF IN-VESSEL CORE SPRAY LINE USING A WELDED CLAMSHELL SLEEVE — QA CLASS: I

X Plant Modification F1-88-199
___ Minor Modification M1- -
___ TEST NO.
___ EXPERIMENT
___ OTHER (Describe) ____________________

A. The proposed change, test or experiment:

1.	( ) Does (X) Does Not	-	Increase the probability of occurrence or consequences of an accident or malfunction of equipment important to safety previously evaluated in the FSAR.
2.	( ) Does (X) Does Not	-	Create the possibility of an accident or malfunction of a type other than any evaluated previously in the FSAR.
3.	( ) Does (X) Does Not	-	Reduce the margin of safety as defined in the basis for Technical Specifications.
4.	( ) Does (X) Does Not	-	Involve a change in the Technical Specifications (nuclear or environmental). Para/Sec. N/A
5.	( ) Does (X) Does Not	-	Involve an unreviewed safety question (1, 2, 3 and/or 4).
6.	( ) Does (X) Does Not	-	Contain Security Safeguards Information.

S.K. Foster for 10/14/88
Prepared by: L. CHI/R. LEGATE
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Date: 10/14/88
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(normally Tech. Serv.)
Title: O&M Engineer
Date: 10/14/88
Reviewed by: T. MOSKALYK TEK
Title: Senior Plant Eng.
Date: 10/14/88

~~(MINOR MOD AUTH. ONLY)~~
~~Dept. Supt: ____________ Date~~
~~Tech. Svc. Supt: ____________ Date~~
~~Supt. of Power ____________ Date~~

PORC MTG. NO. & DATE 88-096 10-14-88

SRC MTG. NO. & DATE ____________

ATTACHMENT 8

NEW YORK POWER AUTHORITY
JAMES A. FITZPATRICK NUCLEAR POWER PLANT
NUCLEAR SAFETY EVALUATION

JAF-SE 88-190

A. SCOPE OF MODIFICATION

A two-part welded clamshell sleeve repair will be performed on the "B" loop of the core spray piping inside the reactor vessel. This two-part sleeve will be installed over the cracked section of pipe (See Figures 1 and 2) and will become the new pressure retaining load path.

The material under the sleeve between the two circumferential welds is assumed to be removed in all stress calculations that have been performed to justify the adequacy of the new design. The sleeve is to be welded along the two axial seams, after fit-up, to restore the cylindrical pipe shape. Two fillet welds will connect the sleeve to either side of the cracked material.

The material to be used for the new clamshell sleeve is ASTM A-312, Type 316L, having a material specification requirement for carbon of 0.02% maximum.

Welding shall be performed in accordance with ASME Code, Section IX, using the SMAW welding process, which will make it easier to maximize the arc angle of the circumferential welds.

Visual inspection in accordance with the requirements of ASME Code, Section III, subsection NG shall be performed after welding. In addition a baseline visual examination shall be performed to meet the requirements of the NRC IE Bulletin 80-13.

All work will be performed in the reactor vessel while the reactor vessel is loaded with fuel. Installation will be performed from a shielded work box lowered using the Refuel Floor crane.

ALARA concerns will be met by a hydrolaze decontamination of the reactor vessel inside wall and the installation of lead shielding hung on the work box and around the general work area. The heavy load analysis associated with lowering the work box into the fueled reactor vessel is not in the scope of this Safety Evaluation and shall be covered under a separate report (Ref. D.11).

B. REASON FOR MODIFICATION

During the NRC IE Bulletin 80-13 augmented in-vessel visual inspections for intergranular stress corrosion cracking (IGSCC), a crack indication was found in the "B" loop of the core spray piping between the core spray nozzle and the shroud in the JAFNPP reactor vessel. The crack is documented in VT Examination Report 88-381 (Reference D.2) performed by General Electric. The crack is located in the section of pipe, approximately 6½" from the pipe to elbow weld and 3/16" from the first pipe to pipe weld below the elbow in the "B" loop header (see Figure 1). The crack is in the heat affected zone (HAZ) of the weld. The crack is estimated to be approximately 10 mils wide and approximately 180 degrees in circumference around the 5-inch schedule 40 pipe.

The existing in-vessel core spray piping is ASTM A-312, Grade TP-304, with carbon content of approximately 0.06% to 0.07% (References 3 and 4). This material in an oxygenated environment with residual weld stress is susceptible to IGSCC (Reference 5, NUREG-0313). Based on the visual inspection of the crack and the past experience in core spray pipe cracking, the most likely cause of the crack is IGSCC. Assuming that it is IGSCC, the crack, most likely initiated from the inside diameter surface and would self-arrest after the stress was relieved as a result of crack propagation.

The Core Spray System is one of several Emergency Core Cooling (ECCS) Systems used to mitigate the consequences of Loss of Coolant Accidents (LOCA) and to assure compliance to 10CFR50.46. The Core Spray System performance can impact fuel MAPLHGR Technical Specification limits if the calculated Peak Cladding Temperature (PCT) for the limiting design basis LOCA is near the 10CFR50.46 limit of 2200°F. Technical Specification limits are also imposed on the performance of the Core Spray System. Surveillance testing validates that the Core Spray System is capable of delivering a specified minimum flow rate at a specified pressure. The LOCA/ECCS analyses as defined in the JAFNPP FSAR and as recently updated (Reference D.6) assumes that most of the core spray water which is injected into the Reactor Pressure Vessel (RPV) enters the core spray spargers above the core.

The presence of a crack in the core spray piping leading to the core spray sparger has the potential to affect the ability of the Core Spray System to perform its design function and/or the performance of the Core Spray System. Therefore, it is necessary to bound the effect of the crack on the Core Spray System and plant safety. This is accomplished by two parallel approaches: 1) determining the most likely cause and effect of the crack, and 2) applying a welded clamshell sleeve to restore the structural integrity of the piping.

To restore the structural integrity of the core spray piping, a clamshell sleeve will be installed around the crack location. The clamshell (Figure 2) is made from 6 inch diameter Schedule 80 pipe. The pipe will be 316L stainless steel with low carbon content (less than 0.02%). The pipe is approximately 4 inches in length and will be slit lengthwise into two halves. The top section of each half will be fillet-welded to the existing pipe to elbow weld and the bottom section will be circumferentially fillet-welded to the downcomer pipe. The two halves will be seam-welded (full penetration) together to form a sleeve over the crack. The two seam welds end preps on the clamshell sleeve may be machined to a 3 to 1 taper to reduce the nominal wall thickness to .378". The minimum wall thickness required by analysis is .318". The machine seam welds will require less weld deposition and still meet the required design wall thickness with complete weld penetration. This design will reduce radiation exposure to craft personnel performing this repair activity. Due to the clearance between the vessel wall and core spray piping, the top and bottom fillet welds of the clamshell may not be 360 degrees around. However, the minimum weld length will be 300 degrees. Stress and leakage calculations will be based on the smaller weld area at the top and bottom of the clamshell sleeve. The installation of the clamshell sleeve is in accordance with Reference D.7.

C. SAFETY EVALUATION

C.1 Structural Evaluation

The existing in-vessel piping was fabricated in accordance with the requirements of General Electric Purchase Specification 21A1056 (Reference D.3) and Purchase Part Drawing 921D791 (Reference D.12). A Field Deviation Instruction number 33/88595 (Reference D.13) required a change in one vertical riser pipe (installed at the 190° azimuth) which added one pipe to pipe weld. The existing core spray piping is classified as non-Code. The pipe material used was ASTM A-312, Grade TP-304. The pipe seam was welded with no filler metal added. The Certified Material Test Reports (CMTR) for the existing piping show that the piping had a carbon content of 0.06% to slightly above 0.07% which is the range of materials from three separate heats used in the Core Spray System in effect at the time of fabrication. All welding was in accordance with Section IX of the ASME Code. Non-Destructive Examination (NDE) of the fabricated structure included visual examination of all components and liquid penetrant inspection of the cover passes of the completed welds. Acceptance criteria for the liquid penetrant examination considered any crack-like or linear indications or incomplete fusion or linearly disposed spot indications of 4 or more spots spaced 1/4 inch or less from edge to edge of the indication to be unacceptable. If detected, all unacceptable defects were completely removed (as evidenced by liquid penetrant inspection) to sound metal and repaired by rewelding. The repaired area would have been again liquid penetrant inspected.

The cracked pipe is to be repaired meeting the intent of the requirements of ASME Section XI, 1980 Edition with Winter 1981 Edition. The repair components are classified as non-Code components, however, the design and analysis process has used as a guideline ASME Section III, sub-section NB, 1986 Edition. The stress analysis shows that all required Class I component stress calculations result in stresses that are within the "Code" allowables if this were a code component.

The material to be used for the new clamshell sleeve is ASTM A-312, Type 316L, having a specification requirement of 0.02% maximum carbon. This material has been shown to be highly resistive to IGSCC (Reference D.5). Weld material used in the clamshell installation is 308L with a minimum ferrite content of 8%. This weld material is also resistive to IGSCC (Reference D.5). The two-part sleeve design with the circumferential fillet welds and full penetration seam welds will bound the existing crack pipe and restore pipe integrity. Laboratory test data and field operating experience have shown that cracks that have initiated and grown due to IGSCC are arrested when reaching weld material. The clamshell sleeve installation design assures that the existing crack in the existing pipe, should it grow, will not again breach the pressure boundary since it will stop at the weld material which is within the new pressure boundary load path.

The welding is to be performed using the SMAW welding process which will make it possible to maximize the arc angle of the circumferential welds. Due to the restricted welding access, the maximum arc length may be limited to 300 degrees. However, the goal is an arc angle of 360 degrees. Should it be necessary to limit the arc length to less than 360 degrees, the amount of leakage between the sleeve and the existing pipe will be negligible and has been considered and evaluated as discussed in Section C.2 of this evaluation.

Stress analysis has been performed and shows that this design (with an assumed circumferential arc length of 300 degrees) satisfies the intent of the ASME Code, Section III, subsection NB. The stress analysis has considered the design basis seismic loading and the affect of the slightly higher mass of the repaired piping and has shown that all design criteria is satisfied. Other calculations performed by G.E. shows that approximately 1/2 inch of pipe ligament is all that is required to ensure that the pipe will not completely severe during Core Spray System injection.

The clamshell sleeve design does result in a creviced condition. Type 316L austenitic stainless steel with 0.02% maximum carbon has been shown to be less susceptible to crevice corrosion that the present Type 304 material. This has been judged to be acceptable for this application since it results in the best combination of design attributes and features of the many design options considered for this repair.

Prior to the repair, the areas of the upper and lower circumferential welds of the clamshell sleeve will be visually examined to meet the intent of the requirements of ASME, B&PCV, Section III, subsection NG-5000. After welding of the repair sleeve is completed, the welds will be visually examined as before. It is judged that the visual inspection, as specified in NG-5000, is adequate to meet the intent of the NB examination requirements. Any additional margin that may be obtained by a liquid penetrant examination (required by NB) both prior to welding and on the finished welds can be compromised by the potential entrapment (inability to remove) of penetrant test materials in crevices (the observed crack) on the original surface and any crevices left by the lack of access for a complete circumferential fillet weld on the ends of the sleeves. The presence of residual penetrant materials may cause IGSCC in creviced areas. In addition, there is the concern for additional personnel radiation exposure. The final liquid penetrant examination, if conducted, can result in a significant increase in exposure as compared to a visual examination.

The repaired in-vessel "B" core spray loop will meet the original design bases requirements for the piping system. The "B" loop is not a code component or piping subassembly, but the repair meets the intent of ASME Section III, Class I components. The clamshell sleeve design can be inspected in the future using the existing in-vessel visual inspection program.

C.2 System Evaluation

The Core Spray System is an integral part of the Emergency Core Cooling System (ECCS) for the plant. The ECCS is designed to ensure that, after the worst case LOCA with an assumed single failure, and independent of the availability of offsite power, the peak cladding temperature (PCT), local oxidation, and hydrogen generation will remain within the limits of 10CFR50.46.

The Core Spray System is designed to protect the core by spraying water over the fuel assemblies to remove decay heat following a postulated design basis LOCA. This protection also extends to smaller breaks after the Reactor Vessel is sufficiently depressurized such that the Core Spray System can provide core cooling. The maximum pressure for core spray injection is 265 psid (reactor to drywell differential pressure) and the rated flow of the core spray pump is 4625 gpm at a reactor to drywell differential pressure of 113 psid. The maximum (run-out) flow of the core spray pump is 6100 gpm (Reference D.6).

The Core Spray System consists of two independent loops. Each loop includes: one 100% capacity centrifugal water pump driven by an electric motor, a spray sparger in the Reactor vessel above the core, piping and valves that convey water from the suppression pool to the sparger and associated controls and instrumentation.

The two line injection from the Core Spray System enters the reactor vessel through nozzles, which are located 180 degrees apart to provide physical separation. Each internal pipe then divides into a semicircular header, with a downcomer at each end which turns through the shroud near the top. A semicircular sparger is attached to each of the four outlets to form two circles, one above the other and both essentially complete circles. Short elbow nozzles are spaced around the spargers to spray the water radially onto the tops of the fuel assemblies.

The basis for the ECCS and core spray performance of JAFNPP for compliance with 10CFR50.46 and 10CFR50, Appendix K, is presented in Reference D.6 and is verified for each reload cycle. The design basis LOCA for JAFNPP is identified as a 100% complete recirculation suction line break with an assumed DC power (battery) failure. With this failure, the available ECCS is one loop of core spray and one pump in each of the two loops of Residual Heat Removal (LPCI) and ADS. The ECCS model used in Reference D.6 is the SAFER/GESTR-LOCA model, a best estimate model developed by the nuclear system supplier (GE). The SAFER/GESTR-LOCA model calculates two sets of PCT, the nominal (best estimate) value and the licensing (Appendix K) value. For the design basis LOCA, the nominal PCT and the licensing PCT are less than 1050°F and 1600°F, respectively. Thus, the PCT has margins of over 600°F to 1150°F to the Appendix K PCT limit of 2200°F. With the SAFER/GESTR-LOCA model, this type of margin is expected in future cycles. This is confirmed in each refueling cycle reload analysis.

For the purpose of core spray pipe leakage a postulated conservative leakage from a crack area equivalent to that of a crack having a 10 mil gap and a 360 degrees circumference (twice the size of the observed crack) was calculated. The calculated leakage flow for this crack size is less than 40 gpm at design basis LOCA conditions. Since each Core Spray System has approximately 100 spray nozzle in each sparger, the leakage flow through the crack is less than the spray flow for one nozzle. It should be noted that the calculation in Reference D.6 has two conservative assumptions related to Core Spray System performance. First, the calculation does not take credit for core spray heat transfer, i.e., no spray flow is assumed to reach the hot fuel bundle. Second, the calculation assumes a 100 gpm leakage from each Core Spray System which bounds the maximum leakage out of the crack. Even if the 40 gpm leakage is considered as additional leakage in the Core Spray System, this additional leakage flow has little impact on the total ECCS injection capability. The total ECCS injection capability for the limiting design basis accident is more than 24,000 gpm provided by one core spray pump and two RHR (LPCI) pumps. Thus, the 40 gpm leakage is less than 0.2% of the total injection flow. Therefore, the additional leakage does not adversely affect the ECCS or Core Spray System performance or the MAPLHGR of the fuel specified in the Technical Specifications.

C.3 Evaluation on Effect on FSAR

C.3.1 Core Spray Lines Description (FSAR Section 3.3.4.7)

The description of the in-vessel core spray lines in FSAR Section 3.3.4.7 identifies the physical path of the core spray lines from the Reactor vessel core spray nozzles to the core spray spargers. This information has been reviewed by the Nuclear Steam Supplier (G.E.) and found to be unaffected by the observed crack or the proposed modification of that piping.

C.3.2 Core Spray System Description (FSAR Section 6.4.3)

The description of the Core Spray System is discussed in FSAR Section 6.4.3. This section discusses how the Core Spray System provides core protection during the postulated design basis LOCA and other postulated situations that require reactor depressurization and low pressure ECCS core cooling. This section also describes the system components and interfaces with other systems such as the suppression pool and the reactor. G.E. has conducted a review of this material and has concluded that the in-vessel core spray crack and the proposed modification of the core spray line do not effect this section of the FSAR.

C.3.3 Loss-Of-Coolant Accident (FSAR Chapter 14.6.1.3)

The LOCA analysis for JAFNPP in Section 14.6.1.3 of the FSAR has been updated and is verified for each reload analysis. As discussed in Section C.2 of this safety evaluation, the LOCA analysis already takes into account 100 gpm leakage in each Core Spray System. The presence of the crack being repaired by the clamshell sleeve would result in less than 40 gpm leakage at the design basis LOCA condition. Therefore, the Reference D.6 calculation bounds the effect of the leakage out of the new core spray piping configuration with the clamshell device and there is no reduction in the margin to the PCT limit of 2200°F.

C.4 Effect on Plant Technical Specifications

The new Core Spray System piping configuration will not have any impact on the Plant Technical Specifications. The new configuration does not affect the capability of the Core Spray System pump to provide rated flow. The postulated amount of leakage out of the crack is bounded by the LOCA analysis. The fuel MAPLHGR limits are unchanged.

C.5 Summary of Safety Evaluation

The repair of the cracked in-vessel core spray piping with the welded clamshell sleeve introduces a new piping configuration in the Core Spray System. This evaluation concludes that this new piping configuration has an insignificant impact on the existing FSAR, LOCA and reload analyses as updated for the upcoming operating cycle 9. The impact on future reload cycles is also insignificant due to the assumption of a higher leakage flow in the Core Spray System in the LOCA analysis and the large margin to the PCT limit of 10CFR50, Appendix K. It is also concluded that there is no effect on system and component design and safety bases as defined in the FSAR. Plant Technical Specifications have been reviewed to assess the effects on applicable Limiting Conditions for Operation, Limiting Safety System Settings, Safety Limits, and reactor thermal parameters and concludes that this new piping configuration does not reduce the margin of safety as defined in the bases for Technical Specifications. The welded clamshell sleeve is used to restore the structural integrity of the core spray piping to ensure delivery of Core Spray System flow into the spargers for core cooling. This does not involve a change in the Technical Specifications.

C.6 Evaluation Summary

Based on the above evaluation, it is determined that the new core spray piping configuration does not involve an unreviewed safety question as defined in 10CFR50.59 for the following reasons:

a. The modification does not increase the probability of occurrence or consequences of an accident or malfunction of equipment important to safety previously evaluated in the FSAR. The welded clamshell sleeve is used to restore the structural integrity of the Core Spray System piping to ensure delivery of core spray flow into the sparger to provide core cooling. It will not cause an accident. In as much as the clamshell sleeve introduces new crevices in the core spray piping, the use of low carbon stainless steel reduces the possibility of IGSCC. Thus, new cracks in the repaired section of the core spray line are not expected. Any potential leakage through the crack and clamshell sleeve is bounded by the analysis assumptions in Reference D.6.

b. The modification does not create the possibility of an accident or malfunction of a type other than any evaluated previously in the FSAR. The clamshell sleeve is used to restore the structural integrity of the Core Spray System piping to ensure delivery of core spray flow into the sparger for core cooling. In as much as the sleeve introduces new crevices in the core spray piping, the use of low carbon stainless steel reduces the possibility of IGSCC. The safety evaluation shows that the modification does not affect the design and safety bases of the Core Spray System and component as defined in the FSAR.

c. The modification does not reduce the margin of safety as defined in the basis for Technical Specifications. The margin of safety is reflected in the operating limits and limiting safety system settings (LSSS) of the Technical Specifications. The modification does not change the MAPLHGR of the fuel or any LSSS. The calculated PCT for the design basis LOCA remains unchanged since the calculation already considered a leakage flow higher than the assumed flow through the crack and clamshell sleeve.

D. REFERENCES

D.1 "Cracking in Core Spray Spargers", NRC, Office of Inspection and Enforcement, IE Bulletin No. 80-13, May 12, 1980

D.2 VT Examination Report 88-381, Dated 10/3/88 General Electric Company

D.3 General Electric Purchase Specification 21A1056, Rev. ., dated 1/9/69

D.4 Certificate of Test, Tube Sales, Heat No. 80242, April 29, 1971

D.5 NUREG-0313, Rev. 2, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping", 1/88

D.6 Wei, P., "James A. FitzPatrick Nuclear Power Plant SAFER/GESTR - LOCA Loss-Of-Coolant Accident Analysis", General Electric Company, NEDC-31317P, October 1986

D.7 General Electric Company, Field Deviation Disposition Request (FDDR), FDDR No. EP1-2001, Rev. 0

D.8 Core Spray Lines Description (JAFNPP FSAR, Sectio 3.3.4.7)

D.9 Core Spray System Description (JAFNPP FSAR, Section 6.4.3)

D.10 Loss-Of-Coolant Accident (JAFNPP FSAR, Chapter 14.6.1.3)

D.11 JAF-SE-88-192, The Evaluation of Shielded Work Bucket for In-Vessel Pipe Repair, 10/12/88

D.12 General Electric Purchase Part Drawing 921D791

D.13 General Electric Field Deviation Instruction (FDI) number 33/88595