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May 17, 1976

Mr. Dennis L. Ziemann, Chief
Operating Reactors - Branch 2
Division of Operating Reactors
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Dresden Station Unit 2
Feedwater Nozzle Examination
NRC Docket No. 50-237

Dear Mr. Ziemann:

Enclosed is the final report for the feedwater nozzle examination conducted May 1, 1976. A preliminary report was delivered to members of your staff during the May 6, 1976 meeting.

One (1) signed original and 39 copies are provided for your use.

Very truly yours,

Michael A. Roseky
for G. A. Abrell
Nuclear Licensing Administrator
Boiling Water Reactors

Enclosure

5236

DRESDEN STATION UNIT 2

FEEDWATER NOZZLE EXAMINATION

1976 REFUELING OUTAGE

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INTRODUCTION

During the Dresden Station Unit 2 1974/1975 refueling outage, the feedwater nozzle blend radii were thoroughly examined using liquid dye penetrant techniques. Initially, a total of approximately 400 linear indications were observed. All indications were removed by grinding as evidenced by liquid penetrant results following the grinding. Maximum grinding cavity depth was 1/2 inch from the cladding surface. This depth is equivalent to a depth of 1/4 inch into base metal. The NRC has been provided a report entitled "Dresden II Feedwater Nozzle Clad Cracking Repair Report" describing the cracking, the method of removal, a fracture mechanics evaluation of the effect of the grind out cavities, the probable cause of cracking, and the corrective actions taken.

For the Dresden Station Unit 2 1976 refueling outage, the recommendations of General Electric Company and the Commonwealth Edison Company Station Nuclear Engineering Department were used in developing a program for examination of the feedwater nozzle. The recommended examinations were scheduled and satisfactorily completed during the outage. The basis for this examination program was the same information presented to the NRC staff by General Electric Company in a meeting on February 25, 1976.

Late in the outage, on the basis of discussions with the NRC, the program was expanded to include further examination of the feedwater nozzle blend radii. This report describes the results of these examinations and an evaluation of these results.

SUMMARY

As a result of discussions with the NRC staff on April 27, 1976, it was agreed to perform a dye penetrant (PT) inspection of accessible areas of the 240° feedwater nozzle on the Dresden Unit 2 reactor vessel. This inspection was intended to provide further validation of the G.E. analyses which were the bases for establishing a two (2) operating cycle inspection interval. The PT inspection of approximately the lower half of the nozzle was completed on May 1, 1976. This inspection revealed the following indications.

Indication No.	Azimuth	Length (Inches)
1	132°	3/64
2	137°	1/32
3	110°	1/8
4	140°	3/64
5	140°	1/16
6	147°	1/16
7	150°	1/32
8	228°	1/16
9	228°	1/16

These nine (9) indications all were in previously unground cladding except indication numbers 1, 2 and 4 which were located in the blend radii of previous grinding. These three (3) indications were less than 0.140 inches depth from the previously unground cladding surface.

Of the nine (9) PT indications, two (2) were selected to be ground out to determine the depth. The longest indication in unground material, indication number 3, and the longest indication in the blend radius of previous grinding, indication number 4, were selected. Indication number 3 was removed by grinding to a depth of 0.070 inches. The cavity was PT examined and no indications were observed. Indication number 4 was removed by grinding to a total depth of 0.070 inches; however, actual metal removed was only approximately 0.030 inches.

These results of the PT inspection and subsequent grinding were not unexpected and were consistent with General Electric Company's understanding of the phenomena and General Electric's analyses for determining inspection intervals.

In addition to the PT inspection described in the preceding paragraph, and ultrasonic inspection of all four (4) feedwater nozzles was performed using the technique developed by Gatti. This inspection showed no indications of reportable magnitude. These results provide further assurance that no significant cracks exist in the nozzles.

Prior to these inspections, a visual inspection of the inside surface of the nozzles was performed using underwater television equipment, and a UT of the nozzles and safe ends was performed using the established inservice inspection procedure.

Only the lower half of the nozzle was PT inspected bacause:

1. Initially, no PT inspection was to be performed. Studies performed by General Electric Company indicate cracks which may have initiated since the last refueling outage will not grow to unacceptable size during the next operating cycle.

2. The highest stress in these nozzles occurs at the top and bottom; therefore, inspection of either one will provide data concerning the severe cracking.

3. The indications found on the lower half were not unexpected and were a depth which validated analytical predictions by General Electric Company.

4. When the lower half grinding was completed on May 2, 1976, five (5) days and 18 Rem to 32 men had already been expended on the job. It was estimated that an additional day would be required to complete the PT inspection of the top half of the nozzle.

5. The acceptable ultrasonic examination using the Gatti technique provided assurance that no cracks had propagated into base material 1/4 inch on any of the nozzles, and provided assurance that cracks were not initiating in the root of previous grinding in base material.

DISCUSSION

PT Inspection of 240° F.W. Nozzle

A liquid penetrant exam was made on the accessible areas on the 240° feedwater nozzle inner radii from approximately the 110° azimuth to the 250° azimuth. The nozzle radii lower half was first cleaned with solvent and hand wire brushing to remove the loose oxide coating. After pre-cleaning, the surface was buffed using flapper wheels. The surface was then cleaned for the liquid penetrant exam. The examination showed nine (9) indications as recorded on the attached data sheet.

The data was reviewed and in accordance with the grinding procedure and established selection criteria, indications numbered 3 and 4 were selected to be removed. Indication number 3 was in virgin clad and indication number 4 was in the blend radii of a previous grind-out which was less than 0.140 inches in depth.

Indication number 3 was ground to a depth of 0.070 inches using a high speed plum burr of approximately 7/16 inch diameter. The cavity was liquid penetrant examined and no crack existed. Indication number 4 was ground to a total depth of 0.070 inches. Actual metal removed was approximately 0.030 inches. The cavity was liquid penetrant examined and no crack existed.

Only the lower half of the nozzle radii was inspected. This area was selected for reasons discussed in the Summary of this report.

UNIT: 2
NOZZLE: 210°

DATE: 5-1-76

IND. No.	PT INDICATION θ	PT INDICATION X	PT INDICATION LENGTH	LOCATION: VIRGIN CLAD	LOCATION: ROOT OF GRIND OUT >.140"	LOCATION: ROOT OF GRIND OUT <.140"	LOCATION: BLEND RADII OF OLD GRIND OUT	LOCATION: IN BASE METAL
1.	132	1 9/16	3/64				X <.140"	
2	131	1 9/16	1/32				X <.140"	
3	110	1 3/4	1/8	X				
4	140	1 3/4	3/64				X <.140"	
5	140	2 1/4	1/16	X				
6	147	1 15/16	1/16	X				
7	150	1 13/16	1/32	X				
8	228	2	1/16	X				

1) Dykon LII PT

θ - AZMUTH LOCATION
X - DISTANCE FROM REF CIRCLE
LENGTH - LENGTH OF PT INDICATION
VIRGIN CLAD - UNGROUND CLAD
GRIND OUT >.140/>.140 - DEPTH OF OLD GRIND OUT IF INDICATION IN ROOT OF GRIND OUT.

DISCUSSION

Evaluation of PT Results

The results of the PT inspection are consistent with the General Electric Company (G.E.) model for predicting crack initiation and crack growth(1). For a reactor with interference fit feedwater spargers and complete crack removal, this model predicts no new cracking in unfatigued cladding. It has been calculated that the effects of previous high frequency fatigue extend to a depth of approximately 1/8 inch into the cladding. The cracks detected by the PT inspections were all less than 1/8 inch in depth measured from the unground cladding surface; therefore, all cracks detected were in previously fatigued material. The two (2) PT indications which were removed by grinding were less than 0.070 inches deep which is well within the predicted 0.140 inches of the G.E. initiation and growth model. The G.E. model predicts that cracks having this depth will not grow beyond a maximum depth of 1/4 inch during the next operating cycle. This minor cracking does not require removal because the cladding does not constitute a structural portion of the reactor pressure vessel.

Removal by grinding of two (2) PT indications provided assurance that the other similar cracks are within the G.E. crack initiation and growth model. Since the maximum stresses in the nozzles occur at the top and bottom of the inner nozzle area, PT in either area is representative of the worst case.

(1) This model was described to the NRC by General Electric Company in a meeting on February 25, 1976. The model is graphically summarized by the following curve of Total Grinding plus Projected Crack Depth versus Number of Startup/Shutdown Cycles. The curve shown is for an initial crack and grind out of 0.5 inch depth. Similar curves can be used to project the growth of initial cracks which were ground out to other depths.

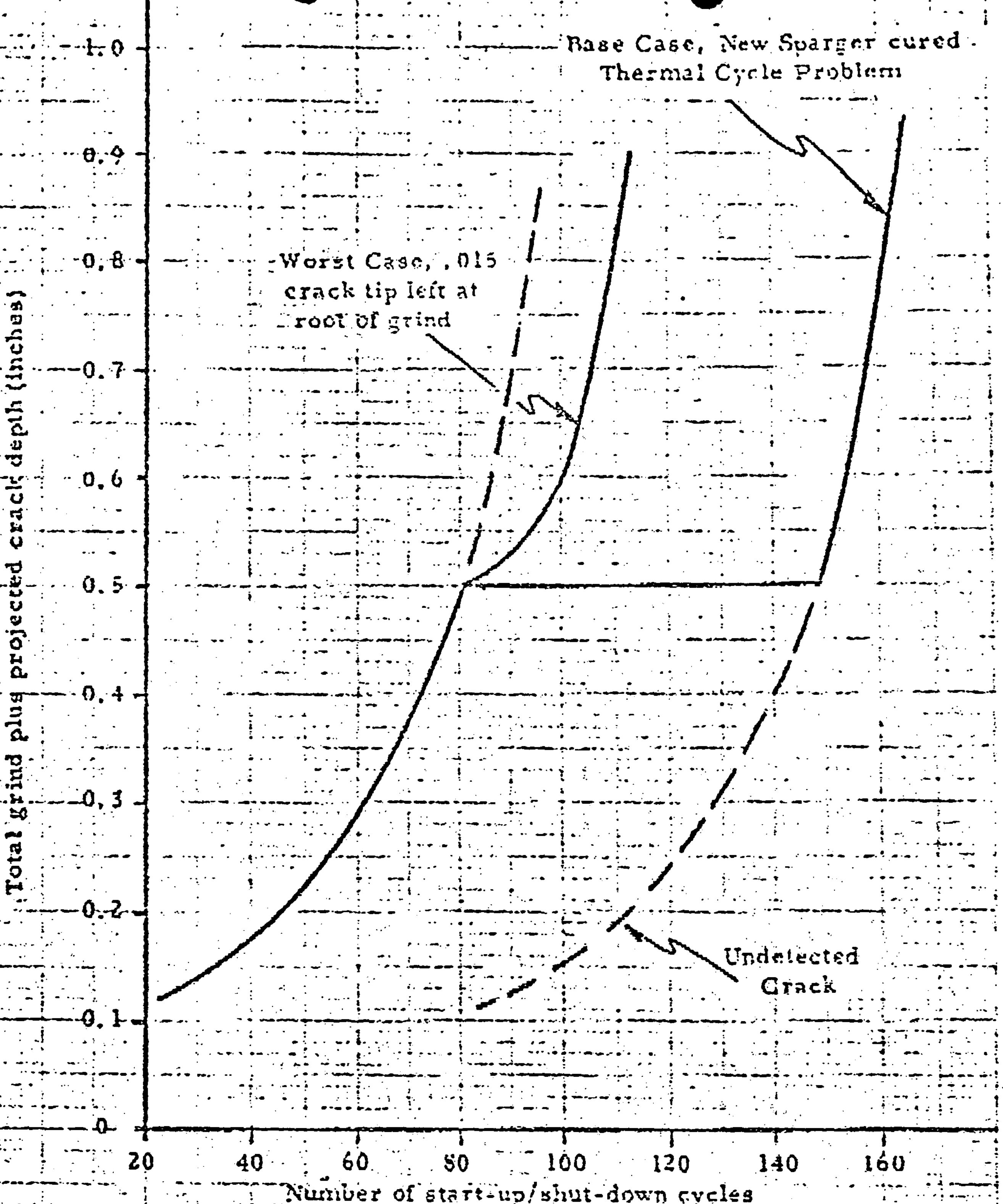


FIGURE 3. Total crack and grind depth versus number start-up/shutdown cycles. Delineates conservative worst case analysis that if a crack started growing in the root of a grind cavity that after a few cycles, the crack would grow as though it had never been repaired.

DISCUSSION

Ultrasonic Inspection of Unit 2 Feedwater Nozzles

The four feedwater nozzle inner-radii of Dresden Unit 2 Vessel were tested by T. Lambert of Lambert and Company and W. Witt of Commonwealth Edison Company Operational Analysis Department on May 1, 1976.

The procedure used was an approved procedure prepared by John Gatti for the Oyster Creek Nuclear Generating Station. Modifications to this procedure had to be made in order to obtain reliable results. The transducer which gave the best results was a 1 MHZ, 1" x 1". The 70° beam angle inside the material had to be used instead of the 60° because of nozzle geometry differences between Dresden and Oyster Creek vessels. The scanning method described could not be utilized because of eccentricity of the nozzle wall. A manual scan was employed.

Results:

None of the nozzles tested gave indications which equal or exceed 10% of primary reference level.

DISCUSSION

TV and ISI Examinations

On April 1, 1976, an ultrasonic examination of the four feedwater nozzle inner radii of Dresden Unit 2 was completed by Nuclear Services Corporation. The procedure used was very similar to General Electric's recommended procedure employing contoured shoes, clockwise and counterclockwise scans, etc. No recordable indications were found using this technique.

As a result of a recommendation by General Electric, the feedwater safe ends were ultrasonically inspected. The safe end to nozzle weld, safe end to pipe weld, and the safe end itself were inspected on all four feedwater lines. The recordable indication found was due to the tight fitting thermal sleeve and to ID and OD geometry.

The feedwater nozzle blend radii were visually inspected on March 27, 1976, via underwater television equipment, including quartz drop lights, camera mounted lights, and general area lighting. Visual acuity was, for the most part, very good. The irregularity of the surface, as a result of prior grinding, caused a slight shadow problem which was minimized by varying camera and lighting angles. A model TC-135 scanning television camera manufactured by Hydro Products was used for the inspection.

DISCUSSION

Crack Evaluation

The continued safe operation of Dresden Unit 2 until the 1977 refueling outage is assured by the good previous grind out and PT, the interference fit sparger, the G.E. model, the results of the PT and UT inspections this outage, and the planned mid-cycle UT. The operation of Unit 2 for an 18 month operating cycle is justified because no cracks that would exceed the code allowable flaw size (.7") are expected before the end of the operating cycle. The detailed justification is best discussed individually for each of the possible category of cracks (those in fatigued clad material, unfatigued clad material and the clad/base metal interface area, and base metal grind outs deeper than 1/16").

Cracks that initiate in or that already exist in the fatigued clad material are postulated to grow to the clad/base metal interface in approximately the 30 startup/shutdown cycles. These are the only type cracks expected and are of little concern because of their expected shallow depth as indicated by the G.E. model and the two grind outs this outage.

No cracks are expected to initiate in the unfatigued clad or the base metal/cladding interface because of the interference fit spargers and no crack tips were left in these areas as indicated by the good grind out and PT. If cracks were postulated to initiate in or reach these areas, or if undetected crack tips exist in these areas, they will not grow to a depth greater than the allowable 0.7 inches in approximately 30 startup/shutdown cycles.

There are three previous grind out areas that are deeper than the base metal/clad interface (1/16" into base metal). These three areas (1/4", 3/16", 1/8" into base metal) are all located at the top of the 240° nozzle and were UT examined this outage with no discernable additional cracking observed. No cracks are expected to initiate in this area because of the interference fit spargers and no crack tips were left in these areas as indicated by the good grind out and PT, the G.E. model as confirmed by recent PT and grind out experience on Dresden 2, and the results of the recent UT examinations. The 1/4" base metal grind out is the only one where an existing crack tip or an initiated crack could grow to over .7" total depth in 30 startup/shutdown cycles. This crack would be noticeable on the mid-cycle UT prior to reaching the code allowable flaw size of .7". The G.E. model and the mid-cycle UT assure that an existing crack tip or initiated crack in these grind out areas would not exceed the code allowable flaw size before being detected or before the end of the operating cycle.

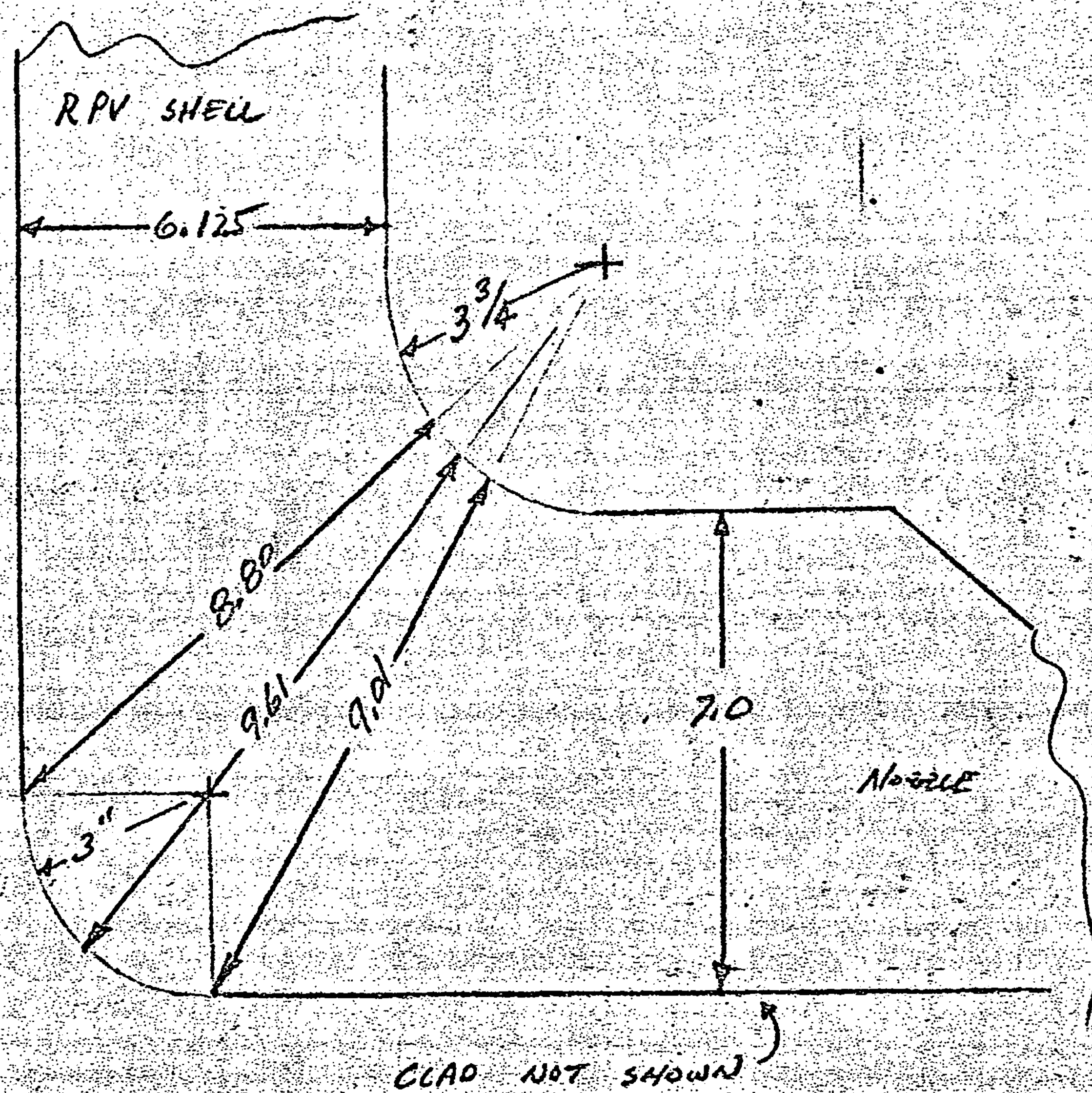
DISCUSSION

Allowable Crack Depth

Paragraph IWB-3600 of Section XI, ASME B&PV code defines the allowable end of life flaw size as $a_f < 0.1\ a_c$ where a_c is the minimum critical flaw size for normal operating conditions. Two interpretations are made in applying the Section XI criteria to the feedwater nozzle. First, the crack is permissable as long as its depth is less than a_f. But, once the crack depth equals or exceeds a_f, it must be repaired. The second interpretation is that since the critical flaw size, a_c, exceeds the wall thickness when the vessel is operated in accordance with the Tech Spec, that the allowable flaw size may be conservatively taken as 1/10 of the minimum base metal path from the crack location in question to the outside surface.

The attached sketch shows the minimum metal paths for different locations on the feedwater nozzle. All cracks found to date on the Dresden 2 feedwater nozzles have been in areas where the minimum metal path has been between 9.0" and 9.6", so the allowable crack depth is 0.90".

NUMBER MMP for B&W FW Noz DATE 5/13/76
SUBJECT (D-2, D-3, QC-1, QC-2, PB-2, PB-3, BF-1, BF-2, BF-3) BY ABJ SHEET ___ OF ___



REF B&W Dwg 113768E (GE VPF# 1248-83-5)

DISCUSSION

Future Actions

The following actions will be taken to provide additional assurance that any cracking during the next operating cycle will be within the allowable limits discussed in the preceding section.

1. An ultrasonic examination of the nozzle inner blend radii will be performed during the first hydraulic snubber inspection outage of the next Unit 2 operating cycle. The inspection will be performed using the procedure described in the "Ultrasonic Inspection of Unit 2 Feedwater Nozzles" section of this report. The next hydraulic snubber inspection will be performed six months plus or minus 25% after startup.

   If, as a result of current development work, an improved UT technique is developed and available, it will be used during this planned inspection.

2. Minimum pressurization temperatures which will preclude brittle failure with a postulated through wall flaw have been calculated for reactor vessel pressure, including inservice hydrostatic testing pressures. The temperature of the feedwater nozzle cladding will be maintained above the more conservative of the minimum pressurization temperature determined from the calculations or determined from the Technical Specifications.

3. A record of the number of startup/shutdown cycles will be maintained during the next fuel cycle on Unit 2. A startup will be considered to occur whenever the turbine is placed on line and a shutdown will be considered to occur when the turbine is taken off line. A startup plus shutdown will be counted as one cycle. On the basis of the G.E. crack growth predictions(1), no cracking beyond allowable limits is expected to occur in 30 startup/shutdown cycles as described in the "Crack Evaluation" section of this report. After 30 startup/shutdown cycles during the next operating cycle, an additional UT examination will be performed during the next unit outage of greater than 72 hours.

(1) This model was described to the NRC by General Electric Company in a meeting on February 25, 1976.

SAFETY EVALUATION

The probability of an occurrence, the consequence of an accident, or the malfunction of safety related equipment, as previously evaluated in the Final Safety Analysis Report is not increased. The structural integrity of the reactor vessel has not been changed. The minor surface indications determined by PT inspection will not penetrate to base metal during the next operating cycle. Since the cladding is not a structural portion of the reactor vessel, cracking in the cladding only does not affect reactor vessel integrity.

The existence of the minor cracking of the feedwater nozzle blend radii cladding will not create the possibility of an accident or malfunction of a different type than previously evaluated in the Final Safety Analysis Report. Any postulated pipe rupture, for whatever reason, has been analyzed and core cooling will be maintained.

The margin of safety, as defined in the basis of the Technical Specification, is not reduced because the structural integrity of the reactor vessel is maintained at the level of the initial acceptance standards.

CONCLUSIONS

The inspections performed confirm that no significant cracks presently exist in the reactor vessel feedwater nozzles and that minor cracks that have developed in the clad have grown at a rate less than predicted by the General Electric Company crack growth rate model. On the basis of these inspection results, we have concluded that only minor cladding cracks exist and the projected growth of these cracks will not reduce reactor vessel integrity during the next operating cycle.