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FRACTURE MECHANICS EVALUATION OF UT INDICATIONS FOUND DURING 1995 REEXAMINATION OF THE FEEDWATER NOZZLE TO SHELL WELDS AT COOPER NUCLEAR STATION

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Prepared for

Cooper Nuclear Station
Nebraska Public Power District

Prepared by

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1. PURPOSE/OBJECTIVE

This analysis documents the results of fracture mechanics evaluation of the indications found at the feedwater nozzle to shell welds by UT reexamination (previous examination was conducted in 1991) during the current refueling outage at the Cooper Nuclear Station (CNS).

Table 1 summarizes the results of the UT examination of N4A, N4C and N4D nozzle to shell welds. This table also includes the indication dimensions as obtained by using the proximity rules of Section XI and the results of comparison with the acceptance standards of Paragraph IWB-3500. All of the indications are classified as subsurface. A review of Table 1 indicates that the most limiting indication is the combined indication no. B' at nozzle N4A weld. Therefore, this indication was evaluated using the fracture mechanics procedures.

The objective of the fracture mechanics evaluation was to determine if this bounding indication meets acceptance criteria of Paragraph IWB-3600.

2. METHODS

1. The fracture mechanics methods used in the analysis are consistent with the procedures outlined in Section XI, ASME Code, 1989 Edition.
2. The primary stress requirements are based on Section III, ASME Code, 1989 Edition.

3. ASSUMPTIONS

1. Based on Reference 1, the hydrotest was assumed to be the most limiting condition from the fracture view point. This is because among all the Level A, B, C and D operating conditions, the hydrotest condition represents the most limiting combination of high stress and low temperature. The temperature for the hydrotest or the pressure test (@1100 psi) was conservatively assumed to be 190°F, based on the Tech Spec PT Curves (Figure 1).
2. Based on Reference 1, the limiting value of the RT_{NDT} at the location of the indications is conservatively assumed as 30°F.
3. Other assumptions, if any, are listed throughout the document.

4. DESIGN INPUTS

The information on the UT indications was obtained from a summary of the inspection results prepared by the UT examination team. Other information such as the material RT_{NDT}, hydrotest temperature, stress state at the subject location, etc. was obtained from previous analyses documented in References 1 and 2.

5. FRACTURE MECHANICS EVALUATION

Per Table 1, the dimensions of the bounding indication B' are: 2a = 0.733 inch, l = 15.80 inches. The section thickness excluding the clad thickness is taken as 5.88 inches.

5.1. *Applied Stresses*

Based on the information contained in References 1 and 2, the stress distribution at the location of the indication can be conservatively represented by a membrane stress of 28 ksi. Therefore, this stress magnitude was used in the calculation of applied stress intensity factor, K_I.

5.2. *Material Fracture Toughness*

The material fracture toughness K_{Ia} is calculated as 153.4 ksi$\sqrt{in}$ based on a RT_{NDT} of 30°F and a hydrotest temperature of 190°F. Using a safety factor of $\sqrt{10}$, the allowable value of fracture toughness K_I is calculated as ($153.4/\sqrt{10}$) or 48.5 ksi$\sqrt{in}$.

5.3. *Fatigue Crack Growth Evaluation*

The bounding indication has been characterized as a subsurface indication; thus, it is not exposed to the reactor water environment. Therefore, the fatigue crack growth relationship for air was used in the evaluation. A total of 720 cycles (120 startup and 600 thermal/pressure cycles) were conservatively assumed to cover the entire cycle duty. This value takes into consideration both vessel and nozzle thermal cycles and, as such, is considered a bounding value. The calculated value of fatigue crack growth rate was 15 micro-inches/cycle at each tip of the indication. This translates into a fatigue crack growth of ($15\times10^{-6}\times2\times720$) or 0.022 inch. When this crack growth is added, a '2a' value of (0.733+0.022) or 0.755 inch.

5.4. *Applied K Calculation and Comparison with Allowable Value*

The applied K value was for the bounding indication including the fatigue crack growth was calculated as 35 ksi√in. As this value is less than the allowable value of 48.5 ksi√in, the bounding indication meets the criteria of Paragraph IWB-3612.

5.5. Section III Local Membrane Stress Limit Evaluation

In addition to the fracture mechanics requirements of Paragraph IWB-3612, the Paragraph IWB-3610(d)(2) states that the primary stress requirements of NB-3200 also need to be satisfied. The limit for the local primary membrane stress intensity is $1.5S_m$. Since the full thickness of the vessel is designed with a primary membrane stress intensity less than S_m, the maximum throughwall (circumferential or longitudinal) flaw depth must therefore be limited to less than 1/3 the low alloy steel (LAS) wall thickness. For an LAS wall thickness of 5.88 inches, this translates into an allowable flaw depth (2a for subsurface flaws) of 5.88/3 or 1.96 inches. Since the bounding indication depth of 0.755 inch is less than this value, the primary membrane stress requirements are satisfied.

5.6. Summary

The bounding indication satisfies both the fracture mechanics and the primary stress criteria and, therefore, operation in the as-is condition with the feedwater nozzle to shell weld indications identified in Table 1, is justified to the end of design life.

6. REFERENCES

[1] GE Report No. GENE-523-133-1191, Revision 1, "Fracture Mechanics Evaluation of the UT Indications in the Cooper Feedwater Nozzle to Shell Weld," November 1991.

[2] GE Report No. GENE-523-134-1191, Revision 2, "Fracture Mechanics Evaluation of UT Indications Found per Reg. Guide 1.150 in the Cooper Feedwater Nozzle to Shell Weld," December 1991.

[3] ASME Boiler and Pressure Vessel Code, Section XI, Rules for In-Service Inspection of Nuclear Power Plant Components, American Society of Mechanical Engineers, 1989 Edition, Paragraph IWB 3640.

[4] ASME Boiler and Pressure Vessel Code, Section III, Rules for the Construction of Nuclear Power Plant Components, American Society of Mechanical Engineers, 1989 Edition.

7. UNITS

English units (inches, ksi, ksi√in) are used.

8. CONCLUSIONS

The report describes the results of the fracture mechanics evaluation of indications found during reexamination of feedwater nozzle to shell welds N4A, N4C and N4D. From a review of the UT data, a bounding indication was identified. The fracture mechanics and primary stress evaluations showed that this bounding indication meets the criteria of IWB-3610 and is, thus, acceptable. Therefore, continued operation in the as-is condition of the feedwater nozzle to shell welds at CNS is justified to the end of design life.

Table 1

Cooper Nuclear Station 1995 UT Examination Results
Feedwater Nozzles N4A, N4C, and N4D

Ind. #	Throughwall "2a"	Length "L"	Separation "S"	Calculated a/L	Allowed a/t	Calculated a/t	Evaluation	Comments
N4A								
A	0.370	5.05	1.0	0.037	2.30	3.10	Reject	Combines into B'
B	0.396	14.29	1.6	0.014	2.30	3.32	Reject	Combines into B'
C	0.150	0.77	1.3	0.097	2.59	1.26	Accept	Combines into B'
D	0.150	0.75	1.3	0.100	2.60	1.26	Accept	Combines into B'
E	0.150	2.16	1.3	0.035	2.30	1.26	Accept	Combines into E'
F	0.184	0.75	1.0	0.123	2.74	1.54	Accept	Combines into E'
G	0.150	0.65	0.8	0.115	2.69	1.26	Accept	
H	0.150	1.85	0.4	0.041	2.30	1.26	Accept	
B'	0.733	15.80	1.0	0.023	2.30	6.15	Reject	Combined iaw IWA-3330
E'	0.334	2.16	1.0	*	2.52	2.80	Reject	Combined iaw IWA-3390
N4C								
5	0.150	0.79	2.2	0.095	2.58	1.26	Accept	
13	0.150	0.25	2.9	0.300	4.10	1.26	Accept	
N4D								
4	0.226	1.42	1.1	0.080	2.52	1.95	Accept	
9	0.150	0.63	1.9	0.119	2.71	1.29	Accept	
10	0.150	1.15	1.7	0.065	2.46	1.29	Accept	
18	0.495	0.75	1.3	0.330	4.40	4.27	Accept	
32	0.396	1.13	1.3	0.175	3.10	3.41	Reject	
33	0.396	1.06	1.5	0.187	3.19	3.41	Reject	
41	0.240	5.02	1.3	0.024	2.30	2.07	Accept	

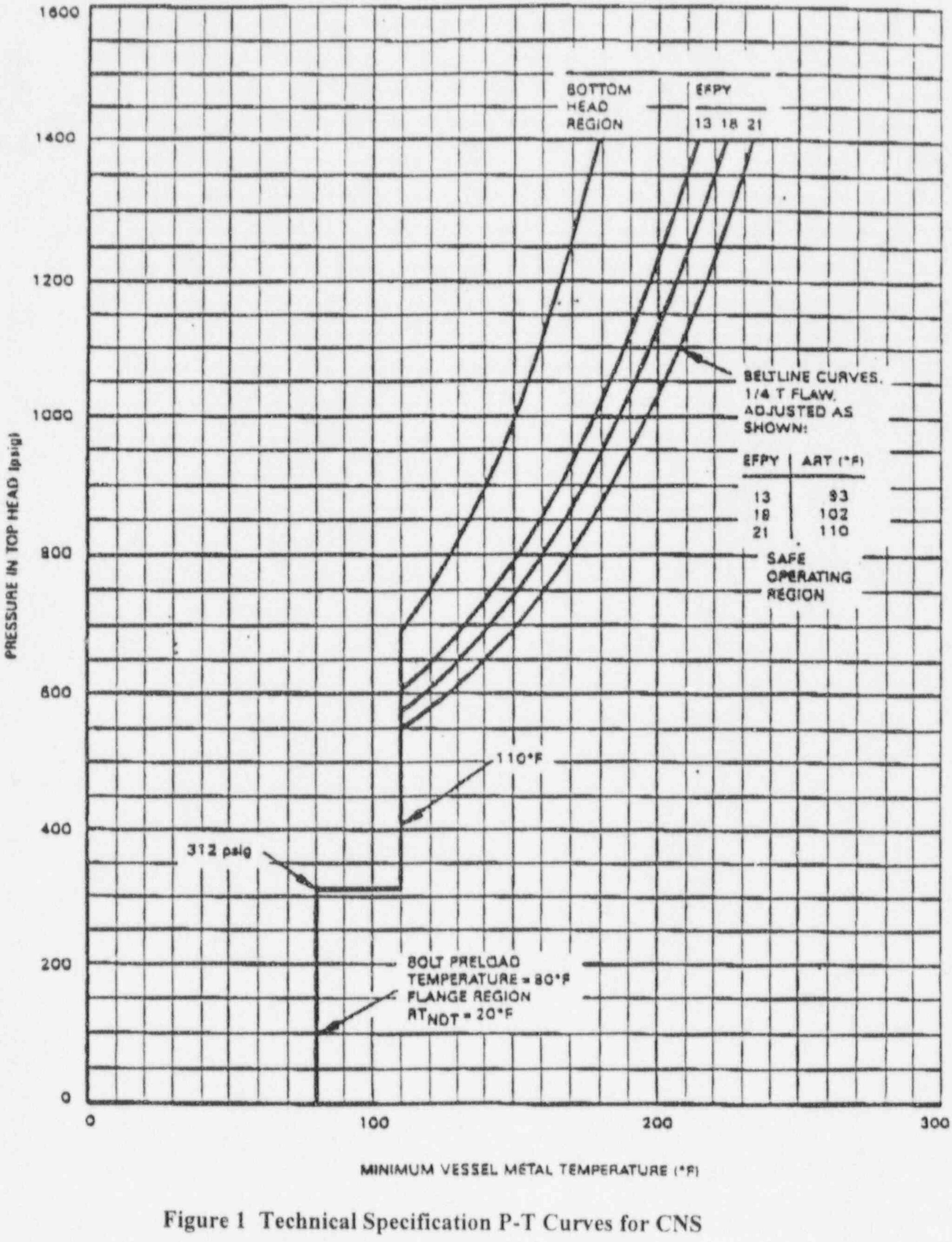

Figure 1 Technical Specification P-T Curves for CNS

Attachment 2
to NLS950240

General Electric Comparative Analysis of UT Indications in Feedwater Nozzle-to-Vessel Welds - 28 Pages Total

COMPARATIVE ANALYSIS OF UT INDICATIONS IN FEEDWATER NOZZLE-TO-VESSEL WELDS N4-A, N4-C, AND N4-D

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1 Dec. 1995

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EXECUTIVE SUMMARY

An ultrasonic (UT) examination of Cooper Nuclear Station's Feedwater Nozzle-to-Vessel Welds and Nozzle Inside Radii (NIR) was performed during Refueling Outage 14 (RFO-14) in the Fall of 1991. The items were examined to provide American Society of Mechanical Engineers (ASME) Section XI examination credit on one weld, as well as automated baseline data for use during future inspection and monitoring activities.

The examination of the NIR revealed no relevant indications; however, examination of the Nozzle-to-Vessel Welds revealed indications that exceeded the acceptance criteria for ASME Code Category B-D welds. Welds N4-A, N4-C and N4-D contained indications that exceeded ASME Section XI, Table IWB-3510-1 requirements. All indications were characterized as either Subsurface Planar or Subsurface Coplanar flaws in accordance with IWA-3300.

The indications received Fracture Mechanics analyses per ASME Section XI, IWB-3600 and Appendix A requirements and were found to be acceptable for continued operation for 40 years or 720 cycles (120 startup / shutdown cycles and 600 thermal / pressure cycles).

The indications were characterized as being welding discontinuities that have been present since the vessel was manufactured. This was shown by a review of fabrication records. There is correlation between UT indications and indications visible in the fabrication radiographs. There was no evidence to suggest the presence of service induced flaws in any of the welds.

A subsequent examination of Nozzle-to-Shell welds N4-A, N4-C and N4-D as required by agreement with the USNRC (reference 9) was performed during RFO-16 in the Fall of 1995. These examinations confirmed the presence of the previously recorded indications; however, the indication dimensions varied from indication dimensions determined during the 1991 examinations in both length and throughwall. These variations in indication dimensions are attributed to differences in examination techniques, equipment and indication reflectivity. The variations are not attributed to flaw growth. The indications continue to appear to have been caused by welding discontinuities present since fabrication.

The comparison of the examination results from the 1991 and 1995 examinations is evaluated as showing no growth in the original flaws. Additional examinations to monitor the indications are therefore not warranted.

1.0 INTRODUCTION

During the Fall 1991 Outage (RFO 14) at Cooper Nuclear Station, ultrasonic (UT) examinations were performed on Feedwater nozzle-to-vessel welds N4-A, N4-B, N4-C and N4-D. The ASME Code examination volume for nozzle-to-vessel welds is illustrated in Figure 1 and is bounded by points A-B-C-D. These examinations were performed for ASME Code credit on N4-C, and to provide an automated UT baseline for use during future ISI and monitoring activities.

Reportable indications were revealed in the N4-A, N4-C, and N4-D welds. Subsequent examinations of nozzle-to-shell welds N4-A, N4-C and N4-D, as required by agreement with the USNRC were performed during RFO-16 in the Fall of 1995. Reportable indications were again detected in the N4-A and N4-D welds.

The automated techniques used at Cooper in 1991 were the result of General Electric's (GE's) on going development activities for the improvement of examination reliability, and represented the best ultrasonic examination available at that time.

General Electric has continued to develop its examination capability. The automated techniques used at Cooper in 1995 were performed using GE's current, state of the art, GERIS 2000 vessel examination system. The two systems are described in Section 2 of this report with emphasis placed on any significant differences between the systems.

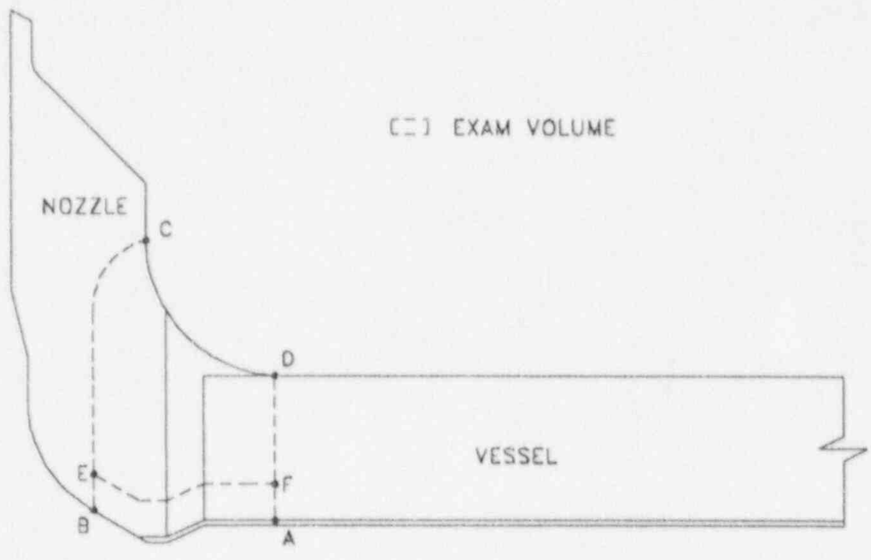


Figure 1
Nozzle-To-Vessel Weld
Examination Volume

2.0 DESCRIPTION OF EQUIPMENT

2.1 General Electric Remote Inspection System (GERIS), 1991 Examinations

Referring to Figure 2-1, an automated scanner moves UT transducers radially and indexes circumferentially around the outside surface of a nozzle and the adjacent surface of the RPV. The UT data is collected and stored in a digital format. When data of particular interest is found, i.e. reflectors exceeding a predetermined amplitude threshold, the complete A-scan is digitized and recorded on optical disks.

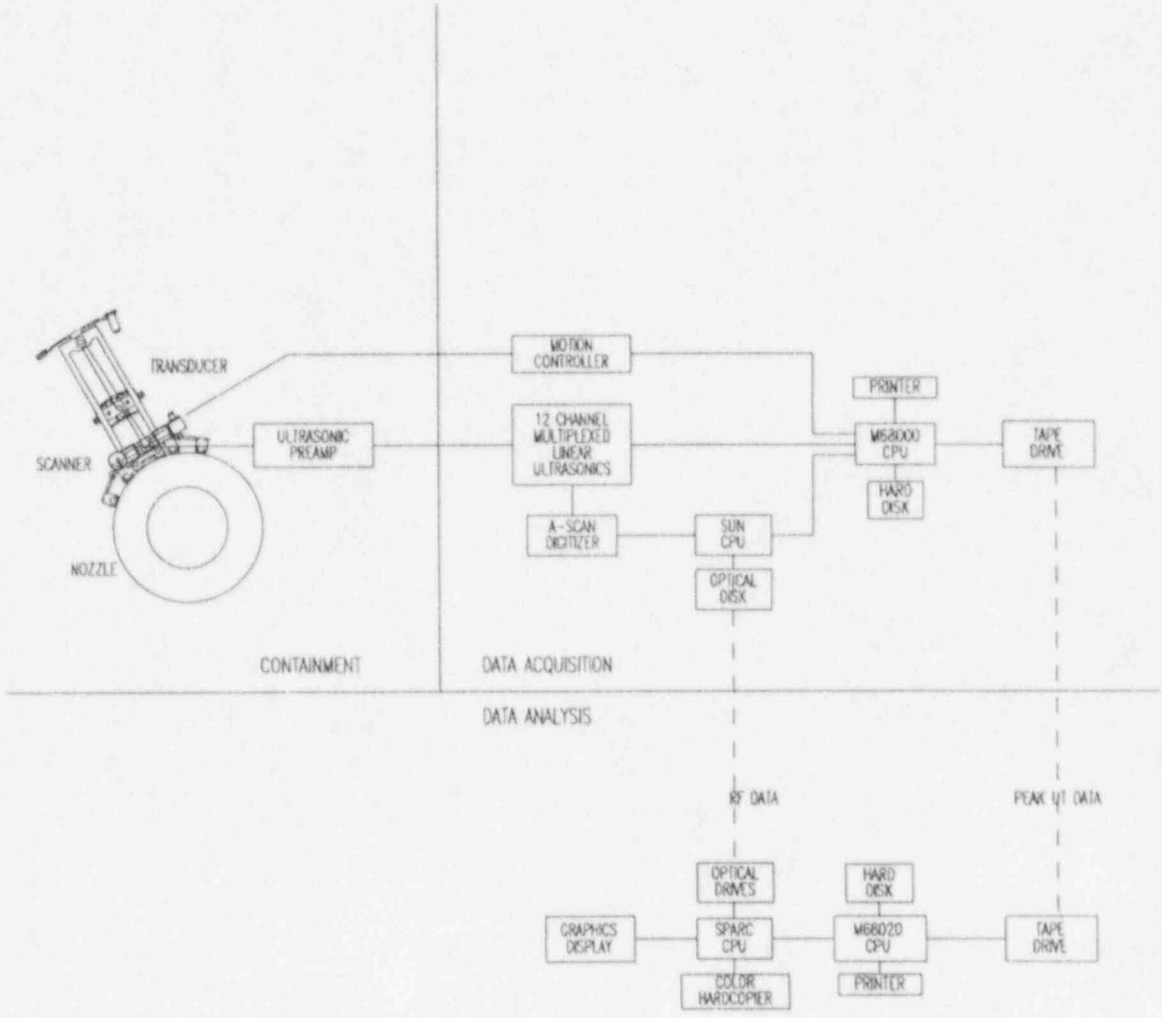


Figure 2-1
GERIS Nozzle Inspection System

2.2 General Electric Remote Inspection System (GERIS) 2000, 1995 Examinations

Referring to Figure 2-2, an automated scanner moves UT transducers radially and indexes circumferentially around the outside surface of a nozzle and the adjacent surface of the RPV. The UT data is collected and stored in a digital format on optical disks. The complete radio frequency (RF) waveform for every A-scan is digitized and recorded. The RF data is processed through a logarithmic amplifier prior to digitizing, yielding an effective dynamic range of greater than 85 dB.

The GERIS 2000 ultrasonic system has several advantages over the previous GERIS system. Ultrasonic data is collected and recorded throughout the entire examination. The use of logarithmic amplification permits the data reviewer to investigate indications regardless of amplitude.

Due to the GERIS electronics hardware design, indications detected with the GERIS system could not be investigated past the threshold level end points. Indications detected with the GERIS 2000 system can be investigated to the loss of signal end points. This permits the GERIS 2000 system to investigate reflectors at amplitudes considerably lower than that of the 1991 exams.

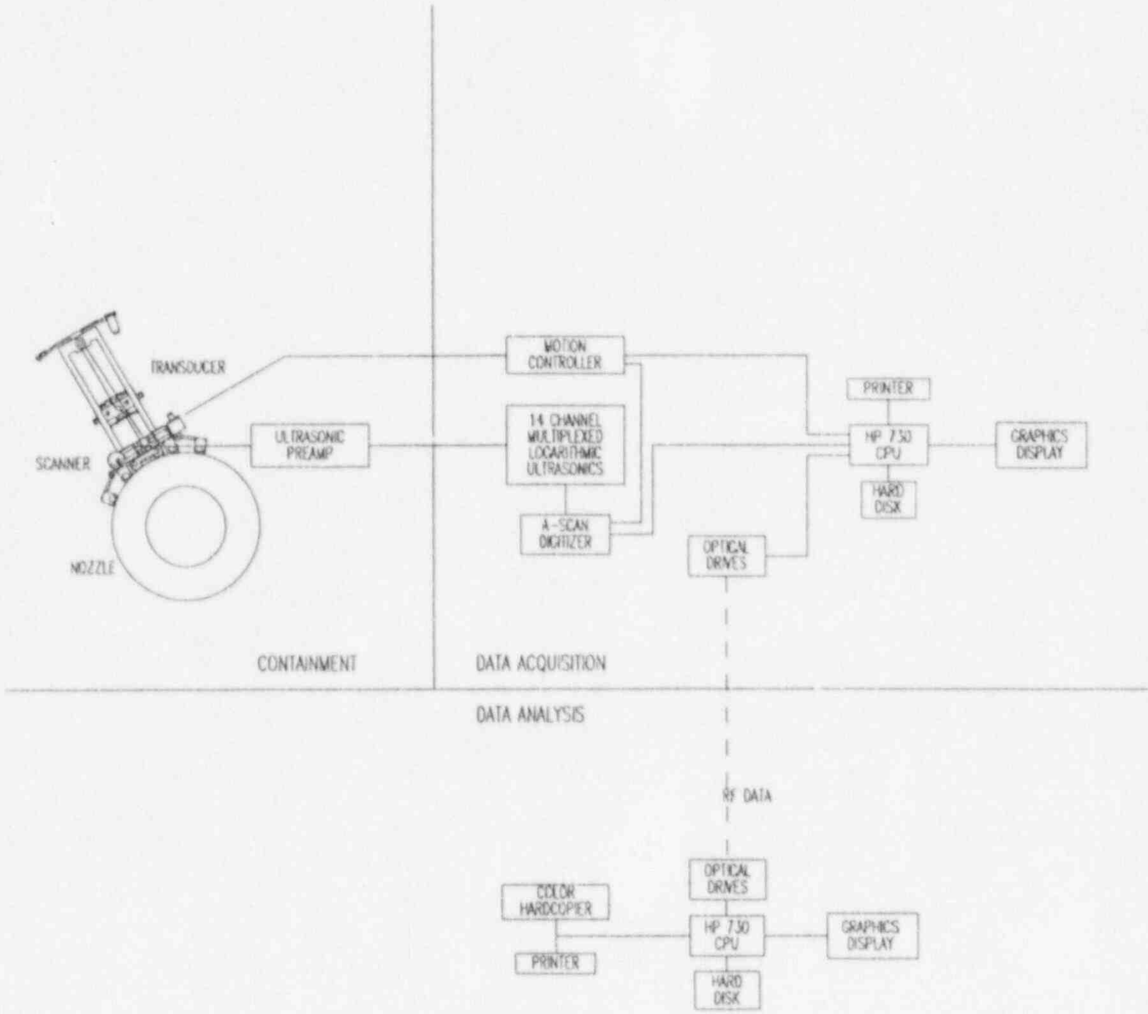


Figure 2-2
GERIS 2000 Nozzle Inspection System

2.3 Nozzle Mounted Scanner

The nozzle mounted scanners for both the 1991 and 1995 examinations are essentially identical.

For scanning the nozzle-to-vessel weld volume, the nozzle-mounted scanner, mounted to a channel track clamped around the nozzle OD cylindrical surface, provides the means of performing a remote ultrasonic examination (Figure 2-3). The nozzle device includes the nozzle tractor, scanner arm and transducer package.

The nozzle tractor consists of a main body with two motor-driven magnetic wheels and two hinged-end sections, each with one motor-driven magnetic wheel assembly. A pendulum and resolver are mounted on the main body to give the angular position of the nozzle tractor. The reciprocating scanner arm is attached to the nozzle tractor and extends perpendicular from, the nozzle track for scanning the nozzle-to vessel welds.

The scanner arm consists of a frame, a stepping motor, a worm-gear-driven resolver, and a ball-screw-driven plate that holds the ultrasonic transducer package. The scanner arm is held to the vessel wall with two spring loaded guide rods on the inboard end, and two magnetic wheels mounted at the outboard end of the scanner arm.

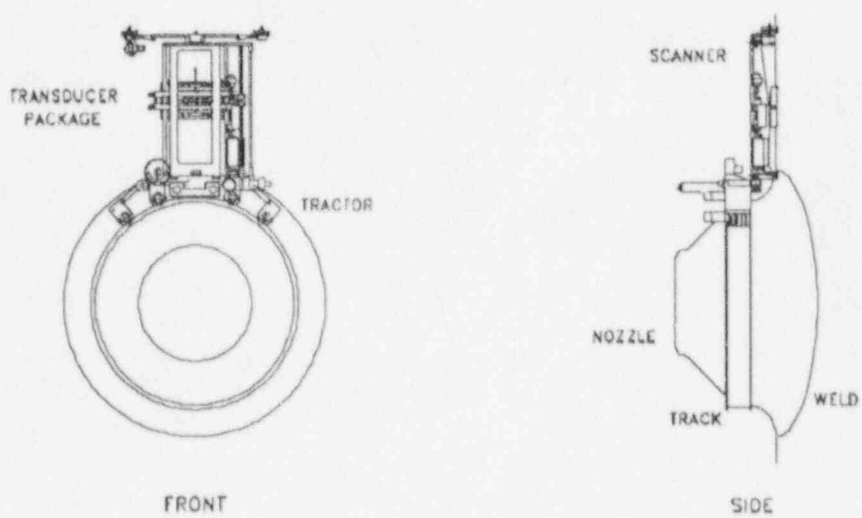


Figure 2-3
Nozzle-Mounted Scanner

2.4 Transducer Packages

The transducer package consists of a combination of search units individually mounted in a frame. The search units produce beam angles as required by the examination technique. The beam angles are identical for the 1991 and 1995 examinations; 45° and 60° shear waves. The angle beam search units are skewed within the package to produce sound beams that will impinge at the ID surface perpendicular and parallel to the weld centerline.

The 1991 and 1995 examinations do not use the same transducer packages. This is due to the use of different search unit designs, and the inclusion of the 0° search unit with the 1995 angle beam scan package. This design required that the search units be mounted further outboard from the scanner centerline in 1995. These changes in package layout required skew angles for the detection of flaws oriented parallel to the weld to be closer to perpendicular with the 1991 package. This change is minimal, but may affect the amplitude of oriented indications.

Search Unit Offsets and Skew Angles

	45° Skew Ang.	Offset	60° Skew Ang.	Offset
1991	- 6.5°	2.27"	5.2°	-2.27"
1995	- 9.1°	3.00"	7.4	-3.00"

2.5 Ultrasonic Search Units

The angle beam search units used for the 1991 examinations were KB Aerotech transducers mounted on Lucite wedges producing 45° and 60° shear waves. The nominal frequency was 2.25 MHz. The size was 1/2" x 1".

The angle beam search units used for the 1995 examinations were RTD transducers with integral wedges producing 45° and 60° shear waves. The nominal frequencies used were 1.0 MHz. and 2.0 MHz. The size of the 45° search units is 32 mm x 22 mm elliptical. The size of the 60° search units is 32 mm x 18 mm elliptical.

The 1.0 MHz. search units are currently the preferred search units for examination based on GE's development program. The 2.0 MHz. search units were used to provide a reference for the comparison of the 1995 to the 1991 examinations.

The ultrasonic transducers used in the 1995 examinations have been optimized for detection and are capable of detecting smaller or less reflective flaws than those used in 1991. This is due to the increased area of the active elements and lower frequencies. More ultrasonic energy is produced and a larger receiving area is available.

The search units used for the 1995 examinations also have a larger bandwidth (BW) than the search units used in 1991. This results in improved vertical resolution capability for the characterization of indications.

Search Units 1991 - 1995

Exam Angle	Manufacturer	Element Size	Frequency	BW @ 3 dB
45° Shear 1995	RTD	22 mm x 32 mm	1 MHz	39.6 %
60° Shear 1995	RTD	18 mm x 32 mm	1 MHz	37.9 %
45° Shear 1995	RTD	22 mm x 32 mm	2 MHz	39.5 %
60° Shear 1995	RTD	18 mm x 32 mm	2 MHz	38.7 %
45° Shear 1991	KB Aerotech	1/2" x 1"	2.25 MHz	17.5 %
60° Shear 1991	KB Aerotech	1/2" x 1"	2.25 MHz	15.4 %

3.0 GOVERNING REQUIREMENTS

Inservice Inspections (ISI) of Class 1 Components at Cooper Nuclear Station are performed in accordance with ASME Section XI, 1980 Edition with Addenda through Winter 1981. UT examinations of Category B-D items are governed by IWA-2232 and the techniques conform to ASME Section V, Article 4. Evaluations of indications in Code Category B-D items are governed by IWB-3500.

Data evaluation and examination performance criteria are supplemented by the requirements of USNRC Regulatory Guide 1.150 Revision 1, Alternate Method. The major effect of the Regulatory Guide is on indication evaluations. Indications detected in the Feedwater Nozzle-to-Vessel welds received the following evaluations:

- All indications equal to or exceeding the 100% Distance Amplitude Correction (DAC) amplitude level were evaluated at the 100% DAC end points. The "a" and "l" dimensions of the bounding rectangle were evaluated in the "X", "Y" and diagonal planes. The results of these evaluations were compared with the requirements of Table IWB-3510-1.

- All indications equal to or exceeding the 50% Distance Amplitude Correction (DAC) amplitude level were evaluated at the 50% DAC end points. The lower evaluation level (50% DAC versus 100% DAC) increases the overall number of indications and the number of indications that may exceed the allowable values. The evaluations are performed in the same manner as that described for indications 100% DAC and greater in amplitude.

- Indications in the inner 1/4T of the vessel thickness were also evaluated in accordance with Regulatory Guide 1.150 requirements. These indications required two evaluations to determine the size. Indications were evaluated using both the 20% DAC end point data with beam spread correction and the 50% DAC end point data. The iteration that produced the larger size was selected for evaluation. The evaluations are performed in the same manner as those for 100% and 50% DAC indications.

- Additionally, data collected during the 1995 examinations was also evaluated using alternate methods. Throughwall dimensioning was determined by tip diffraction based methods. The indication throughwall size is determined by identifying diffracted signals from both the upper and lower extremities of the indication. The sweep position of the diffracted signals are measured and the indication throughwall dimension is calculated. Length dimensioning was determined using the 1/2 maximum amplitude end points. The maximum amplitude of the indication is identified, and the indication is followed until the amplitude of the indication drops below 1/2 the maximum amplitude, this point is the indication end point. The length of the indication is determined by the distance between the end points. These methods have been demonstrated as providing flaw dimensions more accurately than the Article 4 or Reg. Guide 1.150 described methods.

3.1 INDICATION SIZING METHODS - 100% DAC REPORT SIZING

The sizing method used by the GERIS 2000 when generating the 100% DAC Reports is an amplitude based technique. This technique relies on the relationship between the reflectivity of the calibration reflectors in the Basic Calibration Block and the detected flaw.

The recorded RF waveforms from the examination volume are processed and all reflectors greater than 20% of DAC amplitude are extracted. The extracted reflectors are recorded along with their sweep, amplitude, and position data in a database. The position data provides the reflector location in 3D coordinates corrected for beam angle, beam orientation, search unit offsets and sweep position.

These reflectors and associated waveforms are reviewed on a 3D graphics display by the data analyst and reflectors determined to be non relevant are discarded.

The remaining relevant reflectors are processed with reflectors greater than 100% of DAC within a minimum separation distance being grouped together to form an indication. The indication is bounded by a 3D box containing all of the grouped reflectors. Further processing evaluates each indication with the locations of any other recorded indications and their proximity. Indications that meet the minimum separation distances as referenced by the ASME Code are combined. Combined indications are bounded by a 3D box that contains all of the reflectors contained in the original indication.

The flaw throughwall dimension is determined by the height of the box in the depth axis. The length of the flaw is determined by the length of the box in the X and Y axis and by the length of the diagonal across the X and Y axis.

The allowable flaw "a/t" is calculated three times using the X, Y, and diagonal length values to determine the "a/l" aspect ratios. The flaw throughwall position and dimension is compared with the material thickness and the appropriate "a" dimension is assigned. The "a/t" value is calculated and the Final Report returns the calculated "a/t" and the allowable "a/t" values for each aspect ratio with any indications exceeding the allowable being noted as requiring further evaluation.

3.2 INDICATION SIZING METHODS - 50% DAC REPORT SIZING

The sizing method used by the GERIS 2000 when generating the 50% DAC Reports is identical to the method used for the 100% DAC Report with the exception that all reflectors exceeding 50% DAC are processed.

3.3 INDICATION SIZING METHODS - 20% DAC REPORT SIZING

The sizing method used by the GERIS 2000 when generating the 20% DAC Reports is identical to the method used for the 100% DAC Report with the exception that all reflectors exceeding 20% DAC are processed. The process is identical to the 100% DAC Report process with two additional exceptions.

The first difference is that the indication throughwall dimension is corrected for beam spread by reducing the indication dimension by the beam height at an equivalent depth. The second difference is that the 20% DAC Report is used to meet Reg. Guide 1.150 recording requirements. As the Reg. Guide requires 20% sizing of indications only in the inner 1/4 T of the examination volume the 20% DAC Report may be limited to this volume.

3.4 INDICATION SIZING METHODS - TIP DIFFRACTION

Indications from the 1995 examination data, correlated with the previous reported indications from 1991, were characterized using tip diffraction techniques. Tip diffraction sizing relies on ultrasonic signals being returned to the search unit from the flaw upper and lower extremities or flaw tips due to diffraction of the sound beam. Two general methods of tip diffraction are commonly used these are:

- The Satellite Pulse Observation Technique (SPOT) also known as the Relative Arrival Time Technique (RATT) requires that both tip diffraction signals be observed simultaneously. The difference in metal path is measured and used to obtain the flaw throughwall dimension. This technique is best suited for flaws with relatively small throughwall dimension.

- The Pulse Absolute Arrival Time Technique (PATT) requires that the tip diffracted signals be individually maximized in amplitude and the sweep position noted for both flaw tips. The difference in metal path is measured and used to obtain the flaw through wall dimension. This technique is best suited for flaws with relatively large throughwall dimensions.

The technique used for any given flaw is determined by the observed signals. When available both techniques are used and the results are compared. The reported flaw size is determined by the method giving the best signal presentation and therefore the highest confidence level. When both techniques are available the correlation is typically very good.

Tip diffraction sizing is considered to be more accurate and repeatable than the commonly used ASME amplitude based techniques as it is dependent on flaw characteristics and not on the relationship between the Basic Calibration Block and the flaw reflectivity.

3.5 INDICATION SIZING METHODS - LENGTH SIZING

The length sizing methods used by the GERIS and GERIS 2000 are amplitude based. They assume that when the amplitude of the indication has fallen to a given level that the search unit position has reached the end point of the indication.

The 100% Report defines that an indication has ended when the indication amplitude has dropped to the 100% DAC level.

The 50% Report defines that an indication has ended when the indication amplitude has dropped to the 50% DAC level.

The 20% Report defines that an indication has ended when the indication amplitude has dropped to the 20% DAC level. Note: Beam spread correction does not affect the 20% DAC Report lengths.

The tip diffraction sizing procedure defines that an angle beam indication, other than near surface indications, has ended when the indication amplitude has dropped to one half of its maximum amplitude level.

3.6 INDICATION SIZING METHODS - LIMITATIONS

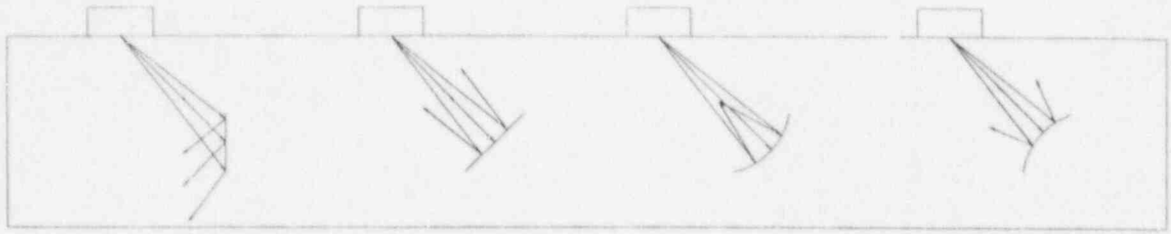
The sizing methods used with ultrasonic examinations rely on indirect measurements of the flaw. As the analyst has no direct means of measuring the flaw, the inherent limitations of the flaw sizing process must be understood.

Amplitude Based Methods

The most common flaw sizing techniques are amplitude based. A direct relationship between the response from the calibration reflectors and the flaw reflectivity is assumed. As the possible shape, orientation, and surface condition of any given flaw is not known, this assumption may not be reliable .

In reference to three simple reflector shapes it can be readily demonstrated that flaws with different shapes can have large effects on the ultrasonic response. Assuming similar length and height consider the following examples as illustrated in Figure 3-1:

- A reflector (A) with a flat surface oriented perpendicular to the ID surface. This orientation would tend to give a low amplitude or an undetectable signal.
- A reflector (B) with a flat surface oriented perpendicular to the sound beam. This orientation would tend to give a large amplitude signal compared to (A).
- A reflector (C) with a concave surface facing the sound beam. This shape would tend to focus the sound beam and enhance the amplitude of the reflected signal.
- A reflector (D) with a convex surface facing the sound beam. This shape would tend to disperse the sound beam and reduce the amplitude of the reflected signal.

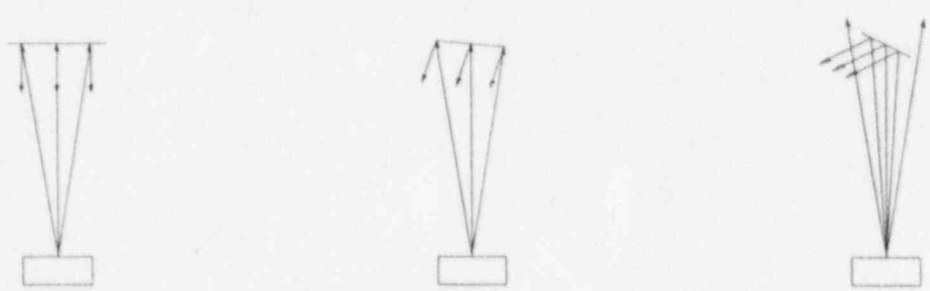


A B C D

Figure 3-1
Effects of Flaw Shape on Ultrasound

Orientation also has a significant effect on ultrasonic response as illustrated in Figure 3-2:

- A reflector (E) with a flat surface oriented perpendicular to the sound beam. This orientation would tend to give a large amplitude signal.
- A reflector (F) with a flat surface oriented at a 10° angle off perpendicular. This orientation would tend to give a smaller amplitude signal.
- A reflector (G) with a flat surface oriented at a 45° angle off perpendicular. This orientation would tend to give a very low amplitude or an undetectable signal.



E F G

Figure 3-2
Effects of Flaw Orientation on Ultrasound

Due to the many factors affecting the reflectivity of any given indication, it can be seen that amplitude based sizing may give inconsistent results. As these factors can be affected by scanning conditions, this inconsistency may be seen on a single indication sized at different times.

Tip Diffraction Methods

Tip diffraction based sizing methods also have limitations that may affect the results. All tip diffraction sizing methods rely on the analyst identifying the diffracted signal from the upper and lower extremities of the indication. These signals are generally low amplitude as only a small portion of the sound beam is diffracted and may not be detectable.

Also in examination areas containing large numbers of flaws it is possible to evaluate two separate flaws as tip diffracted signals from a single indication. The result in this case is that a throughwall flaw dimension equal to the separation distance is assigned.

Another condition that may affect the results is that most flaws are not regular in shape. The upper and lower extremities normally vary in depth. In this case the flaw throughwall dimension obtained is dependent on the position along the length of the indication.

The amplitudes of the tip diffracted signals are affected by the same conditions as the signals used for amplitude based sizing. Due to the many factors affecting the amplitude of any given reflector, the tip diffracted signals may not always be present. Tip diffraction sizing is not always possible for all flaws and some flaws may be able to be sized at one time and not at another due to minor variations in scan conditions.

Length Sizing Methods

All of the length sizing methods used with the GERIS 2000 are amplitude based. The same conditions that affect the amplitude based throughwall sizing techniques affect length sizing. Flaws that have been sized at one time may appear to have changed in apparent length or indications may appear to have joined or separated.

Additionally all of the length sizing methods share a common weakness. Generally all ultrasonic search units have better vertical resolution capability than horizontal resolution capability.

Indications that are aligned along a single plane at the same or equivalent depth and that are separated by less than the horizontal beam dimension may appear as a single indication. This is due to the indication metal paths being identical, and as one indication is falling off in amplitude the next indication will be increasing in amplitude.

As most fabrication related flaws are due to failures in the welding process and as most welding progresses along the length of the weld, it is not uncommon for multiple aligned separate flaws to be present in welds at the same depth.

Summary

Tip diffraction based sizing methods are more accurate and repeatable than amplitude based sizing as they are dependent on the characteristics of the flaw itself. However, all sizing techniques have limitations and if these limitations are not fully understood, inherent errors in the flaw sizing methods may be interpreted as apparent flaw growth.

Reactor Pressure Vessel flaws that are propagating can be expected to be well defined and distinct in presentation. This is due to the flaw being under tension, required for flaw growth, and relatively non-transparent to ultrasound. Planar flaws under compression normally are poor or intermittent reflectors due to their transparent nature.

Special attention is required for indications showing apparent flaw growth. Consideration should be made regarding the results of other search units examining the area. When the search units viewing the indication area from the opposing directicn or other complementary angles fail to strongly confirm the flaw length and throughwall dimensions, variations in scan conditions should be suspected.

4.0 DESCRIPTION OF INDICATIONS - RFO-14 AND RFO-16

4.1 DESCRIPTION OF INDICATIONS - NOZZLE N4-A

1991 RFO-14 ASME Report Indications

The 1991 RFO-14 examination of Feedwater Nozzle-to-Vessel weld N4-A recorded indications exceeding the 20%, 50% and 100% DAC amplitude levels. Eight (8) of the recorded 50% DAC indications exceeded the acceptance standards of Table IWB-3510-1.

The eight reported flaw indications were characterized as subsurface planar flaws in accordance with IWA-3000. These indications were attributed to welding flaws remaining from vessel fabrication

Numerous low amplitude reflectors were recorded throughout the examination volume from an azimuth of 50° through 130° and from 240° through 315°. These reflectors are attributed to fabrication flaws contained within the weld volume.

Reference Figure 4-1 for indication location.

1991 RFO-14 Manual Indication

Manual examination of Feedwater Nozzle-to-Vessel weld N4-A recorded one (1) indication exceeding 50% DAC. This indication was characterized as a subsurface planar flaw in accordance with IWA-3000. The indication exceeded the acceptance standards of Table IWB-3510-1.

The manual examination was performed to obtain coverage of portions of the examination area not accessible to the automated GERIS system.

1995 RFO-16 ASME Report Indications

The 1995 RFO-16 examination of weld N4-A recorded indications exceeding the 20%, 50% and 100% DAC levels. Low amplitude reflectors were recorded at less than 20% DAC throughout the examination volume. These low amplitude reflectors were concentrated from an azimuth of 50° through 130° and from 240° through 315°.

Seven indications in the 1995 ASME Reports correlated with the previous reportable indications and were evaluated to Table IWB-3512-1.

1995 50% Report indication 11 was correlated with 1991 50% Report indication 7 (rescanned area) and evaluated as acceptable.

1995 50% Report indication 15 was correlated with 1991 50% Report indication 3 and evaluated as reportable.

1995 50% Report indication 21 was correlated with 1991 50% Report indication 16 and evaluated as reportable.

1995 50% Report indication 23 was correlated with 1991 50% Report CoPlanar X indications 30-31-32 and 31-32-33 and evaluated as reportable.

1995 50% Report indication 24 was correlated with 1991 50% Report indication 34 and evaluated as reportable.

1995 50% Report indication 28 was correlated with 1991 50% Report indication 38 and evaluated as reportable.

1995 50% Report indication 30 was correlated with 1991 50% Report indication 1 and evaluated as acceptable.

Reference Figure 4-2 for indication location.

1995 RFO-16 Manual Indication

Manual examination of Feedwater Nozzle-to-Vessel weld N4-A recorded one (1) indication exceeding 50% DAC. This indication was characterized as a subsurface planar flaw in accordance with IWA-3000. The indication exceeded the acceptance standards of Table IWB-3512-1.

The 1995 manual indication correlated with the 1991 manual indication.

The manual examination was required to obtain coverage of portions of the examination area not accessible to the automated GERIS system.

1995 RFO-16 Tip Diffraction Sized Indications

Indications correlating to 1991 50% Report indications 1, 3, 7 (R), 16, 34, 38 and coplanar Y indication 30-31-32 and 31-32-33 were identified and characterized using tip diffraction techniques. The indications correlated with the previous reportable indications and were evaluated to Table IWB-3512-1.

1991 50% Report indication 1 was identified and evaluated as acceptable.

1991 50% Report indication 3 was identified and evaluated as reportable.

1991 50% Report indication 7 (R) was identified and evaluated as acceptable.

1991 50% Report indication 16 was identified and evaluated as reportable.

1991 50% Report indication 34 was identified and evaluated as reportable.

1991 50% Report indication 38 was identified and evaluated as reportable.

1991 50% Report coplanar Y indications 30-31-32 and 31-32-33 were identified and evaluated as reportable.

Reference Figures 4-3 and 4-4 for indication location.

4.2 DESCRIPTION OF INDICATIONS - NOZZLE N4-C

1991 RFO-14 ASME Report Indications

The 1991 RFO-14 examination of Feedwater Nozzle-to-Vessel weld N4-C recorded indications exceeding the 20% DAC amplitude level. Two (2) of the recorded indications exceeded the acceptance standards of Table IWB-3510-1.

The two reported indications were characterized as subsurface planar flaws in accordance with IWA-3000. The indications were attributed to welding flaws remaining from vessel fabrication.

Numerous low amplitude reflectors were recorded throughout the examination volume from an azimuth of 345° through 0° and from 60° through 125°. These reflectors are attributed to fabrication flaws contained within the weld volume.

Reference Figure 4-5 for indication location.

1995 RFO-16 ASME Report Indications

The 1995 RFO-16 examination of weld N4-C recorded no indications exceeding the 20% DAC level. Low amplitude reflectors were recorded at less than 20% DAC throughout the examination volume. These low amplitude reflectors were concentrated from an azimuth of 345° through 0° and from 60° through 125°.

The apparent sensitivity of the 1991 examination is greater than the apparent sensitivity of the 1995 examination. The ultrasonic sensitivity for both examination systems was established using the Basic Calibration Block and the calibrations were reviewed and verified correct by Level III reviewers. The difference in apparent relative sensitivity is attributable to normal variations in scan conditions.

1995 RFO-16 Tip Diffraction Sized Indications

Indications correlating to the 1991 20% Report indications 5 and coplanar Y indication 13-20 were identified at levels less than 20% of DAC and characterized using tip diffraction techniques. Both indications were evaluated as acceptable to Table IWB-3512-1.

Reference Figure 4-6 for indication location.

4.3 DESCRIPTION OF INDICATIONS - NOZZLE N4-D

1991 RFO-14 ASME Report Indications

The 1991 RFO-14 examination of Feedwater Nozzle-to-Vessel weld N4-D recorded indications exceeding the 20%, 50% and 100% DAC amplitude levels. Six (6) of the recorded 50% DAC indications exceeded the acceptance standards of Table IWB-3510-1. Three (3) of the recorded 100% DAC indications exceeded the acceptance standards of Table IWB-3510-1. The 100% DAC indications are coincident with three of the 50% DAC indications.

The six reported flaw indications were characterized as subsurface planar flaws in accordance with IWA-3000. These indications were attributed to welding flaws remaining from vessel fabrication.

Numerous low amplitude reflectors were recorded throughout the examination volume from an azimuth of 120° through 260° and from 315° through 0°. These reflectors are attributed to fabrication flaws contained within the weld volume.

Reference Figures 4-7 and 4-8 for indication location.

1995 RFO-16 ASME Report Indications

The 1995 RFO-16 examination of weld N4-D recorded indications exceeding the 20%, 50% and 100% DAC levels. Low amplitude reflectors were recorded at less than 20% DAC throughout the examination volume. These low amplitude reflectors were concentrated from an azimuth of 120° through 260° and from 315° through 0°. Two indications correlated with the previous reportable indications were evaluated to Table IWB-3512-1.

1995 50% Report indication 5 was correlated with 1991 50% Report indication 41 and evaluated as acceptable.

1995 50% Report indication 7 was correlated with 1991 50% Report indication 18 and evaluated as reportable.

Four of the 1991 reportable indications could not be directly correlated with indications in the 1995 50% Report. They were contained in the general area of the recorded low amplitude reflectors.

Reference Figure 4-9 for indication location.

The apparent sensitivity of the 1991 examination is greater than the apparent sensitivity of the 1995 examination. The ultrasonic sensitivity for both examination systems was established using the Basic Calibration Block and the calibrations were reviewed and verified correct by Level III reviewers. The difference in apparent relative sensitivity is attributable to normal variations in scan conditions.

1995 RFO-16 Tip Diffraction Sized Indications

Indications correlating to the 1991 50% Report indications 4, 18, 32, 33, 41 and coplanar Y indication 4-10 were identified and characterized using tip diffraction techniques. The indications were evaluated to Table IWB-3512-1.

1991 50% Report indication 4 was identified and evaluated as acceptable. Indication 4 is the same as 1991 50% Report coplanar Y indication 4-10.

1991 50% Report indication 18 was identified and evaluated as acceptable.

1991 50% Report indication 32 was identified and evaluated as reportable.

1991 50% Report indication 33 was identified and evaluated as reportable.

1991 50% Report indication 41 was identified and evaluated as acceptable.

Reference Figure 4-10 for indication locations.

5.0 COMPARISON OF THE 1991 AND 1995 EXAMINATION RESULTS

A comparison was made of the of the 1991 and 1995 ASME Report examination results. In general, areas having recorded indications during the 1991 examination contained indications during the 1995 examination. Most indications observed in both examinations were aligned with the shell side fusion line. The remaining indications were aligned with the nozzle side fusion line or within the weld metal itself. No recordable indications were observed in the base material.

In 1991 the ultrasonic indications were compared with radiographic indications recorded in the fabrication records. Most, but not all, of the RT indications could be directly correlated to UT indications. Some, but not all, of the UT indications could be directly correlated to RT indications. This indicates that not all flaws present were detected during the 1991 examination and also implies that not all flaws present were detected during the fabrication radiography.

This is not unexpected as both the ultrasonic and radiographic methods can give inconsistent results for certain types of flaws. Both methods are sensitive to the orientation of the flaw axis and the interrogating beams.

The comparison of the 1991 to 1995 ASME Report results showed that some, but not all, of the previously recorded indications were recorded in 1995. The comparison also showed that some indications recorded during the 1995 examination had not been recorded in 1991.

A comparison was made for the indications that could be directly correlated between the 1991 and 1995 examinations. This comparison was performed using the 2 MHz data to minimize the effects due to frequency.

The 1991 and 1995 DAC Reports showed poor correlation for both length and throughwall dimension.

The 1991 DAC Reports and the 1995 tip diffraction results showed good correlation for length dimension for the N4-C and N4-D welds; however, poor correlation was shown for the N4-A weld. The correlation for throughwall dimension was poor for most indications. In most cases the results reported for the tip diffraction methods were smaller.

To determine if the poor correlation between the 1991 and 1995 data was due to variations in the scanner setup or ultrasonic equipment, a comparison was made of the 1 MHz and 2 MHz examination results. This data was collected using the identical scanner, track setup and ultrasonic equipment, excepting search units. This comparison should show good correlation in number and location of indications with the only difference being due to frequency.

The comparison of the 1 MHz and 2 MHz ASME Report results showed poor correlation for number of indications, location, length, and throughwall dimension. This effect shows that the indications are more sensitive to scan conditions than is normally observed.

The tip diffraction results showed good correlation for throughwall dimension between the 1 MHz and 2 MHz data.

The poor correlation observed in the Feedwater Nozzle welds is most likely due to the flaw characteristics. The characteristic that is most likely to cause the poor correlation is flaw reflectivity. Reflectivity is dependent on the flaw size, shape, orientation, and the proximity to other reflectors. Previous testing on full scale GE vessel mockups have consistently shown good or excellent correlation on implanted flaws. These implanted flaws, typically fatigue cracks, should closely represent planar reflectors in vessel welds.

The most probable condition that would cause the inconsistent examination results would be a series of intermittent irregular planar flaws aligned in a single plane at the same approximate depth. This condition could readily occur during the welding process due to partial side wall fusion, or deposition of thin wall slag deposits along a single weld pass.

This condition would tend to create a series of ultrasonic reflectors that would be very sensitive to scan conditions. As the individual reflectors would be at equivalent depths, any two reflectors interrogated by the sound beam simultaneously would appear as a single indication. During subsequent examinations the scan conditions may vary, and individual flaws may become more or less reflective. This would result in an apparent increase or decrease in flaw length.

This same condition could also cause the apparent increase or decrease in flaw throughwall dimension when using amplitude based techniques. Again assuming two reflectors in the sound beam simultaneously, the indication would appear to have a given depth. During subsequent examinations the scan conditions may vary, and individual flaws may become more or less reflective. This would result in an apparent increase or decrease in flaw throughwall dimension.

This condition would also adversely affect the tip diffraction sizing results for length, as length sizing with this method is amplitude based.

The final evaluation of the 1991 and 1995 examination data indicates that a condition similar to that described above is present in the Feedwater nozzles at Cooper Nuclear Station. This evaluation is based on the ultrasonic characteristics of the indications and on the inconsistent results obtained when using methods that normally produce extremely repeatable results in mockups containing known planar flaws.

Additional supporting evidence is that numerous similar indications have been observed by General Electric using the GERIS 2000 in examinations of other vessels. Although these indications have been located in vessel weld seams, predominately in vertical welds with weld preparations similar to those used in the Cooper Feedwater nozzle-to-shell welds, they possess many of the same characteristics. These characteristics are:

- The indications are found in welds with essentially no weld preparation i.e. straight wall butt welds similar to the straight wall barrel type nozzle to shell welds used at CNS
- The indications are aligned with the weld fusion line.
- The indications are normally observed in clusters or as multiple indications.
- The indications are observed at similar depths along the length of the weld.
- The indications show preference or are more reflective to a specific angle or beam direction.

The only significant difference between the indications observed in the other straight wall preparation vessel welds and the indications in the CNS nozzle-to-shell welds is in the number or concentration of reflectors. This difference can be readily explained by the increased difficulty of fabricating a tight radius heavy wall weld.

The indications recorded during the 1991 and 1995 examinations are in the same general locations and all differences in individual indications are attributed to changes in scan conditions. The indications in Feedwater nozzles N4-A, N4-C, and N4-D do not possess the ultrasonic characteristics expected of a service induced flaw, or of a flaw in propagation. They do possess the characteristics of fabrication related flaws. The indications are characterized as flaws remaining from vessel fabrication.

Reference Tables 1, 2, 3 and 4 for indication correlation data.

6.0 CONCLUSION

The UT indications detected in the 1991 examinations were demonstrated as originating from welding discontinuities present since vessel fabrication. The indications detected in the 1995 examinations have also been evaluated as originating from welding discontinuities.

The fracture mechanics analysis performed in 1991 (reference 7) showed the plant to be suitable for continued operation for the remaining plant life. Flaw growth, if any, was predicted to be small.

The fracture mechanics analysis performed in 1995 (reference 8) analyzed a bounding flaw with a length of 15.8 inches and a throughwall dimension of 0.733 inches.

The size of the bounding indication was determined by tip diffraction sizing techniques and extended throughout an area containing numerous indications. Any future apparent changes in the bounding indication due to changes in reflectivity, would most likely reduce the length of the indication.

The indications showed either essentially no change or a reduction in throughwall dimension. The indications did show changes in apparent length. These changes have been attributed to changes in the ultrasonic conditions.

The indications remain characterized as flaws remaining from vessel fabrication. The comparison of the 1991 and 1995 ultrasonic data indicates that the recorded flaws have remained essentially unchanged.

The indications that exceeded the allowable flaw size have been analyzed per IWB-3600 (1989) Edition and have been found to be acceptable for continued service. The analysis shows them to be acceptable for the remaining plant life (reference 8).

The comparison of the examination results from the 1991 and 1995 examinations is evaluated as showing no growth in the original flaws. Additional examinations to monitor the indications are therefore not warranted.

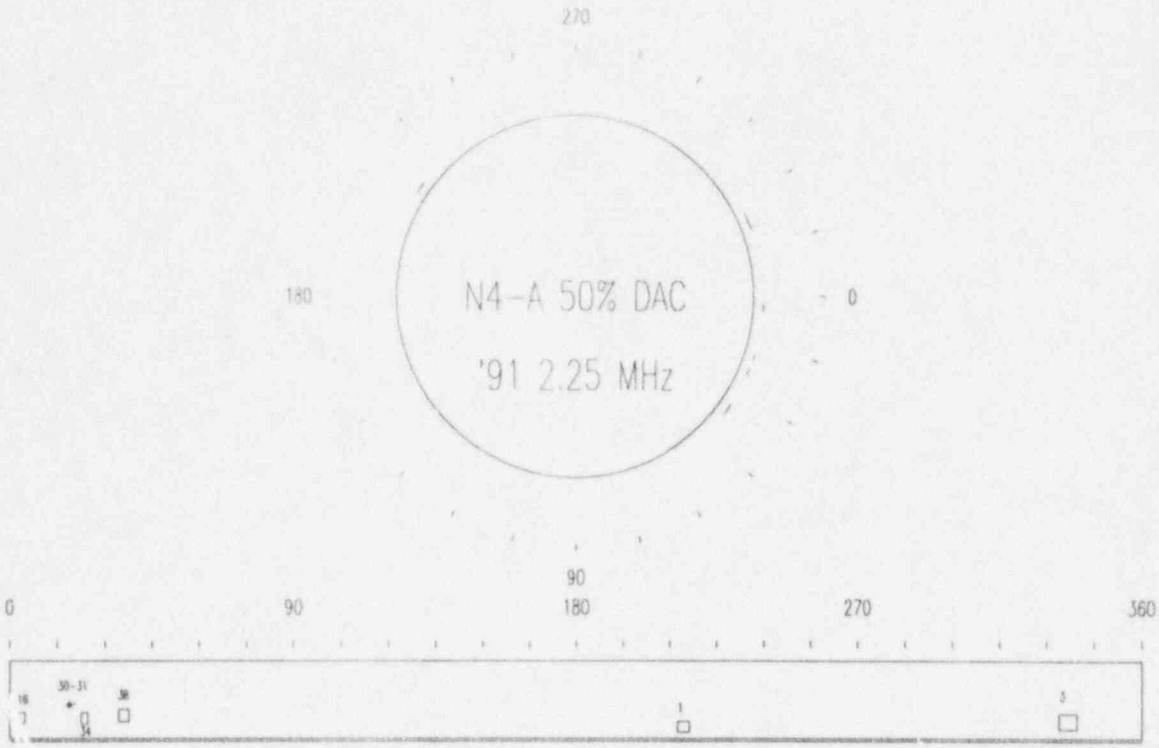


Figure 4-1

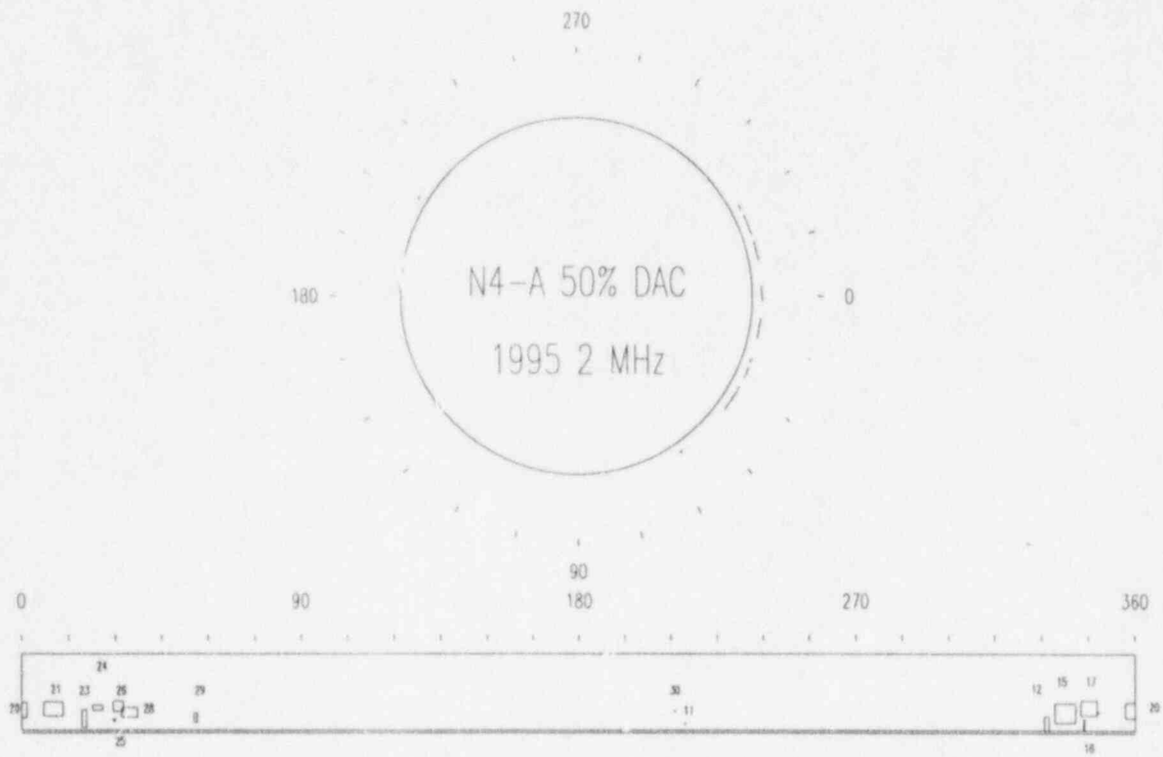


Figure 4-2

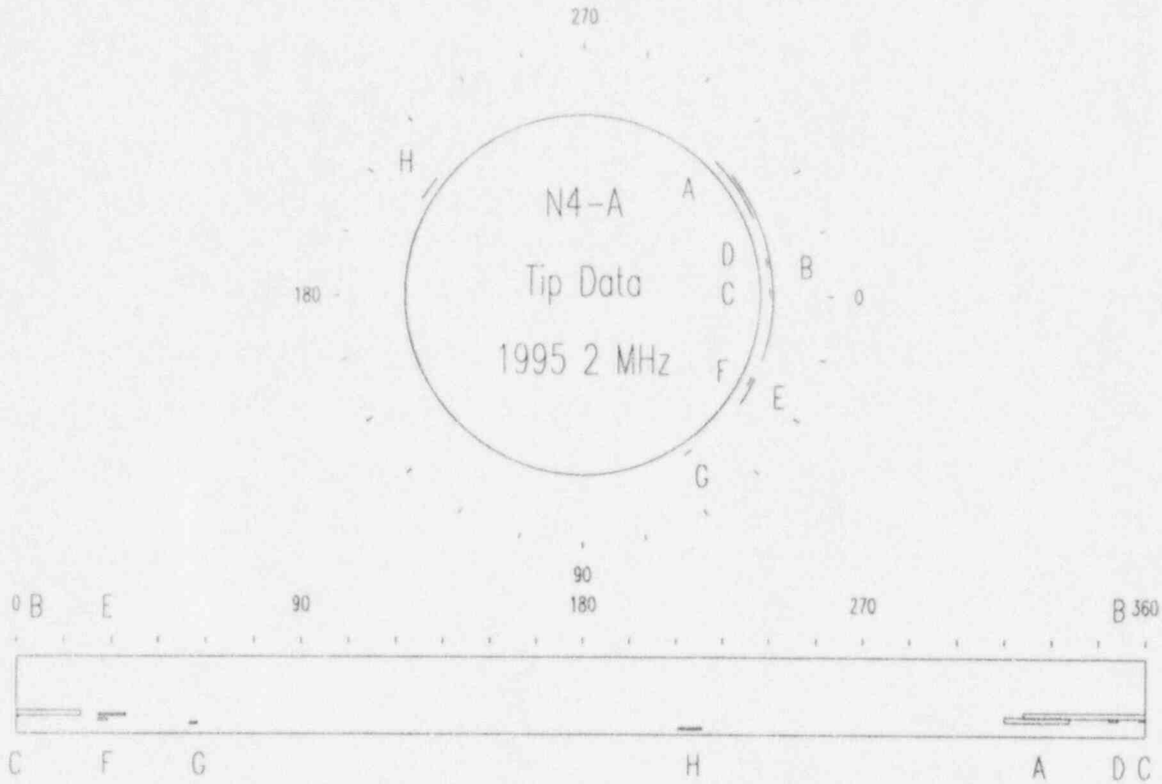


Figure 4-3

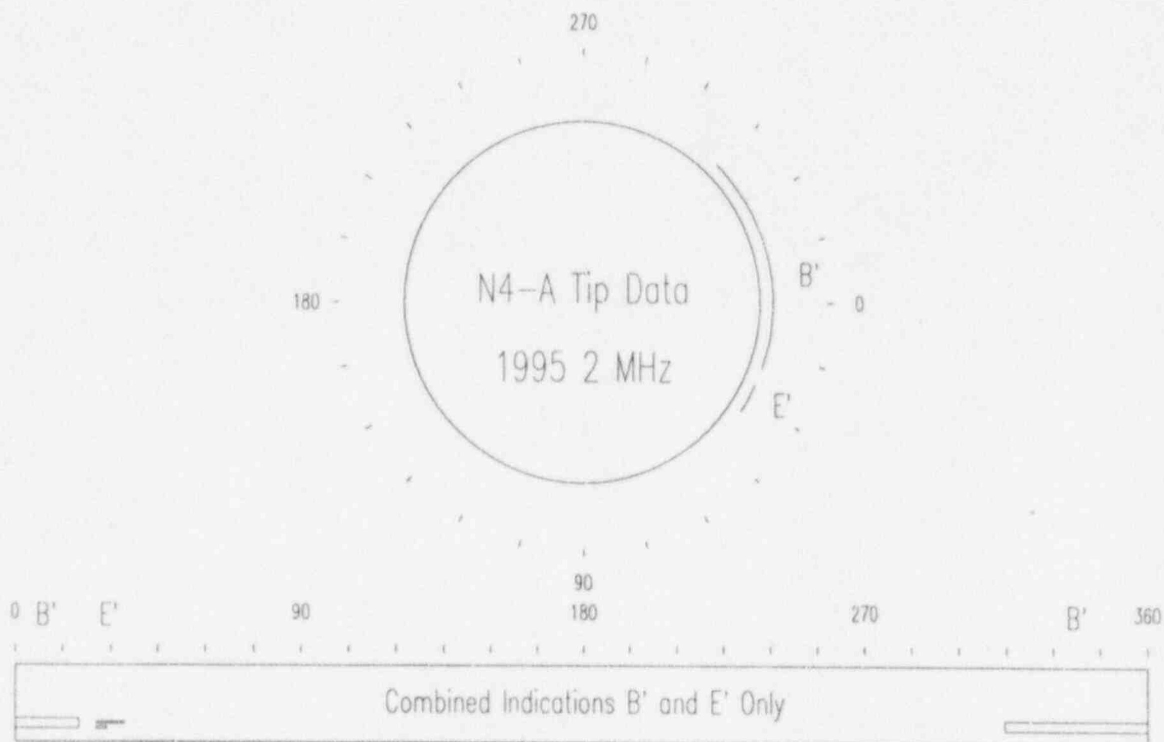


Figure 4-4

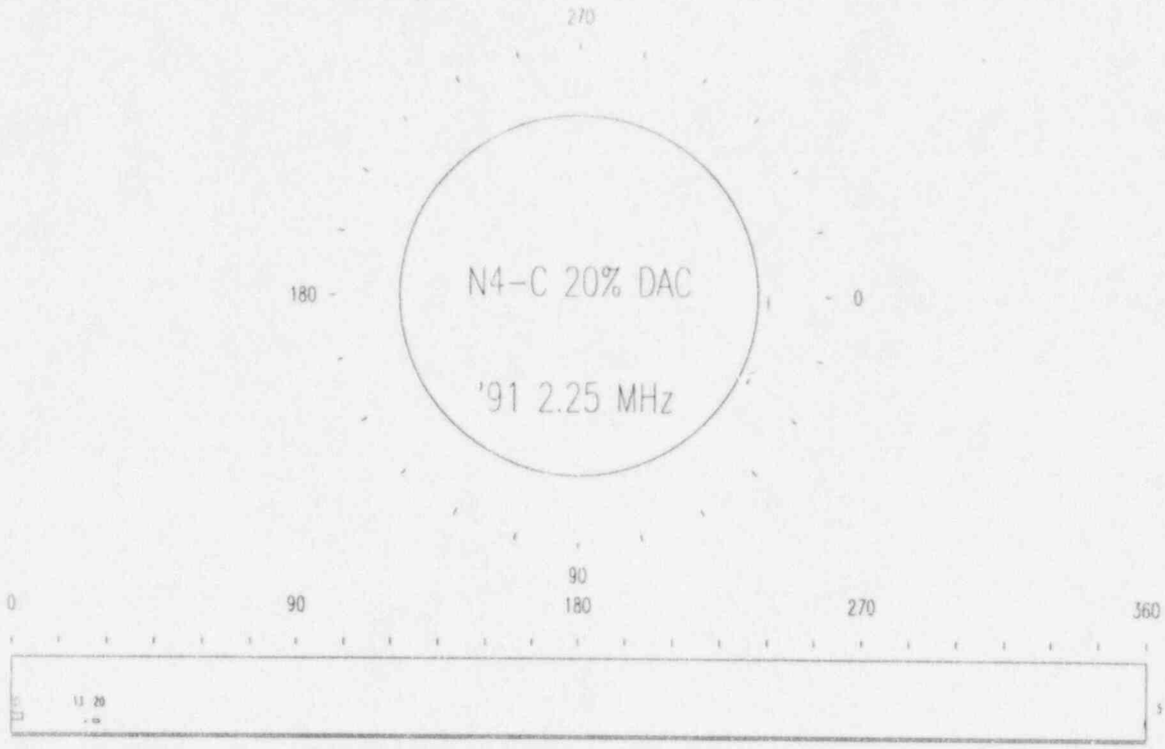


Figure 4-5

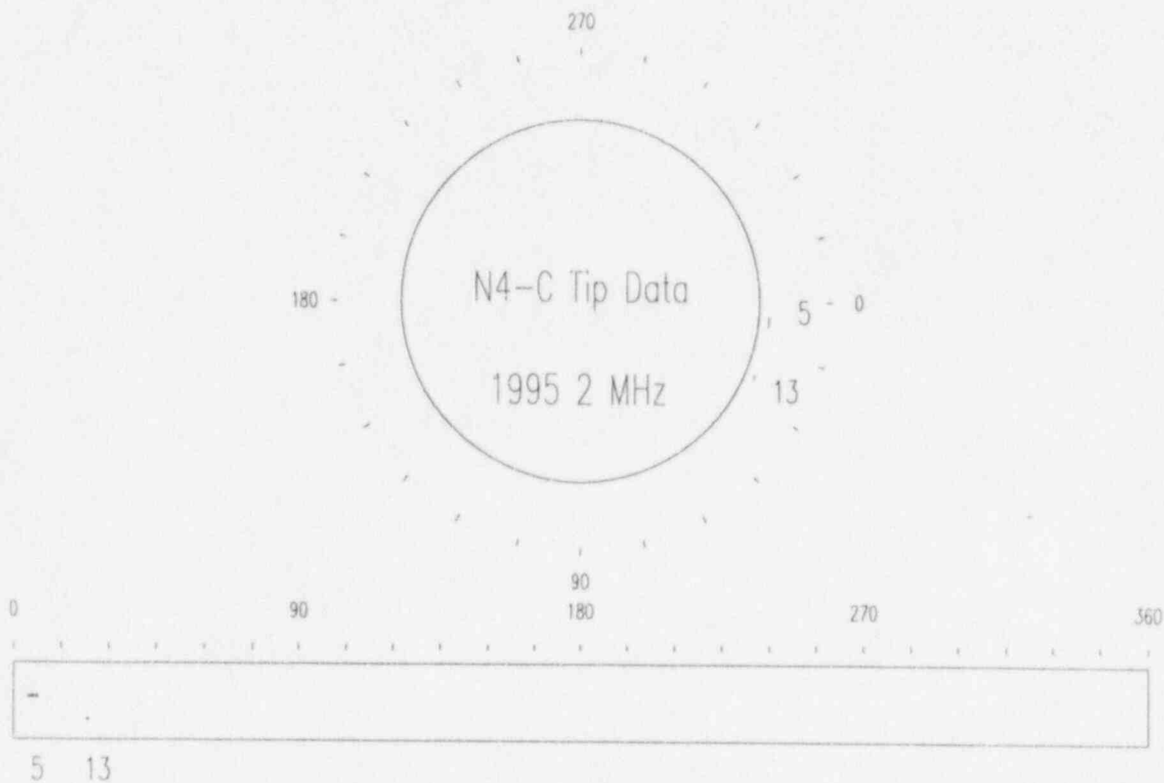


Figure 4-6

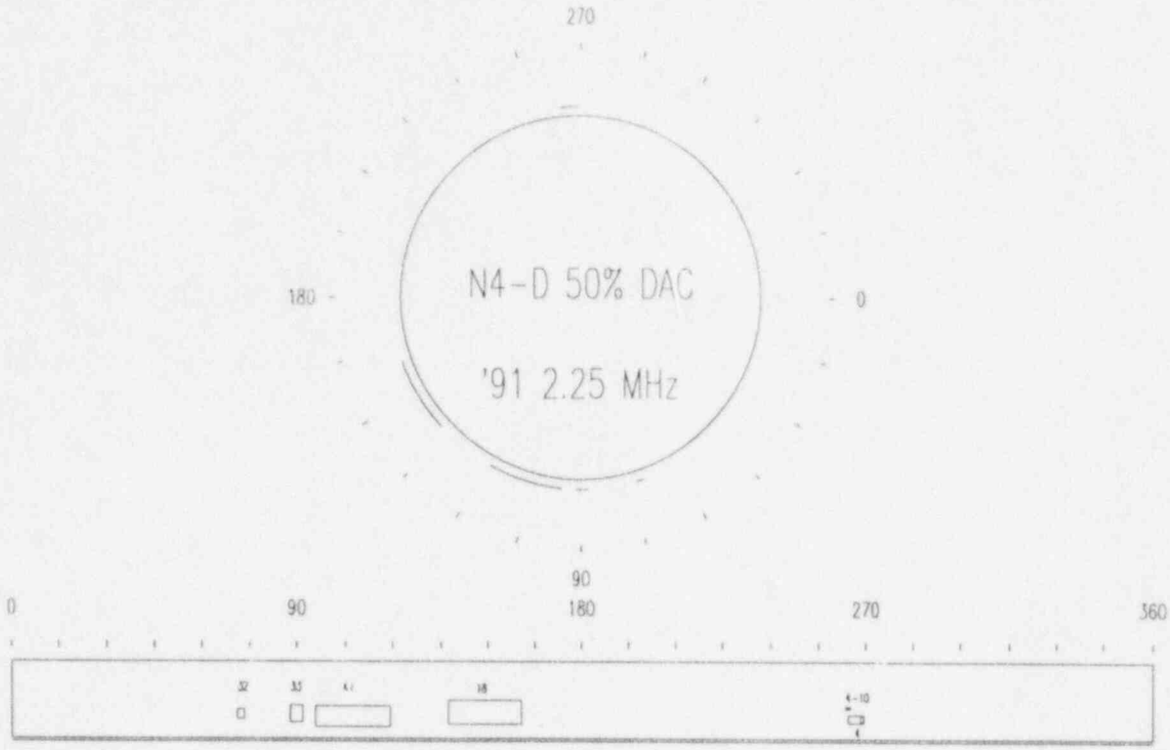


Figure 4-7

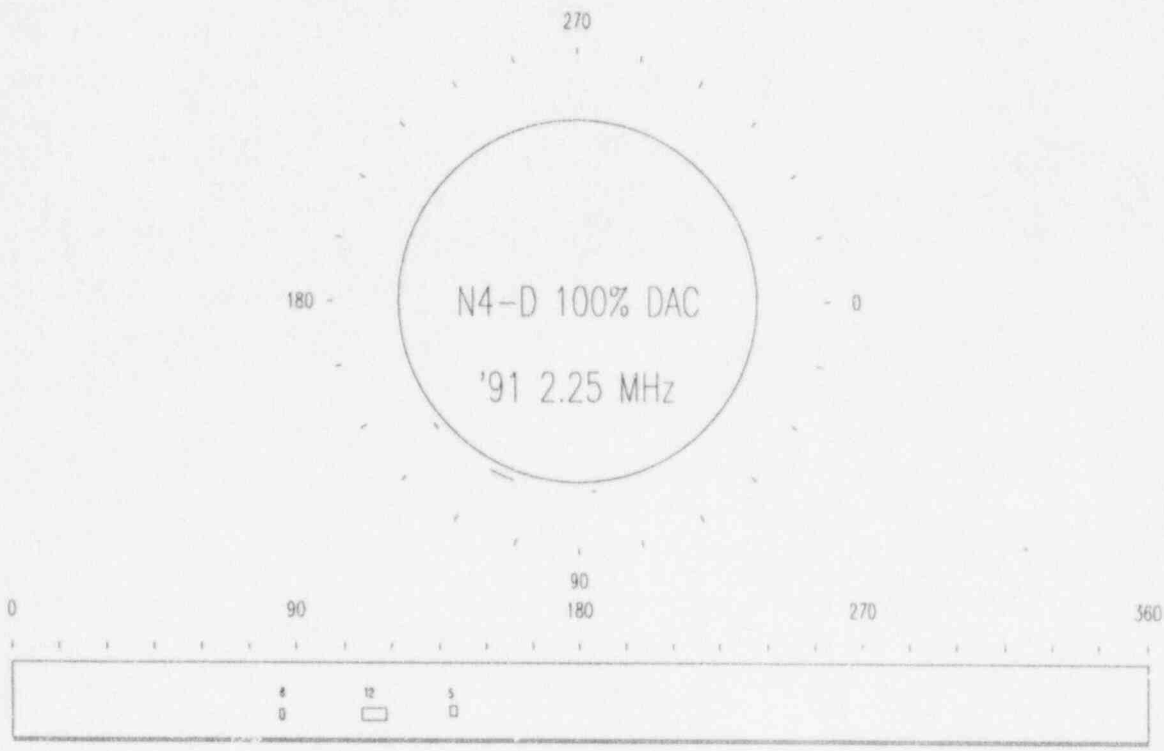


Figure 4-8

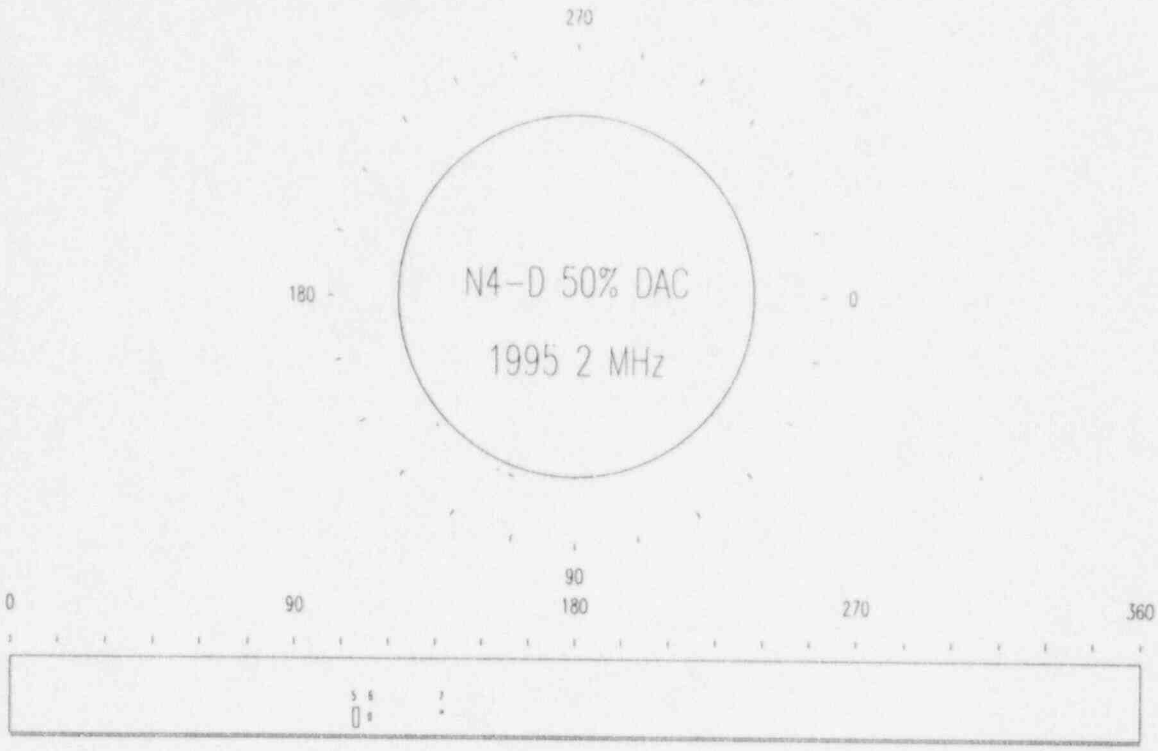


Figure 4-9

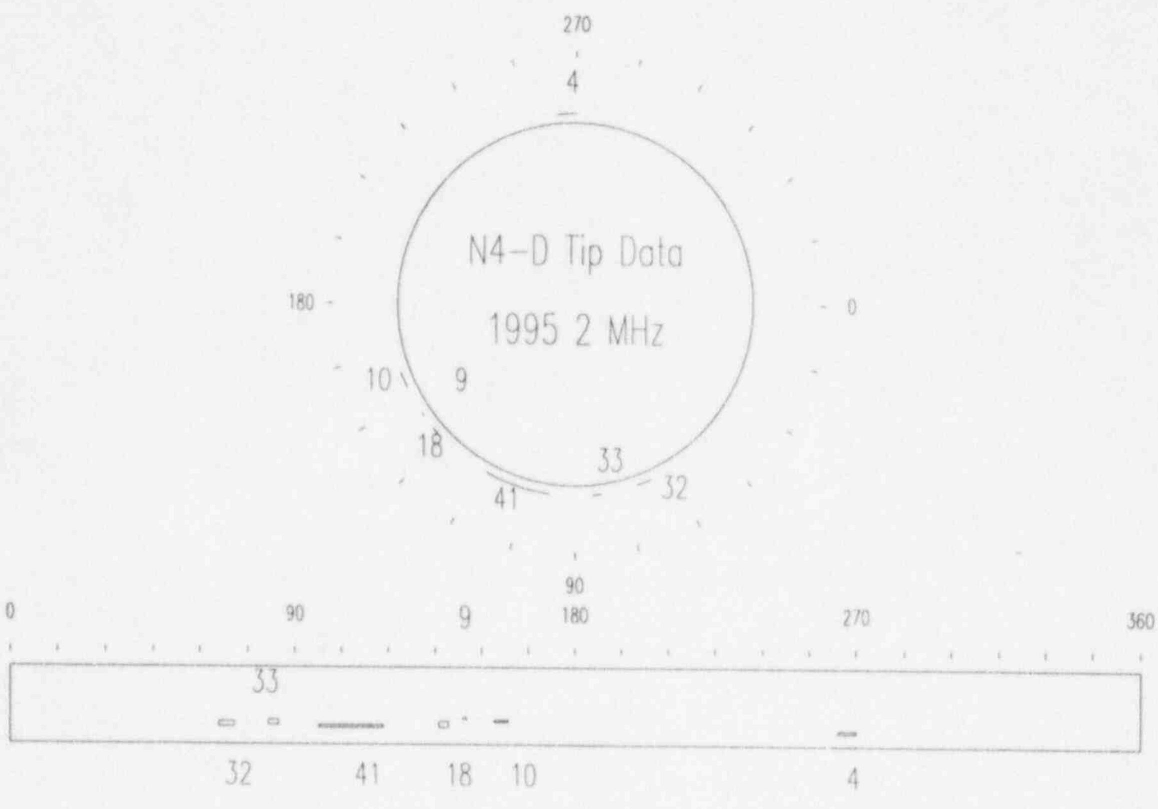


Figure 4-10

Cooper Feedwater Nozzles - Table 1
Nozzle-to-Shell Weld N4-A, 1991 to 1995 ASME Results

1991 50% DAC	Type	Max Amp	Flaw Thruwall	Flaw Length		1995 50% DAC	Type	Max Amp	Flaw Thruwall	Flaw Length
Note 1	~	~	~	~		12	SubSurf	100	1.16	0.36
3	SubSurf	84	1.17	1.397		15	SubSurf	100	1.49	1.57
Note 1	~	~	~	~		16	SubSurf	75	0.91	0.1
Note 1	~	~	~	~		17	SubSurf	100	1.13	1.25
Note 1	~	~	~	~		20	SubSurf	91	1.19	1.13
16	SubSurf	83	0.75	0.554		21	SubSurf	146	1.24	1.52
30-31-32	CoPlanar X	86	0.2	0.385		23	SubSurf	121	1.36	0.34
31-32-33	CoPlanar X	86	0.2	0.385		23	SubSurf	121	1.36	0.34
34	SubSurf	81	0.86	0.482		24	SubSurf	100	0.57	0.8
Note 1	~	~	~	~		25	SubSurf	51	0.13	0.29
Note 1	~	~	~	~		26	SubSurf	100	0.77	0.82
38	SubSurf	67	0.93	0.891		28	SubSurf	110	0.75	1.28
Note 1	~	~	~	~		29	SubSurf	75	0.74	0.24
1	SubSurf	110	0.82	0.939		30	SubSurf	51	0	0
7 (R) *	SubSurf	59	0.57	0.771		11	SubSurf	51	0	0

Note 1: Not recorded on the 50% DAC Report

* Rescan of area containing indication 1. Indication 7 (R) is the same as 1

Indication 11 is the same as 30.

All 1995 data is from the 2 MHz examination data.

1991 100% DAC	Type	Max Amp	Flaw Thruwall	Flaw Length		1995 100% DAC	Type	Max Amp	Flaw Thruwall	Flaw Length
1	SubSurf	110	0.4	0.193		NR @ 100%	~	~	~	~
NR @ 100%	~	~	~	~		6	SubSurf	146	0.67	1.084

NR @ 100% = Not recorded on 100% Report

All 1995 data is from the 2 MHz examination data.

Indication 6 is the same as 50% Report indication 21.

Cooper Feedwater Nozzles - Table 2
Nozzle-to-Shell Weld N4-C, 1991 to 1995 ASME Results

1991 20% DAC	Type	Max Amp	Flaw Thruwall	Flaw Length		1995 20% DAC	Type	Max Amp	Flaw Thruwall	Flaw Length
5	SubSurf	23	0.46	0.963		NR @ 20%	~	~	~	
13-20	CoPlanar Y	21	0.24	1.156		NR @ 20%	~	~	~	
* 13	SubSurf	21	0.11	0.289		NR @ 20%	~	~	~	
* 20	SubSurf	21	0.24	0.265		NR @ 20%	~	~	~	

NR @ 20% = Not recorded on 20% Report

* Indications combining to form 13-20

All 1995 data is from the 2 MHz examination data.

Cooper Feedwater Nozzles - Table 3
Nozzle-to-Shell Weld N4-D, 1991 to 1995 ASME Results

1991 50% DAC	Type	Max Amp	Flaw Thruwall	Flaw Length		1995 50% DAC	Type	Max Amp	Flaw Thruwall	Flaw Length
* 4	SubSurf	70	0.6	1.156		NR @ 50%	~	~	~	~
* 10	SubSurf	78	0.13	0.385		NR @ 50%	~	~	~	~
18	SubSurf	174	1.81	5.66		7	SubSurf	62	0.24	0.265
32	SubSurf	113	0.77	0.554		NR @ 50%	~	~	~	~
33	SubSurf	156	1.27	1.975		NR @ 50%	~	~	~	~
41	SubSurf	172	1.57	5.66		5	SubSurf	121	1.5	1.397
4-10	CoPlanar Y	78	0.73	1.397		NR @ 50%	~	~	~	~

NR @ 50% = Not recorded on 50% Report
* Indications combining to form 13-20
All 1995 data is from the 2 MHz examination data.

1991 100% DAC	Type	Max Amp	Flaw Thruwall	Flaw Length		1995 100% DAC	Type	Max Amp	Flaw Thruwall	Flaw Length
5	SubSurf	174	0.79	0.506		NR @100%	~	~	~	~
8	SubSurf	156	0.81	1.3		NR @100%	~	~	~	~
12	SubSurf	172	0.97	1.855		1 & 2	SubSurf	121	0.31	0.89

NR @100% = Not recorded on 100% Report
Indication 5 same as 50% Report indication 18.
Indication 8 same as 50% Report indication 33.
Indication 12 same as 50% Report indication 41.
All 1995 data is from the 2 MHz examination data.

Feedwater Nozzles N4A, N4C, and N4D
Tip Diffraction Sizing Results

Ind. #	Throughwall "2a"	Length "L"	Separation "S"	Calculated a/L	Allowed a/t	Calculated a/t	Evaluation	Comments
N4A								
A	0.370	5.05	1.0	0.037	2.30	3.10	Reject	Combines into B'
B	0.396	14.29	1.6	0.014	2.30	3.32	Reject	Combines into B'
C	0.150	0.77	1.3	0.097	2.59	1.26	Accept	Combines into B'
D	0.150	0.75	1.3	0.100	2.60	1.26	Accept	Combines into B'
E	0.150	2.16	1.3	0.035	2.30	1.26	Accept	Combines into E'
F	0.184	0.75	1.0	0.123	2.74	1.54	Accept	Combines into E'
G	0.150	0.65	0.8	0.115	2.69	1.26	Accept	None
H	0.150	1.85	0.4	0.041	2.30	1.26	Accept	None
B'	0.733	15.80	1.0	0.023	2.30	6.15	Reject	Combined IWA-3330
E'	0.334	2.16	1.0	*	2.52	2.80	Reject	Combined IWA-3390
N4C								
5	0.150	0.79	2.2	0.095	2.58	1.26	Accept	None
13	0.150	0.25	2.9	0.300	4.10	1.26	Accept	None
N4D								
4	0.226	1.42	1.1	0.080	2.52	1.95	Accept	None
9	0.150	0.63	1.9	0.119	2.71	1.29	Accept	None
10	0.150	1.15	1.7	0.065	2.46	1.29	Accept	None
18	0.495	0.75	1.3	0.330	4.40	4.27	Accept	None
32	0.396	1.13	1.3	0.175	3.10	3.41	Reject	None
33	0.396	1.06	1.5	0.187	3.19	3.41	Reject	None
41	0.240	5.02	1.3	0.024	2.30	2.07	Accept	None

7.0 REFERENCES

1) Regulatory Guide 1.150, Revision 1, "Ultrasonic Testing of Reactor Vessel Welds During Preservice and Inservice Examinations, USNRC, February 1983.

2) ASME B&PV, Section V, Nondestructive Examination, 1980 Edition including Winter 1981 Addendum.

3) ASME B&PV, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, 1980 Edition including Winter 1981 Addendum.

4) NP-1406-SR, "Nondestructive Examination Acceptance Standards Technical Basis and Development for Boiler and Pressure Vessel Code ASME Section XI, Division 1, and Special Report", EPRI, May 1980.

5) NP-719-SR, "Flaw Evaluation Procedures, Background and Application of ASME Section XI, Appendix A - Special Report", EPRI, August 1978.

6) GE-NE-508-014-1191 Rev 1, "Analysis of UT Indications in Feedwater Nozzle-to-Vessel Welds N4A, N4C, and N4D", GENE, December 6, 1991.

7) GE-NE-523-124-1191 Rev 2, "Fracture Mechanics Evaluation of UT Indications Found Per Reg. Guide 1.150 in the Cooper Feedwater Nozzle to Shell Weld", GENE, December 17, 1991.

8) GE-NE-523-A128-1195 "Fracture Mechanics Evaluation of UT Indications Found During 1995 Reexamination of the Feedwater Nozzle to Shell Welds at Cooper Nuclear Station"

(9) Letter from Roby B. Bevan, USNRC, dated February 13, 1991, "Cooper Nuclear Station- Staff Acceptance of Fracture Mechanics Evaluation of Flaw Indications (TAC NO. M82258)" with enclosure "Safety Evaluation by the Office of Nuclear Reactor Regulation Nebraska Public Power District Cooper Nuclear Station Docket No. 50-298 TAC No. M82258".

Attachment 3
to NLS950240

Updated Pages to the Nebraska Public Power District Third Ten-Year Interval Inservice Inspection Program (Index to Section 7 and Relief Request RI-19) - 3 Pages Total

INSERVICE INSPECTION RELIEF REQUESTS

Relief Request	Rev.	Summary
RI-01	0	24" HPCI Turbine Exhaust 10" Branch Connection - Withdrawn
RI-02	0	Use of Existing Calibration Blocks for Ultrasonic Examination of Class 1 and 2 Components.
RI-03	0	Reactor Vessel Top Head Nozzle Inner Radius Examinations
RI-04	0	Intentionally Left Blank
RI-05	0	Inspection of Residual Heat Removal (RHR) Heat Exchanger Tubesheet-to-Shell Welds.
RI-06	0	Circumferential and Longitudinal Welds in the Reactor Pressure Vessel
RI-07	0	Inspection of the RPV Support Skirt to Reactor Vessel Bottom Head Weld.
RI-08	0	Expansion Criteria for Welds Governed by Generic Letter 88-01 and NUREG 0313, Rev. 2.
RI-09	0	Exemption from Appendix VII Ultrasonic Examination Personnel Qualification Requirements.
RI-10	0	Use of the 1989 Addenda of Section XI to Govern Repair Procedures (IWX-4000) Replacements (IWX-7000).
RI-11	0	Successive Examination Requirements for Class 1 and 2 vessels.
RI-12	0	Alternative Examination of Class 1 and 2 Piping Longitudinal Seam Welds.
RI-13	0	Examination and Testing of Class 1, 2, and 3 Snubbers
RI-14	0	Alternative Rules for the Selection and Examination of Class 1, 2, and 3 Integrally Welded Attachments
RI-15	0	Examination of Peripheral Control Rod Drive Housing Welds
RI-16	0	Use of the Examination Requirements, Examination Method, and Acceptance Standard of the 1989 Addenda of ASME Section XI for Reactor Vessel Closure Head Nuts.
RI-17	0	Integrally Welded Shear Lugs
RI-18	0	Integrally Welded Attachment to the RHR Pump Casings
RI-19	0	Feedwater Nozzle-to-Vessel Welds

INSERVICE INSPECTION RELIEF REQUESTS

RELIEF REQUEST NUMBER: RI-19

COMPONENT IDENTIFICATION

Code Class:	1
References:	IWB-2420(b), Table IWB-2500-1
Examination Category:	B-D
Item Numbers:	B3.90
Description:	Nozzle-to-Vessel Welds
Component Numbers:	Feedwater Nozzles N4A, N4C, and N4D

CODE REQUIREMENT

IWB-2420(b) states that flaw indications or relevant conditions are evaluated in accordance with IWB-3142.4 and the component qualifies as acceptable for continued service, the areas containing such flaw indications or relevant conditions shall be reexamined during the next three inspection periods.

Table IWB-2500-1 requires a volumetric examination be performed on nozzle-to-vessel welds defined by the volume shown Figure IWB-2500-7.

BASIS FOR RELIEF

Specific relief is requested on the basis that the proposed alternative would provide an acceptable level of quality and safety.

Flaw indications in Feedwater nozzle-to-vessel welds, N4A, N4C, and N4D, were identified during the 1991 refueling outage and were reexamined during the 1995 refueling outage. The flaws are attributed to construction defects and are not considered to be service induced. The fracture mechanics evaluation in 1991 found the flaws to be acceptable per IWB-3600. The reexamination in 1995 indicated that the flaws have remained essentially unchanged from the 1991 examination. The 1995 fracture mechanics evaluation shows that the flaws are acceptable for the remaining life of the plant. Radiation doses of approximately 4 Person-Rem were received during the examinations in 1995.

Since the flaws have remained essentially unchanged from the 1991 examination, the indications are acceptable per Subarticle IWB-3600 of ASME Section XI, and the fracture mechanics analysis shows the indications to be acceptable for the remaining life of the plant, additional successive examinations as required by Paragraph IWB-2420(b) of the Code are not warranted. Furthermore, additional exposures of approximately 8 Person-Rem would be experienced during the performance of these examinations over the next two inspection periods.

INSERVICE INSPECTION RELIEF REQUESTS

RELIEF REQUEST NUMBER: RI-19

PROPOSED ALTERNATE EXAMINATION

CNS will perform the volumetric examination of Feedwater nozzle-to-vessel welds N4A, N4C, and N4D, once during the third ten-year interval in accordance with Table IWB-2500-1.

APPLICABLE TIME PERIOD

Relief is requested for the third ten-year interval of the Inservice Inspection Program for CNS.