# NSP PRODUCTION PLANT MAINTENANCE

INSERVICE INSPECTION
NONDESTRUCTIVE EXAMINATION PROCEDURE

TITLE: ULTRASONIC EXAMINATION OF REACTOR VESSEL NOZZLE BORE

NUMBER: ISI-UT-6 REVISION: 0

PREPARED BY: Robert A Kellerhall III REVIEWED BY: [signature]

APPROVED BY: L Ricker EFFECTIVE DATE: 7-14-89

## 1.0 PURPOSE

This procedure sets forth the instructions for ultrasonic examination of reactor vessel nozzle inner bore surfaces.

## 2.0 REFERENCES

This procedure is in compliance with applicable portions of the following referenced documents:

2.1 American Society of Mechanical Engineers Boiler and Pressure Vessel Code.

2.1.1 Section V, "Nondestructive Examination", 1977 edition, addenda thru Summer 1978.

2.1.2 Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components", 1977 edition, addenda thru Summer, 1978.

2.2 American Society for Nondestructive Testing, Recommended Practice No. SNT-TC-1A, June 1975 Edition, "Personnel Qualification and Certification in Nondestructive Testing".

## 3.0 APPLICABILITY

3.1 This procedure is applicable to examinations performed at Northern States Power Company's Monticello Nuclear Generating Plant.

3.2 This procedure is applicable to examinations performed from the outside nozzle surface on both clad and unclad vessels. (For clad vessels, examination shall be performed form the unclad side only).

## 4.0 DEFINITIONS

No definitions identified in this procedure.

## 5.0 PREREQUISITES

### 5.1 Procedure Qualification

This procedure shall be qualified for specific examinations, personnel, and equipment by performing and documenting a successful calibration.

### 5.2 Personnel Requirements

5.2.1 Personnel performing examinations governed by this procedure shall be certified in accordance with an approved program that complies with the requirements of reference 2.2 and as modified by reference 2.1.2.

5.2.2 Nondestructive examination personnel shall be certified to at least Level I in the ultrasonic method to operate equipment and at least Level II to interpret the examination results.

5.2.3 Personnel shall demonstrate natural or corrected near-distance acuity, with at least one eye, by reading the Jaeger No. 1 print on a Jaeger test chart at not less than I2 inches. Equivalent measures of near-distance acuity may be used (e.g. Ortho-Rater test).

5.2.4 Personnel shall demonstrate the capability to distinguish the colors applicable to the examination method and the ability to differientiate contrast between these colors.

5.2.5 These vision examinations shall be conducted annually by personnel qualified to conduct the examinations.

### 5.3 Preparations

5.3.1 Documentation

Prior to examination performance, the examination supervisor and examiners shall assure themselves that the following documents have been issued and that they understand all the identified requirements pertaining to the performance of the examination:

A. Work Request (WR) and/or Work Request Authorization (WRA)

B. Radiation Work Permit (RWP), when applicable.

5.3.2 Physical

The examiners shall assure themselves that the following applicable physical preparations have been completed prior to examination performance:

A. Insulation removal

B. OSHA requirements (ladders, lighting, scaffolding, etc.)

C. Cleanup requirements

D. Safety precautions

5.3.3 Surface Requirements

A. As far as practicable, examination surfaces shall be clean and free from any condition which, in the opinion of the examiner, might impede the performance of a meaningful examination.

B. Any deviation from the above surface requirements shall be reported to the cognizant NSP supervisor or coordinator for evaluation and corrective action and shall be recorded on the Examination Report, Figure 5.

## 6.0 EQUIPMENT REQUIRED

### 6.1 Instrumentation

6.1.1 Ultrasonic instruments shall be of a standard commercial pulse echo type, meeting the following requirements:

A. Vertical linearity of ±5% of the full screen range over at least 80% of the calibrated screen height.

B. Amplitude control accurate over the instrument range to ±20% of nominal value.

C. Amplitude controls calibrated in units of 2 dB or less.

6.1.2 Ultrasonic instrument internal alignment and calibration shall be verified and certified within 90 days prior to use.

6.1.3 Electronic recording instruments, when used, shall meet the requirements of ISI-UT-2.

6.2 Transducers, Wedges, Cables

6.2.1 Transducer essential properties (bandwidth, center frequency, and relative gain) shall be certified.

6.2.2 Transducers and wedges shall be selected according to Table 6.2.2. Where both right and left handed wedges are required, the table indicates R and L. The examination zones are defined in Figure 1.

TABLE 6.2.2

| Nozzle Identification | Wall | Zone | Transducer Diameter | Wedges | Freq. |
|---|---|---|---|---|---|
| N-2, 3, 4, & 5 | 5"-8" | 2 | 1" | 30° @ 20° R&L | 1 MHz |
| | | 3 | 1" | 30° | 1 MHz |
| N-6 & 7 | 1"-3" | 2 | .5"-1" | 30° (*from radius) | 1-2.25 MHz |
| | | 3 | .5"-1" | 30° | 1-2.25 MHz |
| N-8, 9, & 10 | 2"-5" | 2 | .5"-1" | 20° (*from radius) | 1-2.25 MHz |
| | | 3 | .5"-1" | 20° | 1-2.25 MHz |
| N-1A & 1B 48.75 to 53.77" | 9.85" | 2 & 3 | 1" | 26° | 1 MHz |

* Examination conducted from nozzle outer radius. Contoured wedges may be used.

6.2.3 Other sizes and/or frequencies may be used for evaluation or in unusual circumstances. Such use shall be documented on the Calibration Report, Figure 2.

6.2.4 Angle beam transducer wedges, when practical, shall have a correct index point and shall produce refracted angles within $\pm 3^{0}$ of their nominal angle when checked on a standard reference block, such as an IIW-2 or Rompas. If the marked index point is incorrect, the correct point shall be marked on the wedge. Any wedge that falls outside the above refracted angle tolerance shall not be used.

6.2.5 Cables connecting transducers and instruments shall be co-axial, with length limited to less than that at which significant signal degradation occurs.

6.3 Couplant Materials

The sulfur and halogen content of couplant materials shall be certified and as low as practicable, but shall not exceed 1% by weight when analyzed according to ASTM SD-129 and ASTM SD-808.

6.4 Calibration Blocks

6.4.1 Monticello's Calibration Block No. 30, Figure 4, shall be used in conjunction with this procedure. This calibration block is made from material of the same specification, type, grade and heat treatment as the vessel shell. In addition, the responses form the bore reflector of this block have been compared to General Electric Company's full size nozzle mockup calibration block that was made from material of the same specification, type, grade and heat treatment as the vessel nozzle forging. The comparison of these two blocks is documented in letter number 77-TGL-227, dated October 5, 1977. This letter is maintained on file by Northern States Power Company.

6.4.2 Standard reference blocks, such as IIW or Rompas, may be used as calibration check reference blocks.

## 7.0 INSTRUCTIONS

7.1 Calibration

7.1.1 Instrument Performance

A. Acceptable instrument performance shall be verified in conjunction with each calibration.

B. Vertical linearity shall be determined as follows:

1. Position an angle beam transducer on the calibration or reference standard such that echoes from any two reflectors may be observed at the same time.

2. Adjust the transducer position as required to obtain a 2:1 amplitude ratio of the two signals, with the larger amplitude at 100% full screen height (fsh).

3. Adjust the amplitude control to set the larger amplitude to successively lower amplitudes in increments of 10% fsh, or 2 dB steps if a fine control is not available, and record the smaller amplitude for each step, on the Calibration Report, Figure 2.

4. Vertical linearity is acceptable when the amplitude ratio remains at 2:1, ±5% fsh, over at least 80% of the calibrated screen height.

C. Amplitude control accuracy shall be determined as follows:

1. Position an angle beam transducer on a calibration or reference block and obtain an echo from a reflector.

2. Set the amplitude of the reflector using the gain control, as indicated in the first column of Table 7.1.1.

3. Increase or decrease the instrument sensitivity by values in the second column of the table, and record the resulting amplitudes on the Calibration Report, Figure 2.

Table 7.1.1

| Amplitude Set | Sensitivity Change | Acceptable Limits |
|---|---|---|
| 80% | - 6 dB | 32% - 48% |
| 80% | -12 dB | 16% - 24% |
| 40% | + 6 dB | 64% - 96% |
| 20% | +12 dB | 64% - 96% |

4. Amplitude control accuracy is acceptable when the recorded amplitudes fall within the acceptable limits shown above.

7.1.2 System Calibration Requirements

A. Calibration shall be performed on a complete system each day prior to use on each material. Any change in instrument, cables, transducer, personnel, and, if used, recording equipment, shall require a calibration check to compare the original calibration response with the calibration or reference block.

B. Calibration shall be performed on the appropriate block conforming to the requirements of paragraph 6.4.

C. Calibration block temperature shall be within 25°F of the item to be examined.

D. For all calibrations, the beam centerline shall be directed at the half-length of the notch, and at right angles to the calibration reflector axis.

7.1.3 Angle Beam Calibration

A. Select the appropriate straight angle (do not use a right or left skew or a curved wedge) search unit according to Table 6.2.2 of Paragraph 6.2.

1. Metal paths and desired angles will vary from nozzle to nozzle in relation to bore size and wall thickness. Table 7.1.3 below, categorizes beam angles and metal paths for the specific nozzles identified.

TABLE 7.1.3

| Nozzle Identification | OD | ID | Wall | Beam Angle for Beam Tangent to Bore ID | Metal Path |
|---|---|---|---|---|---|
| N-2: Recir. Inlet | 24.25" | 14.125" | 5.1" | $35.6^0$ | 9.75" |
| N-3: Main Steam | 30.0" | 16.0" | 7.0" | $32.2^0$ | 12.36" |
| N-4: Feedwater | 23.0" | 10.75" | 6.1" | $28^0$ | 10.05" |
| N-5: Core Spray | 24.25" | 11.7" | 6.3" | $29^0$ | 9.98" |
| N-6: Spray & Spare | 11.25" | 6.1" | 2.6" | $33^0$ | 4.73" |
| N-7: Head Vent | 7.5" | 4.2" | 1.65" | $34^0$ | 3.11" |
| N-8: Jet Pump Instr. | 10.7" | 3.6" | 3.6" | $20^0$ | 4.89" |
| N-9: CRD Return | 11.75" | 3.5" | 4.1" | $17^0$ | 5.17" |
| N-10: SBLC | 6.4" | 2.3" | 2.0" | $21^0$ | 2.99" |
| N-1: Recir. Outlet (Tapered) | 48.75" to 53.77" | 26.125" to 36.375" | 9.85" | Beam $45^0$ to Flaw $25.5^0$ to $27^0$ | 11.88" to 12.04" |

B. Perform sweep range calibration as follows:

1. Position the search unit on a Rompas, IIW, or other reference block.

2. Using the delay and range controls, display enough multiple reflections from the reference block to enable the sweep to be calibrated over the full range of the test as identified in Table 7.1.3.

C. Perform sensitivity calibration as follows:

1. Position the search unit to obtain a maximum response from the notch reflector located in the bore of Calibration Block No. 30, Figure 4.

2. Adjust the sensitivity to set the amplitude of the response from this notch to 80% fsh, and mark the signal location and peak on the screen or record per 6 below. This is the Primary Reference Sensitivity.

3. Obtain, record, and mark on the screen or record per 6 below, the amplitude and sweep location of a convenient reflector from a reference block, such as an IIW or Rompas.

4. Lock all adjustable instrument controls possible.

5. Transcribe the calibration points and all required data to the Calibration Report, Figures 2 and 3.

6. When marking directly on the screen is prohibited by the instrument manufacturer, a recording of the screen responses for the calibration reflectors shall be made and shall be in the possession of the examiner during all examinations performed.

D. A calibration check shall be performed before and after each examination with a skewed or curved wedge as follows:

1. After calibration is established using the straight angle search unit, mount either the right or left hand skewed wedge on the transducer.

2. Without changing sensitivity, obtain, record, and mark on the screen or mark per 7.1.3.c.6, the amplitude and sweep location of the same reference reflector used in C.3 above.

7.2 Performance

7.2.1 Calibration Check

A. Calibration shall be verified at intervals not to exceed four hours, at the beginning and end of each examination, and with any change in personnel or system components.

B. Calibration shall be verified by comparing sweep and amplitude responses from either the calibration or reference standard.

C. For any change in amplitude or sweep responses, or both, the following action shall be taken:

1. If any point on the DAC curve has decreased by more than 20% or 2dB of its amplitude, all data sheets since the last calibration check shall be marked void. A new calibration shall be made and recorded and the voided examination area shall be reexamined.

2. If any point on the DAC curve has increased by more than 20% or 2dB of its amplitude (whichever is smaller), recorded indications taken since the last valid calibration or calibration check may be reexamined with the correct calibration and their values changed on the data sheets.

3. If a point of the Primary Reference Metal Path has moved on the sweep line more than 10% of the sweep reading or 5% of full sweep, whichever is greater, correct the sweep range calibration and note the correction in the Examination Report. If reflectors were recorded on the Examination Report, those reflectors shall be voided and a new calibration shall be recorded, and the voided examination areas shall be reexamined with the corrected calibration.

7.2.2 Scanning Sensitivity

A. Scanning sensitivity shall be at least two times (+6 dB) the Primary Reference Sensitivity.

B. For cladded nozzles, penetration of the ultrasound shall be verified by observing the "clad roll" indication.

7.2.3 Examination Coverage

A. Examination Zones 2 and 3, Figure 1, shall be completely examined by overlapping scans in opposing directions (clockwise and counterclockwise) using transducers selected according to Table 6.2.2.

B. Transducer overlap shall not be less than 10%.

C. Scan directions are shown in Figure 6.

7.2.4 Scanning Speed

Scanning speed shall not exceed 6 inches per second.

7.2.5 Limitations

Limitations preventing full compliance with 7.2.2, 7.2.3, or 7.2.4 shall be identified on the Examination Report, Figure 5.

## 8.0 REPORTING

### 8.1 Reference System

8.1.1 Indication recording is based on the scan direction and reference system shown in Figure 6.

8.1.2 Scan descriptions shall be as follows:

A. Angle beam scans will be labeled by arabic numerals, i.e., 1, 2, 3, etc.

B. L-wave scans will be labeled by arabic numerals followed by an L, i.e., 1L, 2L, etc.

### 8.2 Reflector Recording of Angle Beam Examinations

8.2.1 Reflectors shall be recorded at the primary reference sensitivity.

8.2.2 Any reflector determined to be a crack shall be recorded regardless of amplitude or size.

8.2.3 Reflectors determined to be geometric or metallurgical in nature shall be recorded on the Examination Report, Figure 5.

A. For a reflector to be defined as geometric, the evaluation should be confirmed by one of the following:

1. Review of radiographs
2. Review of weld joint design
3. Previous examination results
4. Weld profile and thickness

8.2.4 All reflectors equal to or exceeding 50% of Primary Reference shall be evaluated and recorded to the extend that their shape, identity, and location can be determined for acceptance/rejection in accordance with ASME Section XI.

A. Preliminary length and depth sizing data shall be taken between 50% DAC points and recorded on the Data Tabulation Form, Figure 7, and Examination Report, Figure 5.

B. The responsible Level III and M&SP Representative shall determine the need for any additional sizing.

8.2.5 Clad interface and backwall (L-wave) reflections need not be recorded.

8.3 Reflector Recording for L-Wave Examinations

8.3.1 Reflectors shall be recorded at primary reference sensitivity.

8.3.2 Record all reflectors that equal or exceed 20% fsh, also record any loss of back reflection greater than 50% that is not attributable to geometry.

8.3.3 All required information as to location, size and depth shall be recorded on the Examination Report Form, Figure 5.

8.4 If strip chart recordings are used, all recorded chart signals shall be identified.

8.5 Documentation

8.5.1 Calibration Report

For each calibration, an Ultrasonic Calibration Report, Figures 2 and 3, shall be completed.

8.5.2 Examination Report

A. For each item examined, an Ultrasonic Examination Report, Figures 5 and, if necessary, Figure 7, shall be completed.

B. The Examination Report shall be traceable to the appropriate Calibration Report.

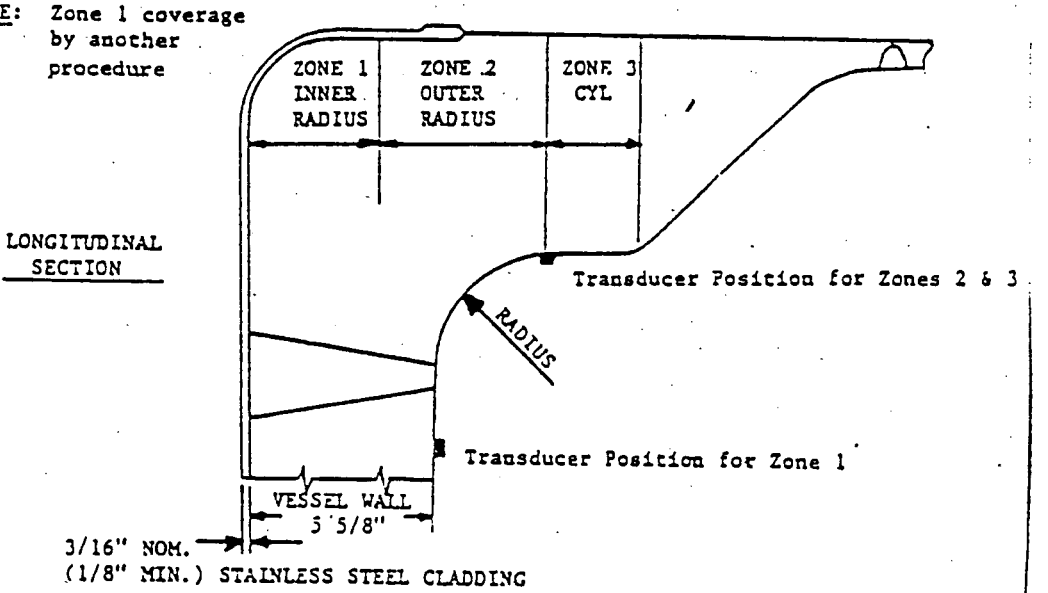
8.5.3 Data Recording of Examinations

If examinations are recorded, i.e., video or strip chart, the recordings shall be performed in accordance with ISI-UT-2.

FIGURE 1
(Typical - Use Current Revision)

NOZZLE BORE EXAMINATION ZONES

NOTE: Zone 1 coverage by another procedure




NOTE: See nozzle drawing for bore surface cladding amount and extent.

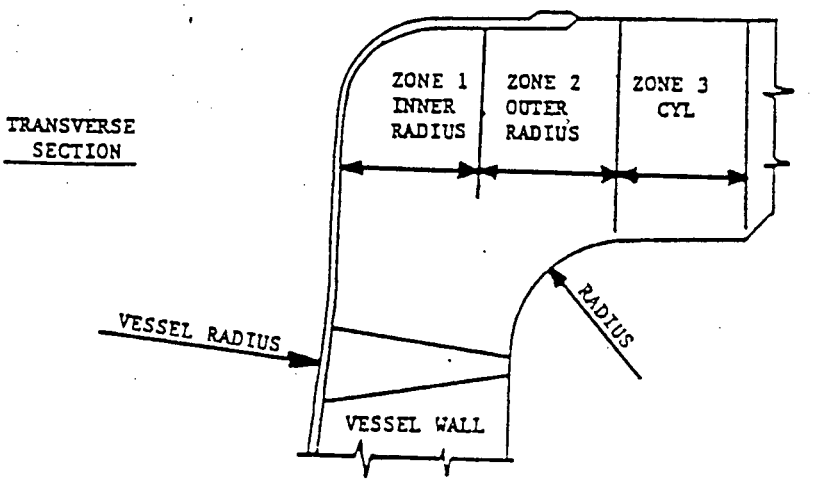


FIGURE 2
(Typical - Use Current Revision)

NORTHERN STATES POWER COMPANY
POWER PRODUCTION DEPARTMENT

Calibration Report NUMBER:

ULTRASONIC CALIBRATION REPORT

PROCEDURE NO: REV.

| CALIBRATION BLOCK Type: S/N: | BLOCK TEMP ° F | REFERENCE BLOCK Type: S/N: | Plant: |
|---|---|---|---|
| CAL. BLOCK MATERIAL: | SIZE & THICK : | ENTRY SURFACE Clad: Unclad: | Exam Company: |
| UT INSTRUMENT(S): Mfr: Model: S/N: ReCal: / / Mfr: Model: S/N: ReCal: / / | RECORDER Mfr: Model: S/N: ReCal: / / | | Calibration Data: Date: / / Time Start: Intermediate: Time Stop: |
| SEARCH UNIT CABLE Type: Length: | COUPLANT: B/N: | | |

SEARCH UNITS

| S/N: | ANGLE: | FREQ: | WAVE MODE: | S.U. MFR: | SIZE: | WEDGE MFR: |
|---|---|---|---|---|---|---|
| | | | | | | |

BEAM ANGLE DATA

| Search Unit | Index Check | Refracted Beam Angle In: Reference Block | Calibration Block |
|---|---|---|---|
| | | deg deg | deg deg |

AMPLITUDE LINEARITY (Signal 2 shall Equal 50% of Signal 1, ±5% F.S.H.)

| | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Signal 1 (Set) | | | | | | | | | | |
| MASTER: Signal 2 (Read) | | | | | | | | | | |
| SLAVE: Signal 2 (Read) | | | | | | | | | | |

AMPLITUDE CONTROL ACCURACY

| | | | | |
|---|---|---|---|---|
| Amplitude Setting: | 80% /- 6dB | 80% /-12dB | 40% /+6dB | 20% /+12dB |
| Acceptable Range: | 32% to 48% | 16% to 24% | 64% to 96% | 64% to 96% |
| MASTER Acutal: | | | | |
| SLAVE Actual: | | | | |

INSTRUMENT SETTINGS AT REFERENCE SENSITIVITY

| | Straight Beam | Angle Beam |
|---|---|---|
| Gain | | |
| Frequency | | |
| Sweep | | |
| Delay | | |
| Damping | | |
| Reject | | |
| Rep. Rate | | |
| Video/Filter | | |

FLAW GATE SETTING

Start:
End:

Beam Spread:

Signal to Noise Ratio:

REMARKS:

Examiner: Level
Examiner: Level
Examiner: Level
Examiner: Level

Contractor Review: Date
N S P Review: Date
A N I I Review: Date

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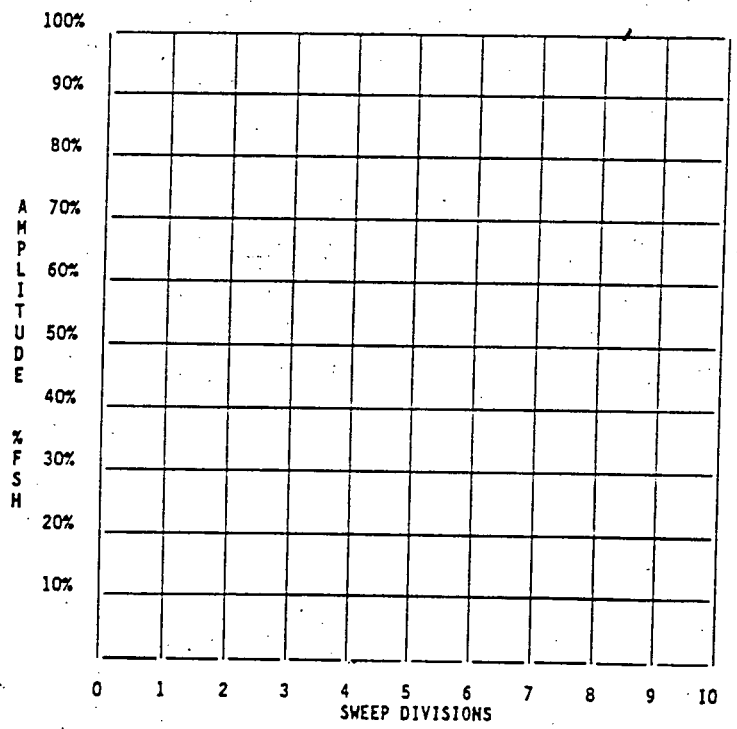
FIGURE 3
(Typical - Use Current Revision)

NORTHERN STATES POWER COMPANY
PRODUCTION PLANT MAINTENANCE

CALIBRATION REPORT NO.:

ULTRASONIC CALIBRATION REPORT - DAC

DISTANCE AMPLITUDE CORRECTION (DAC) CURVE PLOT
AT REFERENCE LEVEL




ALL DAC POINTS MUST BE IDENTIFIED

| NUMBER | REFLECTOR | MAX AMP | METAL PATH | SWEEP |
|---|---|---|---|---|
| ____ | ____ | ____ % | ____ in. | ____ Div. |
| ____ | ____ | ____ % | ____ in. | ____ Div. |
| ____ | ____ | ____ % | ____ in. | ____ Div. |
| ____ | ____ | ____ % | ____ in. | ____ Div. |
| ____ | ____ | ____ % | ____ in. | ____ Div. |
| ____ | ____ | ____ % | ____ in. | ____ Div. |
| ____ | ____ | ____ % | ____ in. | ____ Div. |

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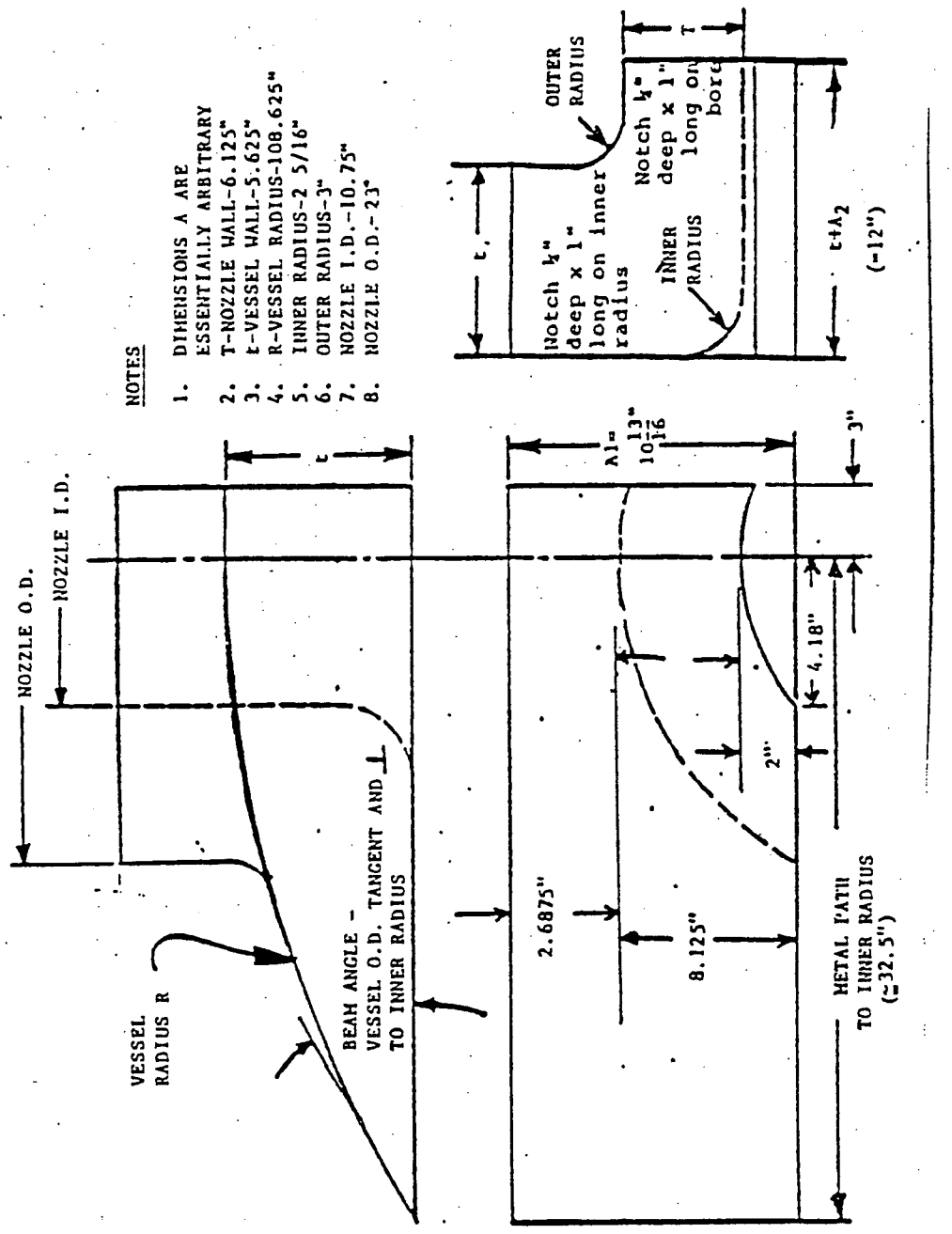
FIGURE 4
(Typical - Use Current Revision)




MONTICELLO CALIBRATION
STANDARD NO. 30

FIGURE 5
(Typical - Use Current Revision)

NORTHERN STATES POWER COMPANY
POWER PRODUCTION DEPARTMENT

REPORT NUMBER:

ULTRASONIC EXAMINATION REPORT

| System/Component | | ISO | Item | | Calibration Report Number: |
|---|---|---|---|---|---|
| Material | Size | Thickness | Entry From: | Surf Type | Plant: |
| Procedure Number | Rev. | | Beam Angle | Part Temp | Exam Company: |
| Eval Level | Reporting Level | | Exam Start Time | | W R Number: |
| Cal Stand. | Reference Standard | | Exam Finish Time | | Exam Date: |

Description of Results at Reference Level: GEO = Geometry; IND = Indication
L = Linear; M = Multiple; S = Spot; NAD = No Apparent Discontinuities.

| SCAN NMBR | RES | IND TYPE | DEPTH | METAL PATH | 'A' DIS | MAX AMP | LOCATION CIRC. | LOCATION AXIAL | LENGTH | ACC | REJ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |

LIMITATIONS:

REMARKS:

Sketch and Scan Directions

Examiner: _____ ___ Level

Assistant Examiner: _____ ___ Level

Contractor Review: _____ Date

N S P Review: _____ Date

ANII Review: _____ Date

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FIGURE 6
(Typical - Use Current Revision)

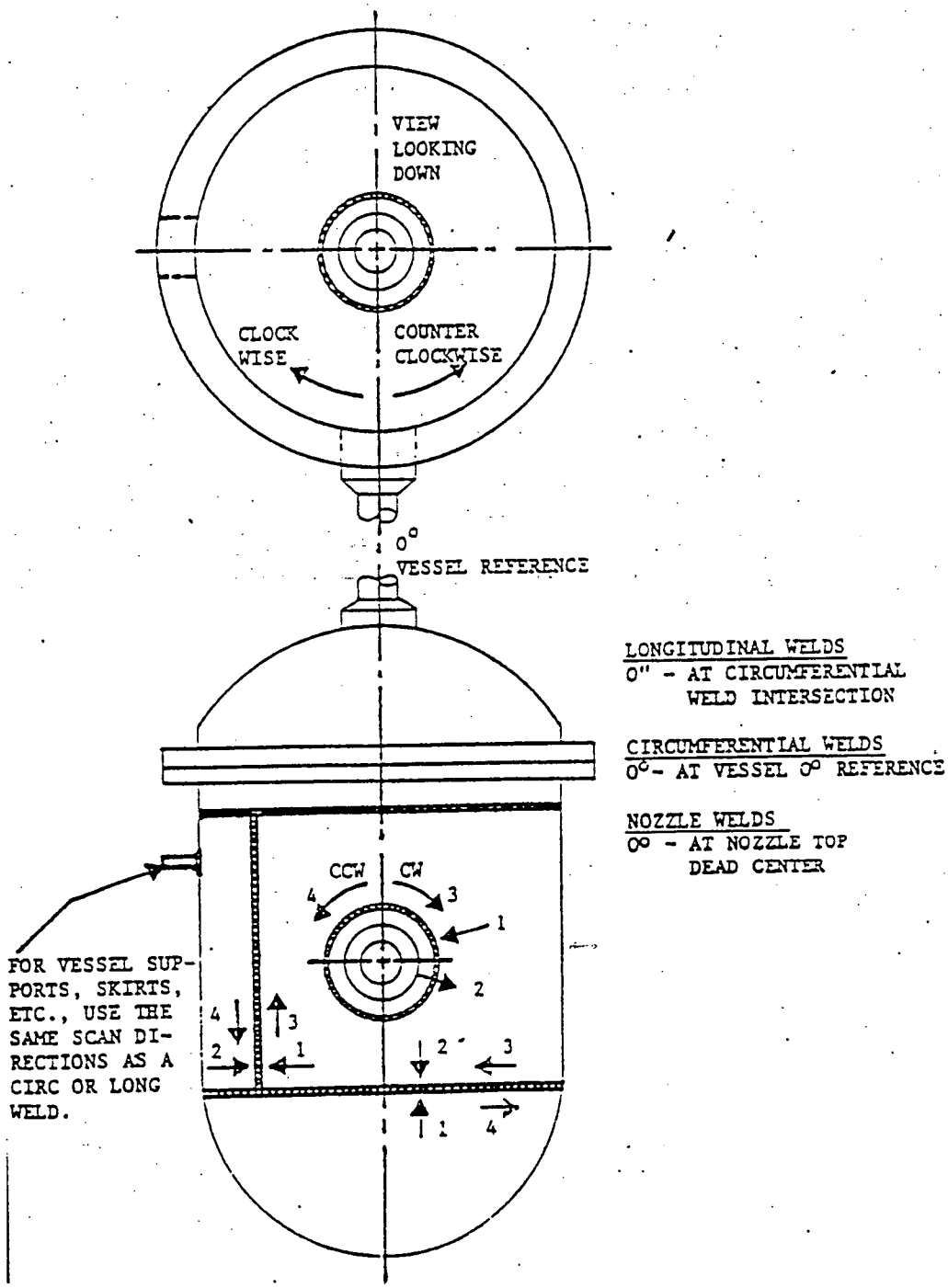

FIGURE 7
(Typical - Use Current Revision)

| NORTHERN STATES POWER COMPANY<br>POWER PRODUCTION DEPARTMENT | REPORT<br>NUMBER: |
|---|---|

ULTRASONIC INDICATION DATA TABULATION

I. INDICATION NO. _____ SCAN NO. _____

II. MAXIMUM AMPLITUDE DATA

1. Amplitude _____
2. Percent DAC _____
3. Sweep _____ Metal Path _____
4. Transducer Position _____

III. INDICATION LENGTH

1. Length measured between ___% DAC limits
2. Indication length _____
3. Tranducer Position _____

IV. INDICATION CROSS SECTION DATA AT _____ INTERVALS ALONG THE INDICATIONS LENGTH BETWEEN _____ % DAC POINTS

1. Reference is from Weld 0° and Weld center line (OR) _____
2. Transducer perpendicular to indication.

| TRANDUCER POSITION ALONG INDICATION | MIN SWEEP | | | MAX AMPLITUDE | | | | MAX SWEEP | | | % OF T | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SWP | MP | POSIT | AMP | SWP | MP | POSIT | SWP | MP | POSIT | DEPTH | DISTANCE FROM SURFACE |
| | | | | | | | | | | | | |

Examiner _____
Signature Level

Asst. Examiner _____
Signatu Level

Contractor Review _____

NSP Review _____

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