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ARKANSAS POWER & LIGHT COMPANY
Arkansas Nuclear One

TITLE: RECORD OF CHANGES AND REVISIONS

FORM NO. 1000.06A

ENGINEERING

REV. # 24

Safety related

SERVICE WATER PIPING
THICKNESS EVALUATION
1309.014 REV. 1

SAFETY RELATED YES NO

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APPROVED BY :

George T Jones by [Signature]

APPROVAL DATE

11-21-89

REQUIRED EFFECTIVE DATE :

8911300193 891122
PDR ADOCK 05000313
Q PDC



PLANT MANUAL SECTION:
ENGINEERING
SERVICES

PROCEDURE/WORK PLAN TITLE:
SERVICE WATER
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1.0 PURPOSE

- 1.1 Establish responsibilities for performance of the examination and analysis of results for monitoring and trending pipe wall thickness changes in the service water system.
- 1.2 Define parameters used in determining repair/replacement requirements for a deficient ASME Section III class 3 component found as a result of this procedure or by other means.

2.0 SCOPE

This procedure outlines the authority, responsibility and duties associated with ultrasonic thickness mapping of the Service Water and Auxiliary Cooling Water Systems for both Unit 1 and Unit 2. The data obtained will be used to determine acceptability of piping wall thickness and to trend general pipe wall reduction and localized pipe wall pitting. The acceptance criteria can also be utilized to evaluate the pressure and structural integrity of other ASME Section III Class 3 low pressure (≤ 200 psig) components.

3.0 REFERENCES

- 3.1 Procedure 1000.061 (Control of Site NDE)
- 3.2 ASME Section III, Subsection NC and ND, (Class 2 and 3 piping), 1986 Edition.
- 3.3 ASME Section V, "Nondestructive Examination", 1986 Edition.
- 3.4 ASNT SNT-TC1A, "Recommended Practice", August, 1980 Edition.
- 3.5 ASME Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, Div. 1, 1980 Edition, Winter 1981 Addenda.
- 3.6 EPRI Report No. SIR-87-010, Acceptance Guideline for Structural Evaluation of Erosion/Corrosion Thinning in Carbon Steel Piping
- 3.7 APL018.0100; Technical Report, Service Water System Piping Corrosion Analysis Methodology for ANO - 1&2 by NUTECH Engineers, Inc.

4.0 DEFINITIONS

- 4.1 Certification - The act of determining, verifying and attesting in writing to the qualifications of personnel processes.
- 4.2 Examination - Denotes the performance of all visual observation and nondestructive testing, such as radiography, ultrasonic, eddy current, liquid penetrant and magnetic particle methods.



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- 4.3 Qualification - (Personnel) - The characteristics or abilities gained through education, training or experience, as measured against established requirements, such as standards or tests, that qualify an individual to perform a required function.
- 4.4 Deficient Component - A component identified by examination to have an unacceptable wall thickness.
- 4.5 Location Number - Unique numerical identification assigned to the inspection site and resultant data tapes. Appendix A provides a cross reference of Location Numbers to isometric drawings.

5.0 RESPONSIBILITIES & AUTHORITIES

5.1 Plant Engineering Superintendent

Provides final review and approval of reports prepared to meet the requirements of this procedure. Also, provide review and approval of all changes to the procedure.

5.2 Mechanical Engineering Supervisor

Ensure that requirements called for in this procedure have been met. Appoint an individual to serve as the contract coordinator. Review and approve reports prepared to meet the requirements of this procedure and review and approve all changes to the procedure.

5.3 Contract Coordinator

- 5.3.1 Coordinate the implementation of this procedure.
- 5.3.2 Prepare revisions to the procedure as required.
- 5.3.3 Ensure reports to document inspection results are issued in a timely manner.
- 5.3.4 Direct contractor in the performance of this procedure.
- 5.3.5 Ensure training and station policy requirements are met by contractor personnel.
- 5.3.6 Identify specific locations to be examined, and maintain drawings indicating locations of examined areas.
- 5.3.7 Prioritize inspection locations in a logical, cost efficient inspection sequence.
- 5.3.8 Initiate job requests to identify scope of work.



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- 5.3.9 Communicate with WCC Planning and Scheduling to ensure proper craft support is provided to erect scaffolding, remove insulation, buff pipe, provide power & lighting, etc.
- 5.3.10 Notify QC prior to work being started.
- 5.3.11 Participate in the determination of the method of repair or replacement for piping found to have unacceptable pipe wall thickness. Initiate PEARS and EARS, if necessary.
- 5.3.12 Analyze test data to determine locations where measured pipe wall thickness is unacceptable, predict future replacement requirements and determine approximate corrosion rates.
- 5.3.13 Ensure that personnel performing ultrasonic examination are qualified by the latest and approved edition of ASNT SNT-TC-1A.

5.4 Contractor

- 5.4.1 Provide necessary equipment, consumables and personnel to perform the pipe wall thickness measurements at designated locations.
- 5.4.2 Provide wall thickness inspection data to the contract coordinator for evaluation.
- 5.4.3 Certify all personnel performing inspections to the latest approved edition of ASNT SNT-TC-1A.
- 5.4.4 Provide a final report summarizing inspection findings, and including inspection data, wall thickness at the deepest pit at each inspection location and average wall thickness at each inspection location.
- 5.4.5 Comply with the AP&L QA program for all work done on site, except for Control of M&TE and Inspection procedures which shall be governed by the contractors QA program.
- 5.4.6 Comply with the contractors QA program for all work performed.

6.0 INSTRUCTIONS

- 6.1 Continuous trending of selected inspection locations will be maintained by sampling the same locations at least once every three years. These locations are identified in Attachment I as Category 1.



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- 6.2 Additional inspection locations will be selected by the coordinator. Inspection locations with average wall thickness less than 87.5% of the nominal wall thickness designed or less than the designed minimum wall thickness at the deepest pit shall be reexamined at the same frequency as Category 1 inspection locations.
- 6.3 The coordinator will permanently identify the inspection locations on the piping isometrics showing locations and inspection location number.
- 6.4 Minimum and nominal wall thickness shall be determined and listed on Attachment I for each inspection location prior to performing the examination.
- 6.5 Job Request, drawings and planning support communications shall be provided to the WCC to ensure adequate job planning.
- 6.6 Quality Engineering shall be notified prior to work being started.

Person Notified _____	Notified By _____	Date _____	Time _____
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- 6.7 Certification review reports have been provided to QC per procedure 1000.061.

Coordinator _____	Date _____
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- 6.8 The examination shall be performed in accordance with Attachment III & IV and procedure 1000.061.
- 6.9 The inspection data including wall thickness at the deepest pit and average wall thickness will be provided to the coordinator upon the completion of the inspection at each location.
- 6.10 The detail inspection data will be provided to the coordinator upon request in order to perform more rigorous analysis of the data when deepest pit and average wall thicknesses are insufficient to determine acceptability.
- 6.11 Final inspection reports are to be kept of examination results.
- 6.12 List all PEARS, EARS, Condition Report and new or revised calculations evaluating examination results which were initiated in the performance of this procedure: _____



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7.0 ACCEPTANCE CRITERIA

- 7.1 Discontinuities revealed by the NDE method of this procedure, shall be evaluated in accordance with ASME Section III and ASME Section XI.
- 7.2 Acceptability of examination results for each inspection location will be determined in accordance with Attachment II and the acceptance method or document will be listed on Attachment I. A condition report will be generated to document the failure to qualify any inspection locations to the initial screening criteria.
- 7.3 If an inspection location cannot be qualified to the applicable code requirements then a repair or replacement sufficient to bring the component in compliance with code requirements should be completed. If such a repair cannot be accomplished without limiting plant operation, and an engineering evaluation has been completed and determined that a temporary repair is sufficient to maintain the component operable until the next scheduled refueling outage, then a "temporary" repair which is not in accordance with code requirements is acceptable. All repairs not in compliance with code shall be brought into compliance with code or replaced prior to heatup following the next scheduled refueling outage.
- 7.4 All examination results are acceptable or appropriate repair/replacements have been completed.

Signature

YES/NO
Circle One

Date

8.0 ATTACHMENTS

- 8.1 Attachment I - Inspection location cross reference listing identifying inspection location #, drawing #, category and minimum wall requirements.
- 8.2 Attachment II - Acceptability Determination of Examination Results.
- 8.3 Attachment III - DNV-UT-A-1.01 (Rev. 0) "Automated Straight Beam Ultrasonic Examination of Piping"
- 8.4 Attachment IV - DNV-UT-M-1.01 (Rev. 0) "Manual Ultrasonic Thickness Measurement of Ferritic Steel and Austenitic Steel."



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ATTACHMENT 1
EXAMINATION LOCATION CROSS REFERENCE LISTING & DATA SHEET

LOCAT. NUMBER	CATEGORY	DRAWING NUMBER	LOCATION DESCRIPTION	DESIGNED NOMINAL WALL	AVG. WALL REQUIRED	AVG. WALL MEASURED	DESIGN MIN. WALL REQUIRED	DEEPEST WALL THICKNESS	INITIAL, SCREEN	QUAL. DOCUMENT
0101		2HRD-33-1	CCW Supply							
0102	1	2HRD-35-1	CCW Return							
0103		13SW141	ICW Return							
0104	1	13SW139	ICW 'A' Cooler Supply							
0105		13SW139	ICW 'B' Cooler Supply							
0106		13SW139	ICW 'C' Cooler Supply							
0107	1	2HBC-83-2	ECP Return							
0108	1	2HBC-76-1	2K4B Return							
0109		2HBC-74-2	2K4B Supply							
0110		2HBC-75-1	2K4A Return							
0111	1	2HBC-63-1	2K4A Supply							
0113		13SW143	Diesel Common Return							
0114		13SW143	K4A Supply							
0115		13SW142	K4B Supply							
0125	1	2HBC-33-1	Loop 1 Supply Header							
0126		2HRD-26-2	Return to Flume							



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ATTACHMENT 1

EXAMINATION LOCATION CROSS REFERENCE LISTING & DATA SHEET

LOCAT. NUMBER	CATEGORY	DRAWING NUMBER	LOCATION DESCRIPTION	DESIGNED		DESIGN		DEEPEST PIT WALL THICKNESS	INITIAL/QUAL. SCREEN DOCUMENT
				NOMINAL WALL	AVG. WALL REQUIRED	MIN. WALL REQUIRED	AVG. WALL MEASURED		
0127	1	13SW103	RB Cooler Supply						
0128		13SW119	Loop 2 Supply Header						
0129	1	13SW108	Decay Mt. Cooler Supply						
0130	1	13SW114	ECP Return						
1543		2HR0-35-1	Downstrm of 2F0-1543						
0301	1	2HBC-78-1	RB Loop 2 Return						
0302		2HBC-50-1	Loop 1 Return Header						
0303		2HBC-69-1	RB Loop 2 Supply						
0304		2HBC-85-1	Supply to 2P7B						
0306		13SW102	Loop 2 Supply Header						
0307		13SW154	Chillers VCR 4 A&B Rtn						
0308		13SW119	Loop 2 Supply Header						
0309		13SW102	Loop 2 Supply Header						
1504		2HBC-76-1	Downstrm of 2F0-1504						
0217	1	2HBC-35-1	SIC-RX Supply						
0219		2HBC-69-1	RB Cooler Supply						



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EXAMINATION LOCATION CROSS REFERENCE LISTING & DATA SHEET
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LOCAT. NUMBER	CATEGORY	DRAWING NUMBER	LOCATION DESCRIPTION	DESIGNED NOMINAL WALL	AVG. WALL	AVG. WALL	DESIGN MIN. WALL	DEEPEST WALL	INITIAL	QUAL. SCREEN	DOCUMENT
				INCHES	INCHES	INCHES	INCHES	INCHES			
2216		2HBC-81-2	2E-27 HX Return								
9999		2HBD-23-2	SW to Cooling Tower								
0131		13SW132	Loop 2 Header at P4C								
0132		13SW134	Loop 1 Header at P4A								
7777		2JBD-35-1	CCW 'A' Outlet								
		2JBD-74-1	ACW Main Return Header								
		2JBD-73-1	ACW Demstrm of 2F0-1690								
		2JBD-50-2	Gen./Hyd. Cooler Supply								
		2JBD-50-3	ACW Main Supply Header								
		2JBD-26-1	2P167A, B Discharge								
		14AC110	Exciter Cir. Return								
		14AC111	Exciter Cir. Supply								
		14AC104	Gen./Hyd. Cooler Return								
		14AC102	TG Lube Oil Cir. Supply								
		14AC103	ACW Return To Flume								

Date of Inspections _____ to _____ Signature _____



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ATTACHMENT II

ACCEPTABILITY DETERMINATION OF EXAMINATION RESULTS

Both the average wall thickness and the wall thickness at the deepest pit must be acceptable. This is determined utilizing Method 1, Initial Screening. Results of applying Method 1, Initial Screening, shall be indicated on Attachment I in the column headed "INITIAL SCREEN" with a "Y" for acceptable and an "N" for unacceptable.

When determining t_{avg} , the profile of the wall thickness must be examined. If there is a preferential concentration of pits which results in an area with an average wall thickness significantly less than t_{avg} , then either the thickness used to apply the initial screening criteria should be based upon the average thickness of this area of preferential pitting, or detail analysis is required.

If initial screening is unacceptable or detailed analysis is required due to preferential pitting a condition report shall be generated. Recalculation of stresses shall be documented with amending calculations and recorded in the calculation log. Repair requirements and engineering operability evaluations of "temporary" non-code repairs shall be directed by condition report action items. If it is determined that the thinned pipe wall is acceptable and will not be replaced for an extended period, then the condition report should be closed, otherwise an action should be assigned to delete the amending calculation after appropriate repairs or replacements are completed. The qualifying or repairing document should be referenced on Attachment I in the column headed "Qual. Document".

Methods 2 or 3 as detailed below may be utilized to qualify wall thickness which fail to meet initial screening criteria. Method 2 is used to evaluate structural integrity when average wall thickness is less than $0.875 t_{avg}$.

Method 3 is used to evaluate pitting areas when the remaining wall thickness at the pit location is less than t_{min} .



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ATTACHMENT II (CONTINUED)

ACCEPTABILITY DETERMINATION OF EXAMINATION RESULTS

Method 1, Initial Screening

If $t_{avg} \geq 0.875 t_{nom}$, then t_{avg} is acceptable

If $t_{pit} \geq t_{min}$, then t_{pit} is acceptable

where;

t_{avg} = average wall thickness measured

t_{pit} = wall thickness measured at the deepest pit

t_{nom} = design nominal wall thickness

t_{min} = design minimum wall thickness

Calculation of

The design minimum wall thickness t_{min} shall be determined using the ASME Section III Class 3 criteria, ND-3641.1 equation (3).

$$t_{min} = \frac{P D_o}{2 (S_h E + P_y) + A}$$

where: D_o = outside diameter, in.

P = internal design pressure, psi.

S_h = basic material allowable stress for material at Design temperature in psi. From ASME I-7.0 or I-8.0. Use Code of Record or value from Qualification of record.

E = joint efficiency from Table ND-3613.4-1 or ND-3613.5

Y = coefficient equal to .4 unless $D_o/t_{min} < 6$;

then $y = \frac{d}{d + D_o}$ where d = inside diameter

A = corrosion allowance. Equal to instrument error for measurement of wall thickness plus appropriate corrosion rates from previous historical data.

Determination of .875 factor for t_{nom}

The manufacturers tolerance for the pipe used in the SW/ACW system is -12.5% of nominal wall. (Reference SA524 and SA530). Therefore the screening criteria for acceptance of pipe average wall thickness is 87.5% of nominal wall. For other systems, the applicable ASME material specification should be reviewed.



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Method 2, Acceptability of Average Wall Thicknesses Below $0.875 t_{nom}$

Reduced wall thicknesses may be analyzed to determine a new calculated stress value. This is done by multiplying the existing maximum stresses by a ratio of the "as measured" section modulus to the "as analyzed" section modulus. This will be conservative in that the stresses due to the pressure term of the stress equation will be increased by application of this ratio, as well as stresses due to moments. This new calculated stress value can then be compared to the allowable stress value as listed on the qualification of record.

If there is a preferential concentration of pits in a single area of the pipe which results in an area with an average wall thickness significantly less than t_{avg} , then either t_{avg} should be based upon the average thickness of this area of preferential pitting or a stress intensification factor should also be utilized in recalculating the maximum stresses. The stress intensification factor should be based upon an unreinforced fabricated tee with dimensions representing the thinned area and with t_{avg} based upon the remaining pipe wall circumference.

The equations are as follows:

$$S_{new} = \frac{Z_a}{Z_m} i S_{old}$$

$$S_{new} \leq S_{allowable} \quad (\text{Acceptance criteria})$$

where:

S_{new} = recalculated maximum stress

Z_m = as measured section modulus = $\pi r^2 t_{avg}$
and r is the nominal mean radius

Z_a = as analyzed section modulus = $\pi r^2 t_{nom}$

i = stress intensification factor. Only used if there is preferential pitting and based upon the SIF for an unreinforced fabricated tee

S_{old} = previous maximum stress from stress report for the appropriate pipe section. The stresses for deadweight, operating basis earthquake, design basis earthquake and thermal expansion should all be addressed.

$S_{allowable}$ = allowable stress as identified in the code of record or qualification of record. This should be evaluated for deadweight and thermal expansion for all piping and for operating basis and design basis earthquake as applicable.



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Method 3, Acceptance of Pit Wall Thicknesses Below t_{min}

If the wall thickness at the deepest pit is less than t_{min} , then the localized thinning may be analyzed to determine if it is acceptable. EPRI Report SIR-87-010 presents three methods for three different types of thinning shapes.

A relatively large locally thinned area may be qualified by using criteria in ASME Section III, NB-3200 to perform a primary membrane stress analysis.

Locally thinned areas with a large axial dimension but a small transverse or hoops dimension may be qualified using ANSI/ASME B31 G which provides guidance for determining the acceptable wall thickness below t_{min} for a given axial length.

Locally thinned areas with small axial and transverse dimensions, may be qualified using Branch Reinforcements guidelines from ASME ND-3643. This can be used to determine acceptability of wall thickness below t_{min} for certain maximum dimensions for the thinned area.

In addition, the corrosion allowance factor, A, may be reviewed to qualify the inspection location for a shorter than original design life. In particular, the inspection location can be qualified for the remainder of the cycle, as long as appropriate actions are taken to repair or replace the pitted area at the next refueling outage.



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ATTACHMENT III



DNV INDUSTRIAL SERVICES INC.
16203 PARK ROW
SUITE 160
HOUSTON, TEXAS 77084

NDT Level III

[Signature] 6/16/88
Date

Q.A. Manager

[Signature] 9-2-88
Date

Client Approver

Date

**AUTOLATED STRAIGHT BEAM
ULTRASONIC EXAMINATION OF PIPING**

PROCEDURE NO. DNV-UT-A-1.01

0	Issued for use	RLK	RKB	6/16/88
Rev. No.	Description	BY	Q.A.	Effective Date



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ULTRASONIC EXAMINATION OF PIPING	DNV-UT-A-1.01	0	

1. PURPOSE

- 1.1 This procedure describes the requirements for automated straight beam ultrasonic examination of wrought and cast steel piping system weld and base metal for the purpose of thickness mapping in piping systems by the contact method.

2. SCOPE

- 2.1 This procedure is applicable to steel piping systems of diameter range 100 mm (4") to 2500 (100") with thicknesses ranging from 3.0 mm (0.197") to 50 mm (2"), using automated equipment commercially known as P-SCAN.
- 2.2 The examination shall be performed with straight beam search units from the outside of the component being examined, when accessible, with the objective of mapping corrosion in the required location. Search unit scanning shall be performed in both circumferential and axial directions from the outside surface, as required.

3. OWNER'S RESPONSIBILITIES

- 3.1 Prior to performing the examination, the owner shall furnish the following information, as applicable:
- a. Identification of the components to be examined
 - b. Location of areas to be examined
 - c. Drawings showing configurations
 - d. Material specifications.
- 3.2 The owner shall arrange erection and removal of staging, scaffolding, and/or other equipment required to gain access to the examination area. The owner shall further be responsible that reasonable precautions are taken for the safety of the examination personnel.
- 3.3 The owner shall arrange removal of insulation and provide a clean surface for a minimum of 300 mm (12") on either side of the examination location.
- 3.4 The owner shall be responsible for pre-examination cleanliness and examination surface preparation, including the removal of paint, scale, rust, etc.



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4. REFERENCES

- 4.1 The following documents are referenced by and are part of this procedure, as applicable:
- 4.1.1 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plants, 1983 Edition.
 - 4.1.2 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section V, Nondestructive Examination, 1983 Edition.
 - 4.1.3 American Society for Nondestructive Testing (ASNT) Recommended Practice SNT-TC-1A, Nondestructive Testing Personnel Qualification and Certification, June 1975 and 1980 Editions.
 - 4.1.4 DNV-ISI Industrial Services, Inc. (DNV-ISI) Written Practice, Nondestructive Testing Personnel Qualification and Certification, March 1988.
 - 4.1.5 Danish Welding Institute (SVC) Manuals
 - a. P-SCAN (PSP-3) Operation Manual, Rev. 1.01, August 1987.

5. PERSONNEL QUALIFICATION

- 5.1 Personnel operating P-SCAN equipment (P-SCAN operators) shall be tested and certified to a minimum of Level II in ultrasonic examination in accordance with DNV-ISI written practice for personnel certification to SNT-TC-1A.
- 5.2 Level II P-SCAN system operators shall be trained and qualified in operation of the scanning and data acquisition equipment and be well versed in both software and hardware usage. Level I and Level I trainee personnel shall assist the operator, as required.
- 5.3 Level II or Level III personnel trained in P-SCAN ultrasonic examination methods shall evaluate P-SCAN data in accordance with the acceptance standards provided by the owner.
- 5.4 Level I and Level I trainee personnel shall receive documented training in the operation of the scanner and appurtenant hardware, including attachment and the set-up necessary prior to scanning.



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6. EQUIPMENT AND MATERIALS

6.1 Test Equipment

6.1.1 The principal equipment for thickness mapping is the SVC P-SCAN. The system has a bandwidth greater than 1.0 to 5.0 MHz and utilizes a logarithmic amplifier of 110 dB range to process signals from the ultrasonic probe. Depth of corrosion may be measured in 0.1 mm steps.

6.1.2 Either of the fully automatic weld scanner AWS-4, AWS-5 or AWS-2, or semiautomatic weld scanner MWS-2 or MWS-1 and appropriate software shall be used for the examination. Later, improved issues of both hardware and software may also be used, provided their performance and data compatibility is verified and documented.

6.2 Search Units

6.2.1 The primary search units used for detection shall be dual element 2 to 6 MHz, 0 degree longitudinal wave contact probes.

6.2.2 Search unit size shall be dictated by the ability of the search unit to maintain good contact with the test surface, but should generally be in the range of 0.05 to 1.0 square inch of active crystal element area.

6.3 Calibration Blocks

6.3.1 Certified IIW blocks or other equivalent designs shall be utilized for calibration.

6.3.2 Other calibration blocks shall utilize a series of machined steps of known thicknesses by which the system can be fine tuned to "read" correct thickness values by fashioning a set of examination parameters on scanning the subject block.

6.3.3 Surface finishes of the blocks shall be representative of the surface finish of the piping to be examined.

6.4 Couplants

6.4.1 Couplants shall be approved by the owner prior to use. For the automatic scanners, pumped water shall be used as a couplant.



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7. CALIBRATION

7.1 Certificates

7.1.1 Current calibration for the following equipment shall be verified prior to use, including certificate numbers, calibration dates and dates due.

- a. Manual UT Instruments
- b. Calibration Blocks
- c. P-SCAN Processor
- d. Ultrasonic Probes

7.2 Instrument Calibration

7.2.1 The manual UT instrument shall be calibrated for screen height linearity, amplitude control linearity and sweep at intervals not to exceed 90 days, in accordance with Supplement 5 and 6, Appendix III, ASME Section XI.

7.2.2 The concepts of screen height, amplitude control and sweep are not applicable to the P-SCAN system. Factors governing the accuracy of measurements of amplitude and position of indications include return echo timing measurements, amplitude measurements and probe position measurements.

7.2.3 The return echo timing and probe position measurement capability shall be checked electronically or, alternatively, by scanning a reference target, e.g., a notched calibration or reference block. This shall be checked every 90 days or before long term examination periods.

7.4 System Calibration and Check

7.4.1 General Requirements

7.4.1.1 Calibration shall include the complete P-SCAN system. Any change in search units, shoes, probes, couplants, cables, or any other parts of the examination system shall be cause for calibration check. Calibration shall be performed on the basic calibration block.

7.4.1.2 The "steps" on the calibration block shall be scanned and system parameters adjusted, as required, such that thickness values being read by the P-SCAN are ± 0.2 mm of actual known step values.



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7.4.1.3 For contact examination, the temperature difference between the examination and basic calibration block surfaces shall not exceed 25 F (14 C).

7.4.1.4 Calibration shall be performed from the surface of the calibration block which corresponds to the component surface to be examined.

7.4.2 **System Calibration Confirmation**

7.4.2.1 Complete system calibration, shall be performed within one day prior to use of the system for examination of those items for which the calibration is applicable.

7.4.3 **System Calibration Check**

7.4.3.1 A system calibration check, which is verification of thickness of "steps" on the calibration block, shall be performed (1) at the start and finish of each examination, (2) with any change in examination personnel and (3) at least every 4 hours during an examination.

7.4.4 **Corrective Actions**

7.4.4.1 If thickness measurements are read by the P-SCAN have decreased or increased by greater than ± 0.2 mm, all data sheets since the last calibration shall be voided. A new calibration shall be made and recorded and the voided areas shall be re-examined.

8. **REFERENCE SYSTEM**

8.1 A reference system shall be established to locate the search unit zero position and to determine its position in reference to piping "landmarks", such that examinations may be duplicated at a later date, if desired. The scan positive Y direction shall follow the flow direction, with the positive X direction clockwise facing downstream.

9. **EXAMINATION**

9.1 **Surface Conditions**

9.1.1 The examination surface shall be free of irregularities, loose materials or coatings which could interfere with ultrasonic wave transmission.



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9.2 Scanning Speed

9.2.1 Scanning speed shall not exceed 150 mm (6 inches) per second. Slower scanning speeds may be necessary.

9.3 Coverage

9.3.1 To ensure complete coverage of the examination area, each pass of the search unit shall overlap at least 10% of the search unit width.

9.3.2 The probe shall be manipulated laterally and longitudinally, such that the sound beam passes through the required examination volume.

9.4 Scanning Technique

9.4.1 A survey of the examination area shall be made to locate longitudinal weld seams, mechanical obstructions, surface irregularities or other conditions that might possibly interfere with scanning.

9.4.2 All measurements, observations and noted obstructions to examination of the required volume shall be recorded by the operator using the P-SCAN coordinate system.

9.4.3 Subsequent to completion of the operations described in 9.4.1 and 9.4.2, above, the scanner guide band, scanner and scanner drive belt will be attached to the pipe being examined, as applicable. Scanning is to commence after completing the required positioning procedure for the type of scanner in use.

10. RECORDING OF DATA

10.1 All data over the entire system dynamic range shall be recorded by the P-SCAN system automatically, or on keyboard command by the operator.

11. INVESTIGATION OF DATA

11.1 Data shall be evaluated on completion of a scan.



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11.2 The operator shall print out the scan data for inclusion with the report. The Side view image is a composite view showing all thickness measurements projected into one plane perpendicular to the examination surface. The Top view shows areas with wall thicknesses measured less than a given level called the display level. By varying this display level, a complete map of thickness topography may be obtained, along with minimum, maximum and "average" thicknesses for the component in the location.

12. ACCEPTANCE STANDARDS

12.1 The acceptance or rejection of reported thickness readings shall be in accordance with criteria established by the owner.

13. RECORDING AND REPORTING

13.1 General

13.1.1 Calibration, system parameters and scanning information shall be recorded at the time of the examination and calibration. Records shall include personnel, date and time, as a minimum.

13.2 Data Disk

13.2.1 Calibration and scan files shall be accompanied by a data set containing, but not limited to, the following information:

- Site identity and system
- Personnel and certification levels
- Date and time
- Scanner type
- Cable type and length

13.3 Documentation

13.3.1 A written report shall be completed by the P-SCAN operator plus hard copy printouts of the scan data.

14. DATA TRANSMITTAL

14.1 Examination records, including calibration sheets, data sheets, and data diskettes (when required), shall be submitted to the owner for retention in terms of the inspection contract.



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DNV INDUSTRIAL SERVICES, INC.
16203 PARK ROW
SUITE 160
HOUSTON, TEXAS 77084

Robert L. King
NDT Level III

6/16/88
Date

L. Keith Brown
Q.A. Manager

6-16-88
Date

J. M. Ray
Client Approval

9-2-88
Date

**MANUAL ULTRASONIC THICKNESS MEASUREMENTS
of FERRITIC STEEL and AUSTENITIC STEEL**

PROCEDURE NO. DNV-UT-M-1.01

0	Issued for use	RLK	RKB	6/16/88
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1. SCOPE

- 1.1 This procedure describes the requirements for the performance of manual ultrasonic thickness measurements of ferritic steel and austenitic steel piping systems.

2. APPLICATION

- 2.1 These requirements are established for the ultrasonic thickness measurement of base material for ferritic and austenitic steel piping having a nominal wall thickness of 0.10 to 4.0 inches. The examination shall be performed by the contact method from the outside, where possible.

3. OWNER'S (CLIENT) RESPONSIBILITIES

- 3.1 In order to perform the ultrasonic examination, the owner shall be responsible for the following information, data and/or services:
- Identification of the areas (component) to be examined
 - Location of the areas to be examined
 - Detailed drawings of the piping system configuration
 - Material specifications
 - Component drawings
 - Erection and removal of staging, scaffolding, or other equipment to provide access to the examination area
 - Removal of insulation, pre-examination cleaning, and examination surface preparation
 - Provide sufficient illumination at the site to properly perform the examination
 - Supply the basic calibration block unless otherwise provided in the contract



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4. **REFERENCES**

- 4.1 The following documents are referenced by and are part of this procedure, as applicable:
 - 4.1.1 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section V, Nondestructive Examination, 1980 Edition with Addenda through and including Winter 1980.
 - 4.1.2 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plants, 1980 Edition with Addenda through and including Winter 1980.
 - 4.1.3 American Society for Nondestructive Testing (ASNT) Recommended Practice SNT-TC-1A, Nondestructive Testing Personnel Qualification and Certification, June 1975 and 1980 Edition.
 - 4.1.4 DNV Industrial Services, Inc. (DNV-ISI) Written Practice, QAP-9.1, Nondestructive Testing Personnel Qualification and Certification, March 1, 1988.

5. **PERSONNEL**

- 5.1 Personnel performing ultrasonic examination in accordance with this procedure shall be qualified in accordance with 4.1.3 above, including references to 4.1.2. Personnel performing operations shall be qualified to at least Level I; interpretation shall be performed by Level II or Level III personnel.

6. **EQUIPMENT REQUIREMENTS**

- 6.1 A pulse-echo ultrasonic flaw detection instrument shall be utilized for this examination. The instrument shall be capable of generating and receiving frequencies over the nominal range of 1 MHz to 5 MHz. Other frequencies may be used if equal or better sensitivity can be demonstrated. The ultrasonic instrument shall be equipped with a stepped gain control calibrated in units of 2 dB or less, accurate over the useful range to 20% of the nominal amplitude ratio, to allow measurement of indication beyond the linear range of the vertical display on the screen. The ultrasonic instrument shall provide linear vertical presentation within $\pm 5\%$ of the full screen height.



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6.2 The nominal search unit frequency shall be 2.25 MHz, unless variables such as production material grain structure necessitates the use of other frequencies to obtain adequate penetration and/or resolution. Search units may utilize either single or dual transducer elements; size shall be in the range of 0.25 inch to 1.0 inch, with the shape being round, square, or rectangular.

6.3 Commercially available couplants such as Ultragel II shall be used for calibration and examination.

6.4 Calibration blocks shall be of the same nominal material as the material to be examined. The basic calibration block shall be a step wedge, representative of the thickness ranges expected in the material. The thickest step shall be of at least the nominal design thickness of the material to be examined.

7. **CALIBRATION**

7.1 **Instrument Calibration**

7.1.1 Instrument calibration for screen height and amplitude control linearity shall be verified at intervals not to exceed three months.

7.2 **Screen Height Linearity**

7.2.1 The ultrasonic instrument shall provide screen height linearity within 5% of full range for at least 80% of the full screen height (FSH) (base line to maximum calibrated screen points). To verify the ability of the ultrasonic instrument to meet the above-designated linearity requirements, position a search unit so that echoes can be observed from any two reflectors in a calibration block. Manipulate the search unit to establish a 2 to 1 ratio of amplitudes between the two echoes. Adjust the gain control so that the larger echo is at 80% FSH, with the smaller echo at 40% FSH. Without moving the search unit, adjust the sensitivity (gain) to successively set the larger echo from 100% to 20% FSH in 10% increments (or 2 dB steps if a fine sensitivity control is not available). Read and record the relative amplitudes of the two echoes to the nearest 1% FSH. The amplitude of the smaller echo must be $50\% \pm 5\%$ FSH of the larger echo.



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7.3 Amplitude Control Linearity

7.3.1 The ultrasonic instrument shall utilize an amplitude control, accurate over its useful range to 20% of the nominal amplitude ratio to allow measurements of indications beyond the linear range of the vertical CRT display. To verify the accuracy of the amplitude control to the above-designated requirements, position a search unit so that an echo from a reflector in a calibration block is peaked on the screen. With the increases and decreases in attenuation shown in Supplement 6 of Reference 4.1.2, the echo amplitude shall fall within the specified limits. Amplitudes shall be estimated to the nearest 1% FSH.

7.4 Search Unit Calibration

7.4.1 Calibration shall include the complete ultrasonic examination system. The original calibration shall be performed on the basic calibration block. Checks shall be made to verify the sweep range calibration and distance amplitude correction. Checks shall include the entire examination system.

7.4.2 The maximum indications shall be obtained with the sound beam oriented perpendicular to the inside surface of the calibration block.

7.4.3 For contact examination, the temperature of the examination and basic calibration block surfaces shall be within 25 degrees F. (14 degrees C).

7.4.4 Calibration shall be performed from the surface of the calibration block which corresponds to the surface of the component from which the examination will be performed.

7.5 System Check

7.5.1 Alternate cables and search units, singly and in combination, that have been included in a prior system calibration may be substituted in the system; such substitution shall not necessitate a calibration check. When any other part of the examination system is changed, a calibration check shall be made on the basic calibration block to verify sweep range and distance amplitude correction values. A calibration check of sweep range and sensitivity values shall be performed:



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a. At the start and finish of each examination;
b. Every 12 hours during the examination, and
c. With every change of personnel.

7.5 Calibration Confirmation

7.5.1 Straight beam calibration shall be performed prior to use of the system in the thickness range under examination. A calibration check shall verify the sweep range calibration.

7.6 Straight Beam Calibration

7.6.1 The nominal frequency shall be 2.25 MHz unless variables such as production material grain structure require the use of other frequencies to assure adequate penetration or improved resolution.

7.6.2 The straight beam calibration shall encompass measurements of sweep range calibration.

7.6.3 For material thickness 1" or less the basic calibration block shall be used to calibrate the screen/sweep to 1.0". Use the sweep fine and delay controls to calibrate each major screen division to 0.10". Use the sweep fine and delay controls to calibrate each major screen division to 0.10", e.g., a 0.20" step echo at 2 screen divisions, a 0.50" step echo at 5 screen divisions, etc.

7.6.4 For material thicknesses of 1.0" to 4.0", the basic calibration block or a certified IIW block may be used to calibrate the screen/sweep to 4.0". With the IIW block on its side and obtaining an echo from the 1.0" thickness, place the first backwall echo at 2.5 screen divisions. While adjusting the sweep fine and delay controls, maintain the first backwall at 2.5 screen divisions and move the 2nd, 3rd, and 4th backwall echoes to 5.0, 7.5, and 10.0 screen divisions, respectively. Each major screen division is now representative of 0.40".

8. SURFACE PREPARATION

8.1 The base metal shall be free of weld spatter, surface irregularities or foreign matter that might interfere with the examination.

8.2 Scanning speed shall not exceed 6 inches per second, slower scanning speeds may be necessary.



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8.3 To ensure complete coverage, scanning of the required examination volume, each pass of the search unit shall overlap a minimum of 10% of the transducer (piezoelectric element) dimension perpendicular to the scan.

9. RECORDING OF INDICATIONS

9.1 Each area examined shall be identified with its minimum, maximum, and nominal remaining wall thickness.

10. ACCEPTANCE STANDARDS

10.1 Acceptance criteria will be established by the owner.

11. REPORTS

11.1 Reports shall consist of a calibration data record and an examination data record which shall contain the following minimum information:

11.1.1 Calibration Data Record

- a. Calibration sheet identification and calibration date.
- b. Client, site or project designation.
- c. Names of examination personnel and levels of certification.
- d. Examination procedure number and revision.
- e. Calibration block identification.
- f. Test instrument identification and serial number.
- g. Search unit identification, serial number, frequency and size.
- h. Beam angle and mode of propagation in material.
- i. Special search units, wedges, and shoe types.
- j. Couplant and batch number.
- k. Instrument setting sufficiently identified to permit repetition of examination at a later date.
- l. Sweep readings from the calibration reflector(s).
- m. Times of initial calibration and subsequent calibration checks.



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11.1.2 Examination Data Record

- a. Data sheet identification and applicable calibration sheet identification.
- b. Date and time period of examination.
- c. Names of examination personnel and level certification.
- d. Examination procedure and revision.
- e. Identification and location of the component and/or the volume scanned. Marked drawings of sketches will satisfy this requirement.
- f. Surface from which the examination is conducted.