TENNESSEE VALLEY AUTHORITY
CHATTANOOGA, TENNESSEE 37401
400 Chestnut Street Tower II

May 2, 1984

84 MAY 8 P1:24

U.S. Nuclear Regulatory Commission
Region II
Attn: Mr. James P. O'Reilly, Regional Administrator
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30303

Dear Mr. O'Reilly:

BELLEFONTE NUCLEAR PLANT UNITS 1 AND 2 - SUPPLEMENTAL RESPONSE TO VIOLATION 50-438/83-24-01, 50-439/83-24-01 - QUESTIONABLE ULTRASONIC EXAMINATIONS

This letter is in response to R. C. Lewis' letter to H. G. Parris dated April 4, 1984 on violation 83-24-01 in which TVA was requested to admit part A.3 and revise our schedule for parts A.4 and A.5. The enclosed information, which delineates our position on these items, was discussed with NRC representatives in an April 17, 1984 telecon.

If you have any questions concerning this matter, please get in touch with R. H. Shell at FTS 858-2688.

To the best of my knowledge, I declare the statements contained herein are complete and true.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

D S Kammer

D. S. Kammer
Nuclear Engineer

Enclosure
cc (Enclosure):
Mr. Richard C. DeYoung, Director
Office of Inspection and Enforcement
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Records Center
Institute of Nuclear Power Operations
1100 Circle 75 Parkway, Suite 1500
Atlanta, Georgia 30339

TENNESSEE VALLEY AUTHORITY

SPECIFICATION FOR ULTRASONIC EXAMINATION OF WELD JOINTS

1.0 SCOPE

This procedure defines the requirements for ultrasonic examination of welds in accordance with the following codes:

ASME Section I, Power Boilers, 1974 edition
ASME Section III, Nuclear Power Plant Components, 1974 edition
ANSI B31.1, Power Piping, 1973 edition through Summer 1974 addenda

1.1 The welding engineering or welding quality control unit at each site shall demonstrate this procedure and each revision or addendum to the satisfaction of the Authorized Nuclear Inspector. This demonstration shall be documented on a form similar to Appendix A.

2.0 EXTENT AND METHOD OF EXAMINATION

2.1 Unless otherwise specified, the entire volume of the weld and heat affected zone shall be examined to detect, locate, and evaluate defects oriented both parallel and perpendicular to the weld.

2.1.1 Where practical the weld shall be examined from both sides by the angle beam method.

2.1.2 Where geometry or base metal reflectors (section 2.2) do not permit angle beam examination from both sides (from either or both surfaces) a combination of angle beam and straight beam examination or straight beam examination from two perpendicular directions shall be used.

BELLEFONTE NUCLEAR PLANT UNITS 1 AND 2
SUPPLEMENTAL RESPONSE TO SEVERITY LEVEL IV VIOLATION
50-438/83-24-01, 50-439/83-24-01
QUESTIONABLE ULTRASONIC EXAMINATIONS

Part A.3

The NRC stated in the April 4, 1984, letter that "although the ASME Code was not cited in this violation, the Code does require recording of 'any significant changes in subsequent rechecks,' thereby, implying the performance of calibration checks" and that the "licensee provided no documented criteria for periodic checks of calibration of ultrasonic examination equipment."

TVA still maintains that our procedure meets the minimum 1974 ASME Code requirements. We disagree that the Code requires the "recording" of any significant change(s) in subsequent rechecks when recalibrating ultrasonic examination equipment. However, as a matter of good practice, we periodically check the integrity of the calibration in process of examination by the use of a portable "rompas" field calibration block. Furthermore, as agreed upon during the December 20, 1983 telecon with NRC representatives, we have improved our program by revising the G-29M process specification 3.M.7.1 to include scanning rate limitations, detailed information regarding calibration (recalibration), the use of transfer techniques, and calibration rechecks. Per NRC's request in the April 17, 1984 telecon, we are submitting the attached revision to the G-29M process specification 3.M.7.1 as evidence of and further delineation of our improvement in the program.

However, we still deny the violation occurred as stated.

Parts A.4 and A.5

We agree that the schedule for achieving full compliance is excessively long for revising the construction ultrasonic testing procedure QCP 7.2. The construction testing procedure QCP 7.2 will now be revised by June 1, 1984, to incorporate all of the changes that have been made to the G-29M process specification 3.M.7.1.

2.2 The entire volume of base metal through which the sound will travel during angle beam examination of the weld shall be examined by the straight beam method to detect reflectors which would interfere with the angle beam examination. (This examination shall be used only to locate areas which would interfere with angle beam examination and shall not be used as an acceptance examination.)

2.3 An example of weld area scanning is given in Figure 1.

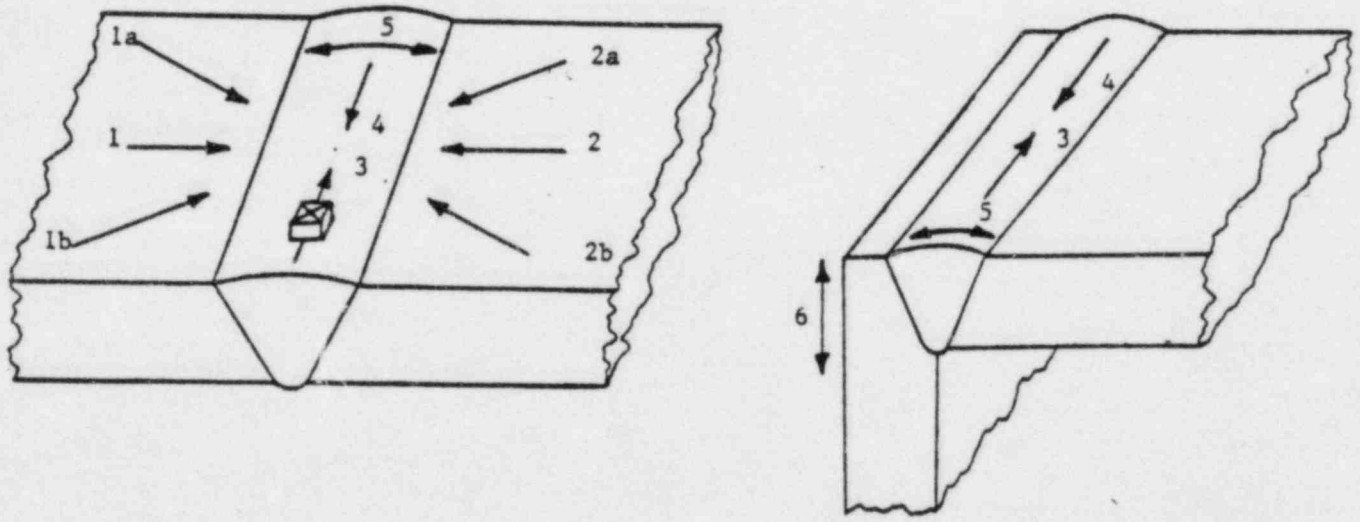

FIGURE 1 EXAMPLE OF WELD AREA SCANNING

Exams 1,2,3, and 4 denotes angle beam examination and shall be performed whenever possible.

Exams 1,3,4, and 5 are acceptable when access permits examination from only one side of the weld.

Exams 5 and 6 denotes straight beam examination per Section 9.0 of this procedure.

If exams 1 and 2 are not possible, exams 3,4,5, and 6 are acceptable.

3.0 EQUIPMENT

3.1 Pulse-echo ultrasonic equipment generating frequencies over the range of 1-5 MHz shall be used. A nominal frequency of 2.25 MHz shall be used for most examinations and 1.5 MHz is recommended for stainless steel, unless factors such as material grain size require the use of other frequencies.

3.2 The equipment shall have a calibrated attenuator (gain control) accurate to ± 2 dB or 20 percent over its range. The range shall be sufficient to allow comparison of indications beyond the viewable portion of the cathode ray tube display.

3.3 For angle beam examination, the system shall produce a beam in the material at an angle of 40 to 75 degrees with respect to the perpendicular to the entry surface.

3.4 For straight beam examination the search unit shall produce a beam in the material which is nominally perpendicular to the entry surface.

3.5 Ultrasonic testing couplants approved for use on nuclear systems and components are glycerine, Vaseline, Exosen, Ultragel, or nuclear grade water. Couplant purchase requirements are listed in Purchase Specification PF-1059.

3.6 Instructions to verify the ability of the ultrasonic instrument to meet the linearity requirements, and to verify the accuracy of the amplitude control of the ultrasonic instrument are found in Appendix B, and shall be documented similar to Appendix D. If the ultrasonic instrument does not meet these linearity requirements the instrument should be repaired.

4.0 CALIBRATION BLOCK

4.1 The flat calibration block shall be as shown in Figure 2.

4.1.1 The material of the block shall be of similar metallurigical structure and have the same or equivalent P-number (Section IX, QW 420) as the material to be examined. P-numbers 1, 3, 4, and 5 shall be considered equivalent.

4.2 For examination of circumferential welds or any longitudinal welds with a contact surface curvature of 20 inches in diameter or less, the calibration block contact surface shall also be curved. The curved calibration block shall be as shown in Figure 3.

4.2.1 The diameter of the part to be examined shall be no less than 90 percent nor more than 150 percent of the calibration block diameter.

4.2.2 Listed below are six curved blocks which will cover a 0.94- to 20-inch-diameter range.

Block Diameter, Inches	Contact Surface Diameter, Inches
1.04	0.94-1.56
1.7	1.56-2.6
2.9	2.6-4.3
4.8	4.3-7.2
8.0	7.2-12.0
13.33	12.0-20.00

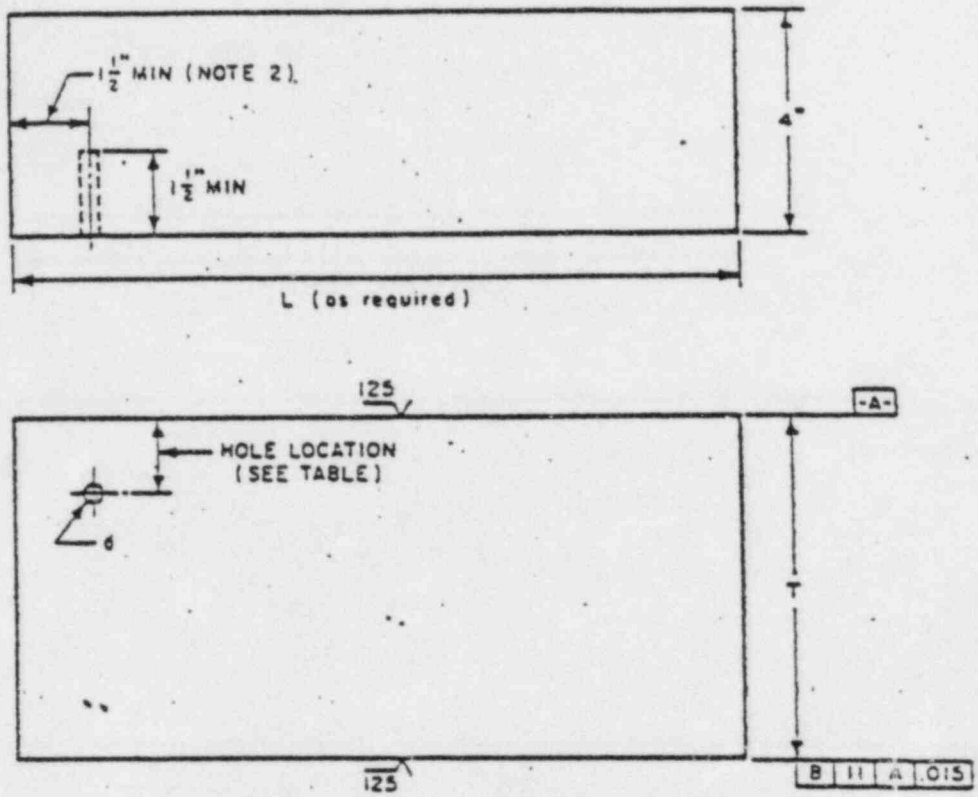

Figure 2 FLAT CALIBRATION BLOCK

L = Length of block determined by the angle of search unit and the vee-path used.
T = Thickness of basic calibration block (see table below).
d = Diameter of side-drilled hole (see table below).
t = Nominal production material thickness.

Nominal Production Material Thickness (t), In.	Calibration Block Thickness (T), In.	Hole Location	Hole Diameteter (d), In.
Up to 1 incl	3/4 or t	1/2 T	3/32
Over 1 thru 2	1-1/2 or t	1/4 T	1/8
Over 2 thru 4	3 or t	1/4 T	3/16
Over 4 thru 6	5 or t	1/4 T	1/4
Over 6 thru 8	7 or t	1/4 T	5/16
Over 8 thru 10	9 or t	1/4 T	3/8
Over 10	t	1/4 T	See Note 1

Note 1 - For each increase in thickness of 2 inches or a fraction thereof, the hole diameter shall increase 1/16-inch.
Note 2 - For block sizes over 3 inches in thickness (T), the distance from the hole to the end of the block shall be 1/2 T min.

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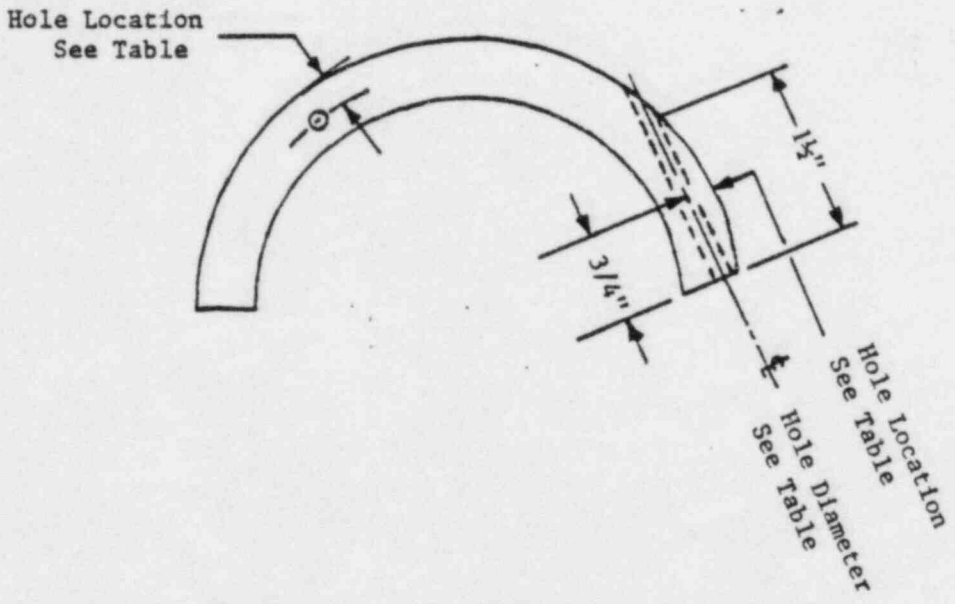


FIGURE 3 CURVED CALIBRATION BLOCK

Refer to Table in Figure #2 for necessary information.

5.0 STRAIGHT BEAM CALIBRATION

5.1 When straight beam examination is used to detect, locate, and evaluate defects in material of 1 inch or greater thickness, a distance-amplitude correction curve shall be constructed, or compensation created electronically.

5.2 The curve shall be constructed as follows using the basic calibration block:

5.2.1 The search unit shall be positioned to obtain a maximum response from the calibration hole at 1/4 T. This is the primary reference response.

5.2.2 The signal shall be adjusted to produce a response of 1/2 of full scale on the cathode ray tube.

5.2.3 Without changing the gain control, the maximum response from the calibration hole at 3/4 T shall be determined.

5.2.4 The points representing the response from 1/4 T and 3/4 T shall be joined by a straight line extended to include the complete test range (Figure 4).

5.3 An electronic distance amplitude device (if used) shall be adjusted such that the maximum response from the calibration hole is equalized over the distance range to be used.

5.4 The reference level for examination shall be the primary reference response corrected for distance.

6.0 ANGLE BEAM CALIBRATION

6.1 A distance-amplitude correction curve or electronic compensation shall be used.

6.2 A distance-amplitude correction curve (if used) shall be constructed as follows using the basic calibration block.

6.2.1 The search unit shall be placed as near as possible to the calibration hole and positioned for maximum response. The approach distance shall not be less than 2 inches or 3/8 node whichever is less.

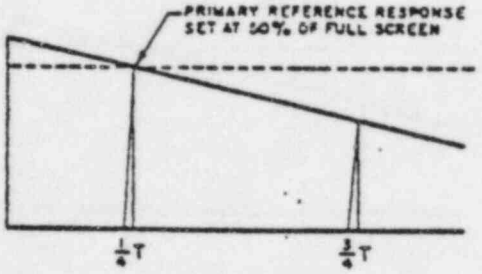
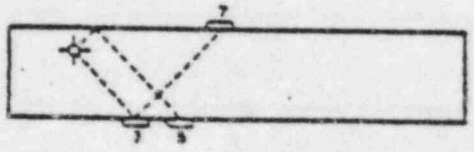


FIG. 4 TYPICAL DISTANCE AMPLITUDE CORRECTION CURVE; STRAIGHT BEAM METHOD



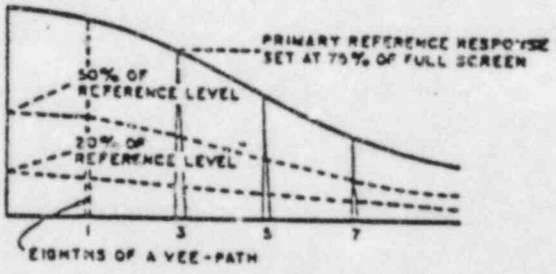


FIG. 5 TYPICAL DISTANCE AMPLITUDE CORRECTION CURVE; ANGLE BEAM METHOD

6.2.2 The response shall be adjusted using the gain control to produce a response of 75 percent of full screen height. This is the primary reference response.

6.2.3 Without changing the gain control, the search unit shall be positioned at other locations covering the examination distance range to be used.

6.2.4 The corresponding responses shall be noted on the cathode ray tube screen.

6.2.5 These points shall be connected with a smooth curve (see Figure 5 for a typical example).

6.3 Electronic distance amplitude correction, if used, shall produce a primary reference response of 50 percent of full screen height over the distance range to be used in examination.

6.4 A transfer method shall be used to correlate the response from the calibration block and the component. A description of the transfer method is found in Appendix C.

6.4.1 For piping circumferential welds, the transfer method shall be used at least once for each weld in pipe 10 inches in diameter and under, and at least once for each 5 feet of weld in larger pipe.

6.4.2 For other welds, the transfer method shall be used at least once for each 10 feet of weld.

7.0 SURFACE PREPARATION

7.1 The weld shall have a surface such that it cannot mask, or be confused with, reflections from defects.

7.2 The contact surfaces for the search unit shall be free from any roughness or weld spatter which would interfere with sound transmission or movement of the search unit.

8.0 ANGLE BEAM SEARCH

8.1 The reference level for monitoring defects shall be the primary reference level (6.2.2) corrected for distance (6.1) and corrected by the transfer method (6.4).

8.2 When possible, scanning shall be performed at a gain setting of 6 dB above the reference level.

8.3 Defects parallel to the weld shall be detected as follows:

8.3.1 The angle beam search unit shall be placed on the contact surface with the beam approximately perpendicular to the weld.

8.3.2 The search unit shall be moved laterally and longitudinally so that the beam passes through the entire volume of weld metal in two different approaches. Each pass of the search unit shall overlap a minimum of 10 percent of the transducer width.

8.3.3 The rate of search unit movement for examination shall not exeed 6 in/sec unless calibration is verified at the higher scanning speed.

8.3.4 Double welded joints may be examined using two search units to detect lack of penetration (Figure 6).

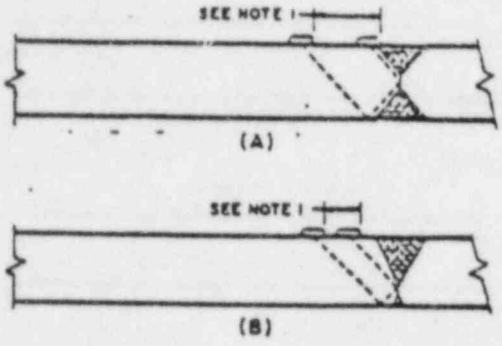
8.4 Defects perpendicular to the weld shall be detected as follows:

8.4.1 Two search units shall be placed astride the weld.

8.4.2 They shall form an angle of less than 45 degrees with the weld (Figure 7).

8.4.3 The search units shall be manipulated such that the entire volume of weld metal is examined. Each pass of the search unit shall overlap a minimum of 10 percent of the transducer width.

8.4.4 Alternatively, if the weld surface is suitably prepared, one search unit may be placed on the weld with the beam parallel to the weld. The unit shall be manipulated such that the entire volume of weld metal is examined. Each pass of the search unit shall overlap a minmum of 10 percent of the transducer (piezoelectric element) dimension perpendicular to the direction of the scan.



Note 1: The Search Units position will vary.

FIG. 6 TYPICAL DOUBLE SEARCH UNIT TECHNIQUE FOR DETECTING LACK OF PENETRATION IN DOUBLE-WELDED JOINTS

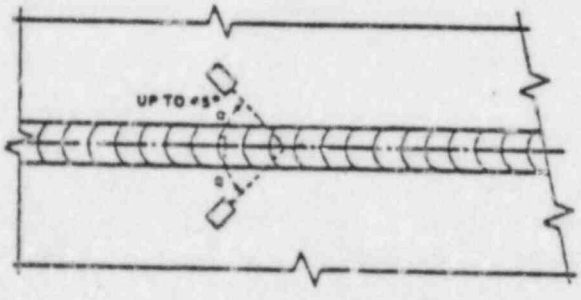


FIG. 7 TYPICAL TWO SEARCH UNIT TECHNIQUE FOR DETECTING TRANSVERSE DISCONTINUITIES IN WELDED JOINTS

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8.5 Reflectors producing a response greater than 20 percent of the reference level shall be evaluated with the gain control at the reference level corrected with transfer.

8.6 The reflectors shall be evaluated to determine their shape, identity, and location in relation to the acceptance criteria of section 10.

8.7 Calibration check shall be made when any part of the examination system is changed, at the finish of each examination or series of similar examinations, every 4 hours during the examination, and when examination personnel are changed. The calibration check shall verify the sweep range calibration and distance amplitude correction.

8.7.1 For sweep range correction, if a point on the DAC curve has moved on the sweep line more than 10 percent of the sweep reading or 5 percent of full sweep, whichever is greater, correct the sweep range calibration and note the correction in the examination record.

If reflectors are recorded on the data sheets, those data sheets shall be voided, a new calibration shall be recorded. All recorded indications since the last valid calibration or calibration check shall be reexamined with the corrected calibration and their values shall be changed on the data sheets.

8.7.2 For distance amplitude correction, if a point on the distance-amplitude correction (DAC) curve has decreased 20 percent or 2dB of its amplitude, all data sheets since the last calibration or calibration check shall be marked void. A new calibration shall be made and recorded and the area covered by the voided data shall be reexamined. If any point of the distance amplitude correction (DAC) curve has increased more than 20 percent or 2dB of its amplitude, all recorded indications since the last valid calibration or calibration check shall be reexamined with the corrected calibration and their values shall be changed on the data sheets.

9.0 STRAIGHT BEAM SEARCH

9.1 When possible, scanning shall be performed at a gain setting of twice (6 dB) the primary reference level.

9.2 The weld shall be scanned by moving the search unit along and across a sufficient contact area to examine the entire weld. Each pass of the search unit shall overlap a minimum of 10 percent of the transducer width.

9.3 The rate of search unit movement for examination shall not exceed 6 in/sec unless calibration is verified at the higher scanning speed.

9.4 Penetration of the sound beam shall be verified by obtaining a back reflection from a parallel surface opposite to the contact surface. Alternatively, the back reflection may be obtained on a metallurgically similar material using approximately the same sound travel distance.

9.5 Reflectors which produce a response greater than 20 percent of the reference level shall be evaluated with the gain control at the reference level corrected with transfer.

9.6 The evaluation shall be sufficient to determine the shape, identity, and location of the reflectors in relation to the acceptance criteria of Section 10.

9.7 Calibration check shall be made when any part of the examination system is changed, at the finish of each examination or series of similar examinations, every 4 hours during the examination, and when examination personnel are changed. The calibration check shall verify the sweep range calibration and distance amplitude correction. See sections 8.7.1 and 8.7.2 if corrections are necessary.

10.0 ACCEPTANCE CRITERIA

10.1 Any reflector interpreted to be a crack, lack of fusion, or incomplete penetration is unacceptable.

10.2 Any reflector is unacceptable if its response exceeds the reference level and its length exceeds:

1/4 inch for t up to 3/4 inch, inclusive;
1/3 t for t from 3/4 inch to 2 1/4 inch, inclusive;
3/4 inch for t over 2 1/4 inch

where t is the thickness of the thinner of the two materials being joined at the weld.

11.0 RECORDS

The minimum records requirements shall be as follows:

1. Identification (including sketch if necessary) of the weld.
2. Operator.
3. Date.
4. Description of ultrasonic equipment and probe.
5. Scan directions and distances.
6. Sketch of any unacceptable reflectors.
7. Calibration data.

   a) all DAC points and point amplitudes, and
   b) transfer data

See Appendix D for Record and Calibration and Data Sheet examples.

12.0 Personnel performing nondestructive examination shall be qualified in accordance with SNT-TC-1A and supplements, "Recommended Practice for Nondestructive Testing Personnel Qualification and Certification." The SNT-TC-1A rating of the personnel interpreting the examination shall be included in the examination report.

Prepared by Donald Zion 3-16-84

Reviewed by Robert M Jones 3-16-84
SNT-TC-1A, Level III

Approved by James E. Roberts 3-16-84

APPENDIX A

TENNESSEE VALLEY AUTHORITY

DIVISION OF CONSTRUCTION

NDE DEMONSTRATION RECORD
ASME

Nondestructive Examination method _____

_____ performed to the requirements of process specification _____ Rev. _____ and addendas _____

_____ has been demonstrated to the satisfaction of the Authorized Nuclear Inspector.

Technician _____ Level _____ Date _____

ANI _____ Date _____

APPENDIX B
EQUIPMENT CALIBRATION

Screen Height Linearity

To verify the ability of the ultrasonic instrument to meet the linearity, position an angle beam search unit as shown in Figure 1 so that indications can be observed from both the 1/2 and 3/4T holes in a basic calibration block. Adjust the search unit position to give a 2 to 1 ratio of amplitudes between the two indications, with the larger set at 80 percent of full screen height. Without moving the search unit, adjust sensitivity (gain) to successively set the larger indication from 100 percent to 20 percent of full screen height, in 10 percent increments (or 2 dB steps if a fine control is not available), and read the smaller indication at each setting. The reading must be 50 percent of the larger amplitude, within 5 percent of full screen height. The settings and readings must be estimated to the nearest 1 percent of full screen. Alternatively, a straight beam search unit may be used on any calibration block which will provide amplitude differences.

Amplitude Control Linearity

To verify the accuracy of the amplitude control of the ultrasonic instrument, position an angle beam search unit as shown in Figure 1 so that the indication from the 1/2T hole in a basic calibration block is peaked on the screen. With the increases and decreases in attentuation shown in the following table, the indication must fall within the specified limits. Other convenient reflectors from any calibration block may be used with angle or straight beam search units.

Indication Set at % of Full Screen	dB Control Change	Indication Limits % of Full Screen
80%	-6dB	32 to 48%
80%	-12dB	16 to 24%
40%	+6dB	64 to 96%
20%	+12dB	64 to 96%

The settings and readings must be estimated to the nearest 1 percent of full screen.

APPENDIX B
EQUIPMENT CALIBRATION

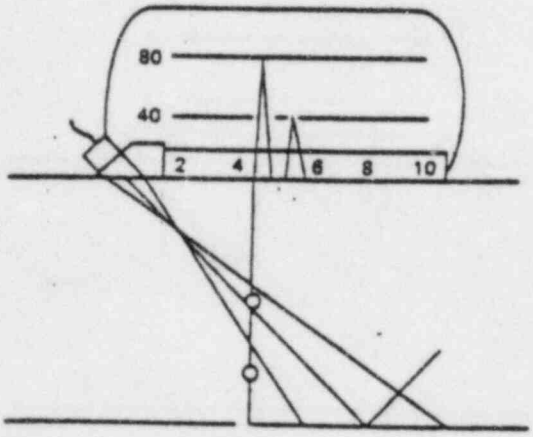

FIG. 1 LINEARITY

APPENDIX C
TRANSFER TECHNIQUE

A. Establish basic calibration per the instructions in either section 5.0 or 6.0 of the procedure.

B. Pitch-Catch (through transmission) Technique

a. With the controls set as they were during basic calibration, connect a second transducer to the UT instrument and switch the instrument to through transmission testing. The second transducer may be of the same angle as the transmitting transducer or a variable angle type.

b. Manipulate the two transducers on the calibration block until a maximum response is shown on the CRT. Mark this point on the CRT.

c. Repeat step b on the material to be examined.

d. Adjust the gain control to bring the response established in c to the same level as established in b.

e. The basic calibration curve can then be used for evaluation of signals.

f. When examining pipe, the transfer technique shall be applied in both the axial and circumferential directions.

APPENDIX D

SAMPLE

INSTRUCTIONS

ULTRASONIC TEST REPORT

STRUCTURE/SYSTEM Example: Base Plates - Mainsteam Restrainst/R4 UNIT 0, 1,or 2

DATE: _____ WELD I.D. Example: 1R4 00024 UT EQPT. SN# & Machine Ty

PROBE FREQ. Actual Freq. 1-5 MhZ PROBE SIZE Dimensions - length & width PROBE ANGLE(S) Actual 1-40° 75°

DAC 75% actual, fullscreen TRANSFER MECHANISM Plastic wedge or search unit

COUPLANT Ultra-gel II, etc. CALIBRATION BLOCK Block SN# & material, size, & dimens

CALIBRATION DATA amount of DBs required to obtain 75% of full screen & transfer.

TEST METHOD(S) A-scan, b-scan, or C-scan CODE CLASS SCAT 1, III 3, III NF, et

COVERAGE entire volume 100% SCAN METHOD(S) contact, immersion, continuous, with overla

AMPLITUDE SETTING 75% of full screen SURFACE CONDITION smooth, flush, groun etc.

EQUIPMENT LINEARITY Acceptable per BNP-QCP 7.2

SKETCH OF UNACCEPTABLE REFLECTORS: Size, length, depth, type - all indications received above 50% of DAC

COMMENTS: _____

Results of the above examination:

OPERATOR _____ ACCEPTED _____ REJECTED _____

ASNT CERT. LEVEL _____

APPENDIX D

NONDESTRUCTIVE EXAMINATION PROCEDURE TVA - DIVISION OF NUCLEAR POWER	LOCATION	UNIT
	CALIBRATION NO.	
	INITIAL CAL TIME	
	FINAL CAL TIME	
AUTHORIZED INSPECTOR ________	DATE	

ULTRASONIC CALIBRATION DATA SHEET

EXAMINER/LEVEL ________ EXAMINER/LEVEL ________

PROCEDURE NO ________ REV ________ REVIEWER/LEVEL ________

EQUIPMENT

INSTRUMENT ________ S/N ________ CABLE ________
RECORDER ________ S/N ________
TRANSDUCER ________ S/N ________ SIZE ________ FREQ. ________ ANGLE ________
CAL BLOCK ________ S/N ________ REF. REFL. ________ TEMP ______ °F
REF BLOCK ________ S/N ________ REF REFL ________ TEMP ______ °F
COUPLANT ________

TYPE EXAMINATION ☐ ANGLEBEAM ☐ LONGITUDINAL ☐ BASE METAL ☐ WELD METAL

LINEARITY CHECK

VERTICAL

SIGNAL 1	100	90	80	70	60	50	40	30	20	10
SIGNAL 2	50									

SIGNAL 2 SHALL EQUAL 50% OF SIGNAL 1 ± 5% OF FULL SCALE

ATTENUATOR

TESTER GAIN	SET	-6	-12	SET	+12	SET	+6
SIGNAL AMP	80%	32 to 48	16 to 24	20%	64 to 96	40%	64 to 96

DAILY LINEARITY CHECKS SATISFACTORY PRIOR TO CAL. BY ________

DISTANCE AMPLITUDE CURVE

DAC

(grid: vertical axis 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100; horizontal axis 1 2 3 4 5 6 7 8 9 10)

SCALE RANGE: 0" - 5" ☐ 0" - 10" ☐ 0" - 20" ☐

INSTRUMENT SET UP

FREQUENCY ☐ 1.0 ☐ 2.25 ☐ 5.0 ☐ OTHER ___
SENSITIVITY/GAIN ________ FINE/DB
________ COARSE/DB
RANGE ________
SWEEP/MAT'L. CAL. ________
DELAY ________
FILTER ________ ☐ OFF
DAMPING ________ ☐ OFF
REJECT ________ ☐ OFF
REP RATE ________
JACK ☐ R ☐ T PAGE ___ OF ___

TVA 6676A (DNP - 3-83)

TENNESSEE VALLEY AUTHORITY

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Part A.3

The NRC stated in the April 4, 1984, letter that "although the ASME Code was not cited in this violation, the Code does require recording of 'any significant changes in subsequent rechecks,' thereby, implying the performance of calibration checks" and that the "licensee provided no documented criteria for periodic checks of calibration of ultrasonic examination equipment."

TVA still maintains that our procedure meets the minimum 1974 ASME Code requirements. We disagree that the Code requires the "recording" of any significant change(s) in subsequent rechecks when recalibrating ultrasonic examination equipment. However, as a matter of good practice, we periodically check the integrity of the calibration in process of examination by the use of a portable "rompas" field calibration block. Furthermore, as agreed upon during the December 20, 1983 telecon with NRC representatives, we have improved our program by revising the G-29M process specification 3.M.7.1 to include scanning rate limitations, detailed information regarding calibration (recalibration), the use of transfer techniques, and calibration rechecks. Per NRC's request in the April 17, 1984 telecon, we are submitting the attached revision to the G-29M process specification 3.M.7.1 as evidence of and further delineation of our improvement in the program.

However, we still deny the violation occurred as stated.

Parts A.4 and A.5

We agree that the schedule for achieving full compliance is excessively long for revising the construction ultrasonic testing procedure QCP 7.2. The construction testing procedure QCP 7.2 will now be revised by June 1, 1984, to incorporate all of the changes that have been made to the G-29M process specification 3.M.7.1.

2.2 The entire volume of base metal through which the sound will travel during angle beam examination of the weld shall be examined by the straight beam method to detect reflectors which would interfere with the angle beam examination. (This examination shall be used only to locate areas which would interfere with angle beam examination and shall not be used as an acceptance examination.)

2.3 An example of weld area scanning is given in Figure 1.

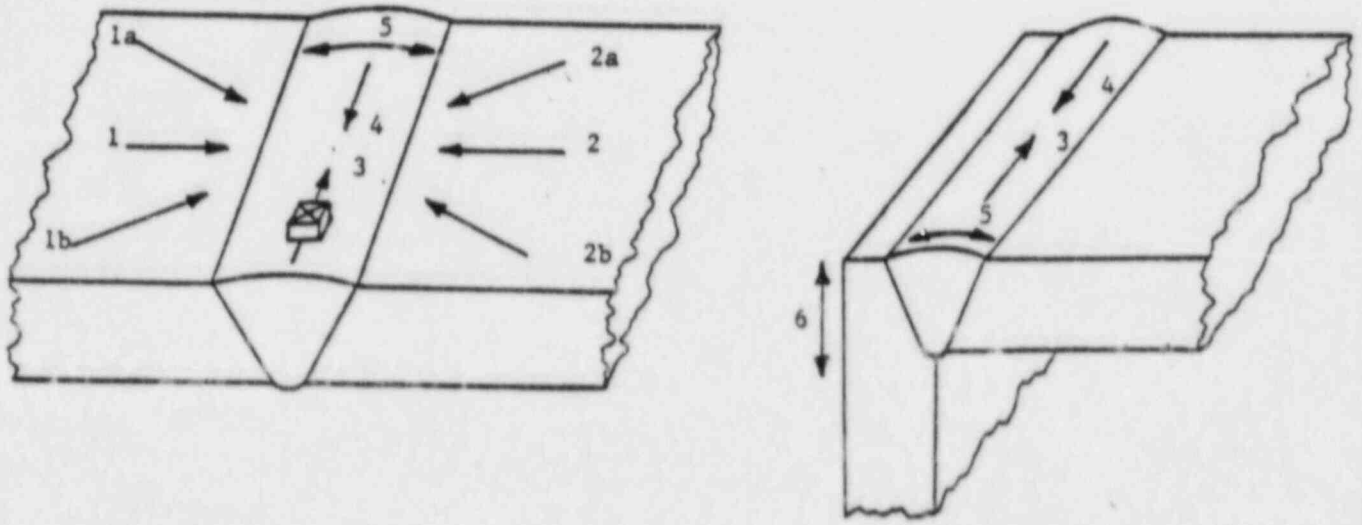


FIGURE 1 EXAMPLE OF WELD AREA SCANNING

Exams 1,2,3, and 4 denotes angle beam examination and shall be performed whenever possible.

Exams 1,3,4, and 5 are acceptable when access permits examination from only one side of the weld.

Exams 5 and 6 denotes straight beam examination per Section 9.0 of this procedure.

If exams 1 and 2 are not possible, exams 3,4,5, and 6 are acceptable.

3.0 EQUIPMENT

3.1 Pulse-echo ultrasonic equipment generating frequencies over the range of 1-5 MHz shall be used. A nominal frequency of 2.25 MHz shall be used for most examinations and 1.5 MHz is recommended for stainless steel, unless factors such as material grain size require the use of other frequencies.

3.2 The equipment shall have a calibrated attenuator (gain control) accurate to ± 2 dB or 20 percent over its range. The range shall be sufficient to allow comparison of indications beyond the viewable portion of the cathode ray tube display.

3.3 For angle beam examination, the system shall produce a beam in the material at an angle of 40 to 75 degrees with respect to the perpendicular to the entry surface.

3.4 For straight beam examination the search unit shall produce a beam in the material which is nominally perpendicular to the entry surface.

3.5 Ultrasonic testing couplants approved for use on nuclear systems and components are glycerine, Vaseline, Exosen, Ultragel, or nuclear grade water. Couplant purchase requirements are listed in Purchase Specification PF-1059.

3.6 Instructions to verify the ability of the ultrasonic instrument to meet the linearity requirements, and to verify the accuracy of the amplitude control of the ultrasonic instrument are found in Appendix B, and shall be documented similar to Appendix D. If the ultrasonic instrument does not meet these linearity requirements the instrument should be repaired.

4.0 CALIBRATION BLOCK

4.1 The flat calibration block shall be as shown in Figure 2.

4.1.1 The material of the block shall be of similar metallurgical structure and have the same or equivalent P-number (Section IX, QW 420) as the material to be examined. P-numbers 1, 3, 4, and 5 shall be considered equivalent.

4.2 For examination of circumferential welds or any longitudinal welds with a contact surface curvature of 20 inches in diameter or less, the calibration block contact surface shall also be curved. The curved calibration block shall be as shown in Figure 3.

4.2.1 The diameter of the part to be examined shall be no less than 90 percent nor more than 150 percent of the calibration block diameter.

4.2.2 Listed below are six curved blocks which will cover a 0.94- to 20-inch-diameter range.

Block Diameter, Inches	Contact Surface Diameter, Inches
1.04	0.94-1.56
1.7	1.56-2.6
2.9	2.6-4.3
4.8	4.3-7.2
8.0	7.2-12.0
13.33	12.0-20.00

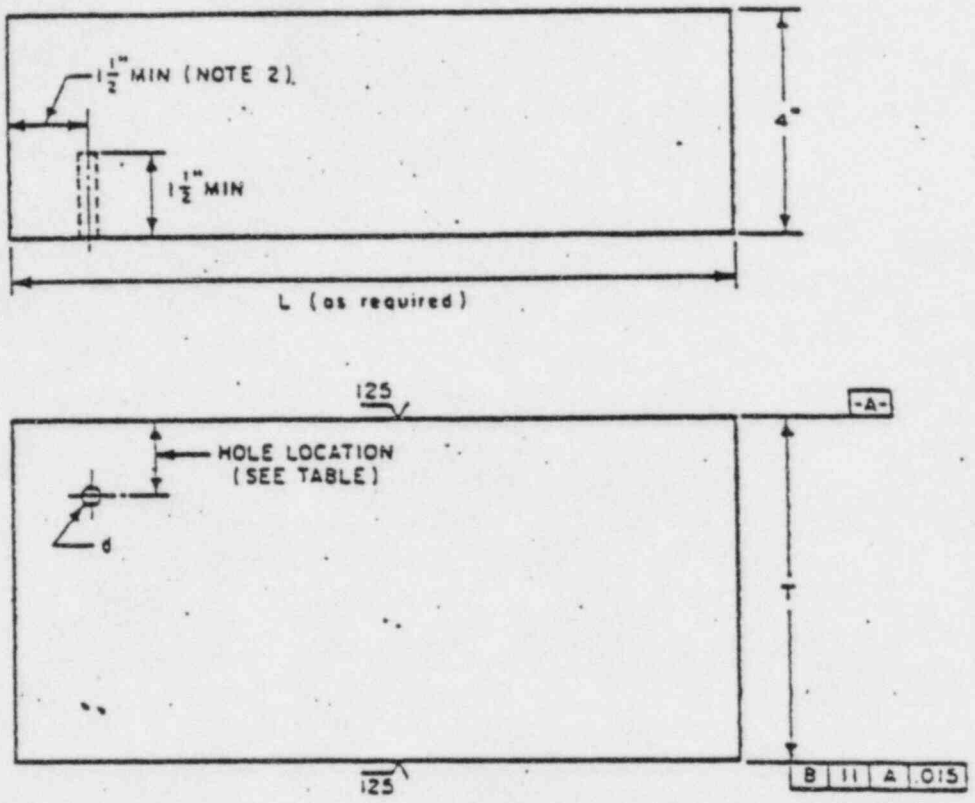


Figure 2 FLAT CALIBRATION BLOCK

L = Length of block determined by the angle of search unit and the vee-path used.
T = Thickness of basic calibration block (see table below).
d = Diameter of side-drilled hole (see table below).
t = Nominal production material thickness.

Nominal Production Material Thickness (t), In.	Calibration Block Thickness (T), In.	Hole Location	Hole Diameteter (d), In.
Up to 1 incl	3/4 or t	1/2 T	3/32
Over 1 thru 2	1-1/2 or t	1/4 T	1/8
Over 2 thru 4	3 or t	1/4 T	3/16
Over 4 thru 6	5 or t	1/4 T	1/4
Over 6 thru 8	7 or t	1/4 T	5/16
Over 8 thru 10	9 or t	1/4 T	3/8
Over 10	t	1/4 T	See Note 1

Note 1 - For each increase in thickness of 2 inches or a fraction thereof, the hole diameter shall increase 1/16-inch.
Note 2 - For block sizes over 3 inches in thickness (T), the distance from the hole to the end of the block shall be 1/2 T min.

E44062.05

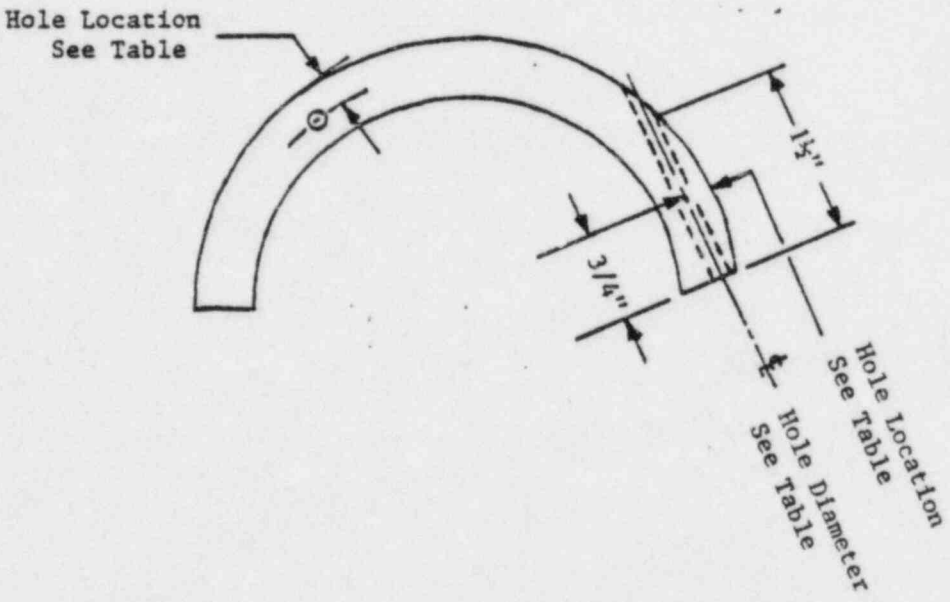


FIGURE 3 CURVED CALIBRATION BLOCK

Refer to Table in Figure #2 for necessary information.

5.0 STRAIGHT BEAM CALIBRATION

5.1 When straight beam examination is used to detect, locate, and evaluate defects in material of 1 inch or greater thickness, a distance-amplitude correction curve shall be constructed, or compensation created electronically.

5.2 The curve shall be constructed as follows using the basic calibration block:

5.2.1 The search unit shall be positioned to obtain a maximum response from the calibration hole at 1/4 T. This is the primary reference response.

5.2.2 The signal shall be adjusted to produce a response of 1/2 of full scale on the cathode ray tube.

5.2.3 Without changing the gain control, the maximum response from the calibration hole at 3/4 T shall be determined.

5.2.4 The points representing the response from 1/4 T and 3/4 T shall be joined by a straight line extended to include the complete test range (Figure 4).

5.3 An electronic distance amplitude device (if used) shall be adjusted such that the maximum response from the calibration hole is equalized over the distance range to be used.

5.4 The reference level for examination shall be the primary reference response corrected for distance.

6.0 ANGLE BEAM CALIBRATION

6.1 A distance-amplitude correction curve or electronic compensation shall be used.

6.2 A distance-amplitude correction curve (if used) shall be constructed as follows using the basic calibration block.

6.2.1 The search unit shall be placed as near as possible to the calibration hole and positioned for maximum response. The approach distance shall not be less than 2 inches or 3/8 node whichever is less.

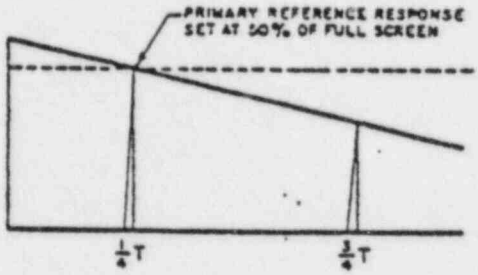
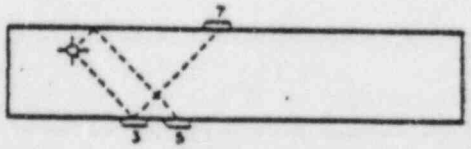


FIG. 4 TYPICAL DISTANCE AMPLITUDE CORRECTION CURVE; STRAIGHT BEAM METHOD



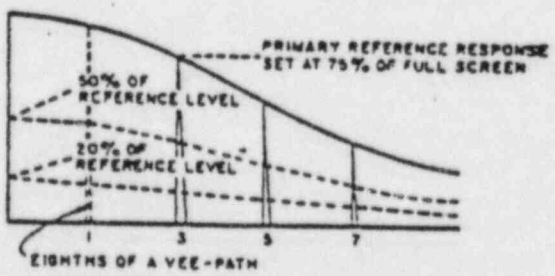


FIG. 5 TYPICAL DISTANCE AMPLITUDE CORRECTION CURVE; ANGLE BEAM METHOD

6.2.2 The response shall be adjusted using the gain control to produce a response of 75 percent of full screen height. This is the primary reference response.

6.2.3 Without changing the gain control, the search unit shall be positioned at other locations covering the examination distance range to be used.

6.2.4 The corresponding responses shall be noted on the cathode ray tube screen.

6.2.5 These points shall be connected with a smooth curve (see Figure 5 for a typical example).

6.3 Electronic distance amplitude correction, if used, shall produce a primary reference response of 50 percent of full screen height over the distance range to be used in examination.

6.4 A transfer method shall be used to correlate the response from the calibration block and the component. A description of the transfer method is found in Appendix C.

6.4.1 For piping circumferential welds, the transfer method shall be used at least once for each weld in pipe 10 inches in diameter and under, and at least once for each 5 feet of weld in larger pipe.

6.4.2 For other welds, the transfer method shall be used at least once for each 10 feet of weld.

7.0 SURFACE PREPARATION

7.1 The weld shall have a surface such that it cannot mask, or be confused with, reflections from defects.

7.2 The contact surfaces for the search unit shall be free from any roughness or weld spatter which would interfere with sound transmission or movement of the search unit.

8.0 ANGLE BEAM SEARCH

8.1 The reference level for monitoring defects shall be the primary reference level (6.2.2) corrected for distance (6.1) and corrected by the transfer method (6.4).

8.2 When possible, scanning shall be performed at a gain setting of 6 dB above the reference level.

8.3 Defects parallel to the weld shall be detected as follows:

8.3.1 The angle beam search unit shall be placed on the contact surface with the beam approximately perpendicular to the weld.

8.3.2 The search unit shall be moved laterally and longitudinally so that the beam passes through the entire volume of weld metal in two different approaches. Each pass of the search unit shall overlap a minimum of 10 percent of the transducer width.

8.3.3 The rate of search unit movement for examination shall not exeed 6 in/sec unless calibration is verified at the higher scanning speed.

8.3.4 Double welded joints may be examined using two search units to detect lack of penetration (Figure 6).

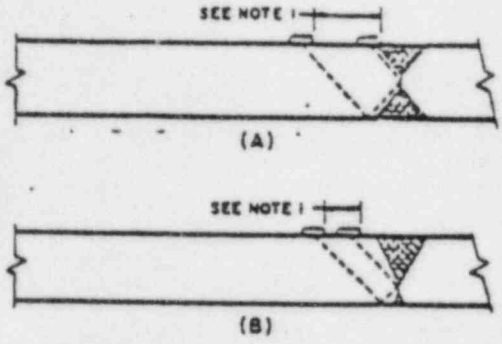
8.4 Defects perpendicular to the weld shall be detected as follows:

8.4.1 Two search units shall be placed astride the weld.

8.4.2 They shall form an angle of less than 45 degrees with the weld (Figure 7).

8.4.3 The search units shall be manipulated such that the entire volume of weld metal is examined. Each pass of the search unit shall overlap a minimum of 10 percent of the transducer width.

8.4.4 Alternatively, if the weld surface is suitably prepared, one search unit may be placed on the weld with the beam parallel to the weld. The unit shall be manipulated such that the entire volume of weld metal is examined. Each pass of the search unit shall overlap a minmum of 10 percent of the transducer (piezoelectric element) dimension perpendicular to the direction of the scan.



Note 1: The Search Units position will vary.

FIG. 6 TYPICAL DOUBLE SEARCH UNIT TECHNIQUE FOR DETECTING LACK OF PENETRATION IN DOUBLE-WELDED JOINTS

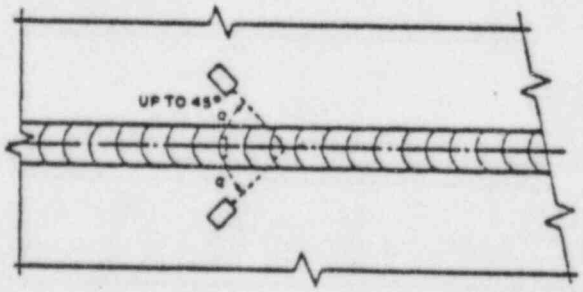


FIG. 7 TYPICAL TWO SEARCH UNIT TECHNIQUE FOR DETECTING TRANSVERSE DISCONTINUTIES IN WELDED JOINTS

8.5 Reflectors producing a response greater than 20 percent of the reference level shall be evaluated with the gain control at the reference level corrected with transfer.

8.6 The reflectors shall be evaluated to determine their shape, identity, and location in relation to the acceptance criteria of section 10.

8.7 Calibration check shall be made when any part of the examination system is changed, at the finish of each examination or series of similar examinations, every 4 hours during the examination, and when examination personnel are changed. The calibration check shall verify the sweep range calibration and distance amplitude correction.

8.7.1 For sweep range correction, if a point on the DAC curve has moved on the sweep line more than 10 percent of the sweep reading or 5 percent of full sweep, whichever is greater, correct the sweep range calibration and note the correction in the examination record.

If reflectors are recorded on the data sheets, those data sheets shall be voided, a new calibration shall be recorded. All recorded indications since the last valid calibration or calibration check shall be reexamined with the corrected calibration and their values shall be changed on the data sheets.

8.7.2 For distance amplitude correction, if a point on the distance-amplitude correction (DAC) curve has decreased 20 percent or 2dB of its amplitude, all data sheets since the last calibration or calibration check shall be marked void. A new calibration shall be made and recorded and the area covered by the voided data shall be reexamined. If any point of the distance amplitude correction (DAC) curve has increased more than 20 percent or 2dB of its amplitude, all recorded indications since the last valid calibration or calibration check shall be reexamined with the corrected calibration and their values shall be changed on the data sheets.

9.0 STRAIGHT BEAM SEARCH

9.1 When possible, scanning shall be performed at a gain setting of twice (6 dB) the primary reference level.

9.2 The weld shall be scanned by moving the search unit along and across a sufficient contact area to examine the entire weld. Each pass of the search unit shall overlap a minimum of 10 percent of the transducer width.

9.3 The rate of search unit movement for examination shall not exceed 6 in/sec unless calibration is verified at the higher scanning speed.

9.4 Penetration of the sound beam shall be verified by obtaining a back reflection from a parallel surface opposite to the contact surface. Alternatively, the back reflection may be obtained on a metallurgically similar material using approximately the same sound travel distance.

9.5 Reflectors which produce a response greater than 20 percent of the reference level shall be evaluated with the gain control at the reference level corrected with transfer.

9.6 The evaluation shall be sufficient to determine the shape, identity, and location of the reflectors in relation to the acceptance criteria of Section 10.

9.7 Calibration check shall be made when any part of the examination system is changed, at the finish of each examination or series of similar examinations, every 4 hours during the examination, and when examination personnel are changed. The calibration check shall verify the sweep range calibration and distance amplitude correction. See sections 8.7.1 and 8.7.2 if corrections are necessary.

10.0 ACCEPTANCE CRITERIA

10.1 Any reflector interpreted to be a crack, lack of fusion, or incomplete penetration is unacceptable.

10.2 Any reflector is unacceptable if its response exceeds the reference level and its length exceeds:

1/4 inch for t up to 3/4 inch, inclusive;
1/3 t for t from 3/4 inch to 2 1/4 inch, inclusive;
3/4 inch for t over 2 1/4 inch

where t is the thickness of the thinner of the two materials being joined at the weld.

11.0 RECORDS

The minimum records requirements shall be as follows:

1. Identification (including sketch if necessary) of the weld.
2. Operator.
3. Date.
4. Description of ultrasonic equipment and probe.
5. Scan directions and distances.
6. Sketch of any unacceptable reflectors.
7. Calibration data.

   a) all DAC points and point amplitudes, and
   b) transfer data

See Appendix D for Record and Calibration and Data Sheet examples.

12.0 Personnel performing nondestructive examination shall be qualified in accordance with SNT-TC-1A and supplements, "Recommended Practice for Nondestructive Testing Personnel Qualification and Certification." The SNT-TC-1A rating of the personnel interpreting the examination shall be included in the examination report.

Prepared by Donald Zion 3-16-84

Reviewed by Robert M Jones 3-16-84
SNT-TC-1A, Level III

Approved by James E. Roberts 3-16-84

APPENDIX A

TENNESSEE VALLEY AUTHORITY

DIVISION OF CONSTRUCTION

NDE DEMONSTRATION RECORD
ASME

Nondestructive Examination method _____

_____ performed to the requirements of process specification _____ Rev. _____ and addendas _____

_____ has been demonstrated to the satisfaction of the Authorized Nuclear Inspector.

Technician _____ Level _____ Date _____

ANI _____ Date _____

APPENDIX B
EQUIPMENT CALIBRATION

Screen Height Linearity

To verify the ability of the ultrasonic instrument to meet the linearity, position an angle beam search unit as shown in Figure 1 so that indications can be observed from both the 1/2 and 3/4T holes in a basic calibration block. Adjust the search unit position to give a 2 to 1 ratio of amplitudes between the two indications, with the larger set at 80 percent of full screen height. Without moving the search unit, adjust sensitivity (gain) to successively set the larger indication from 100 percent to 20 percent of full screen height, in 10 percent increments (or 2 dB steps if a fine control is not available), and read the smaller indication at each setting. The reading must be 50 percent of the larger amplitude, within 5 percent of full screen height. The settings and readings must be estimated to the nearest 1 percent of full screen. Alternatively, a straight beam search unit may be used on any calibration block which will provide amplitude differences.

Amplitude Control Linearity

To verify the accuracy of the amplitude control of the ultrasonic instrument, position an angle beam search unit as shown in Figure 1 so that the indication from the 1/2T hole in a basic calibration block is peaked on the screen. With the increases and decreases in attentuation shown in the following table, the indication must fall within the specified limits. Other convenient reflectors from any calibration block may be used with angle or straight beam search units.

Indication Set at % of Full Screen	dB Control Change	Indication Limits % of Full Screen
80%	-6dB	32 to 48%
80%	-12dB	16 to 24%
40%	+6dB	64 to 96%
20%	+12dB	64 to 96%

The settings and readings must be estimated to the nearest 1 percent of full screen.

APPENDIX B
EQUIPMENT CALIBRATION

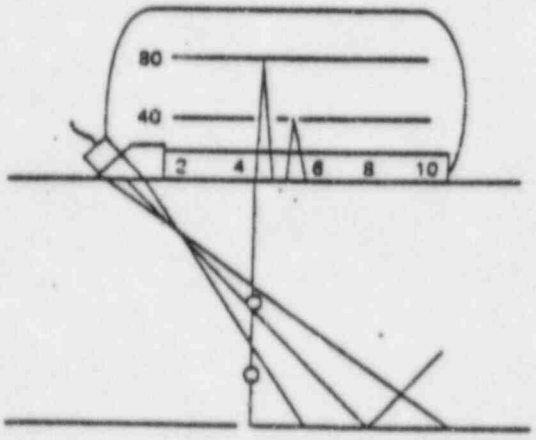


FIG. 1 LINEARITY

APPENDIX C
TRANSFER TECHNIQUE

A. Establish basic calibration per the instructions in either section 5.0 or 6.0 of the procedure.

B. Pitch-Catch (through transmission) Technique

a. With the controls set as they were during basic calibration, connect a second transducer to the UT instrument and switch the instrument to through transmission testing. The second transducer may be of the same angle as the transmitting transducer or a variable angle type.

b. Manipulate the two transducers on the calibration block until a maximum response is shown on the CRT. Mark this point on the CRT.

c. Repeat step b on the material to be examined.

d. Adjust the gain control to bring the response established in c to the same level as established in b.

e. The basic calibration curve can then be used for evaluation of signals.

f. When examining pipe, the transfer technique shall be applied in both the axial and circumferential directions.

APPENDIX D

SAMPLE

INSTRUCTIONS

ULTRASONIC TEST REPORT

STRUCTURE/SYSTEM Example: Base Plates - Mainsteam Restrainst/R4 UNIT 0, 1,or 2

DATE: _____ WELD I.D. Example: 1R4 00024 UT EQPT. SN# & Machine Ty

PROBE FREQ. Actual Freq. 1-5 MhZ PROBE SIZE Dimensions - length & width PROBE ANGLE(S) Actual L-40° 75°

DAC 75% actual, fullscreen TRANSFER MECHANISM Plastic wedge or search unit

COUPLANT Ultra-gel II, etc. CALIBRATION BLOCK Block SN# & material, size, & dimens

CALIBRATION DATA amount of DBs required to obtain 75% of full screen & transfer.

TEST METHOD(S) A-scan, b-scan, or C-scan CODE CLASS SCAT 1, III 3, III NF, et

COVERAGE entire volume 100% SCAN METHOD(S) contact, immersion, continuous, with overla

AMPLITUDE SETTING 75% of full screen SURFACE CONDITION smooth, flush, groun etc.

EQUIPMENT LINEARITY Acceptable per BNP-QCP 7.2

SKETCH OF UNACCEPTABLE REFLECTORS: Size, length, depth, type - all indications received above 50% of DAC

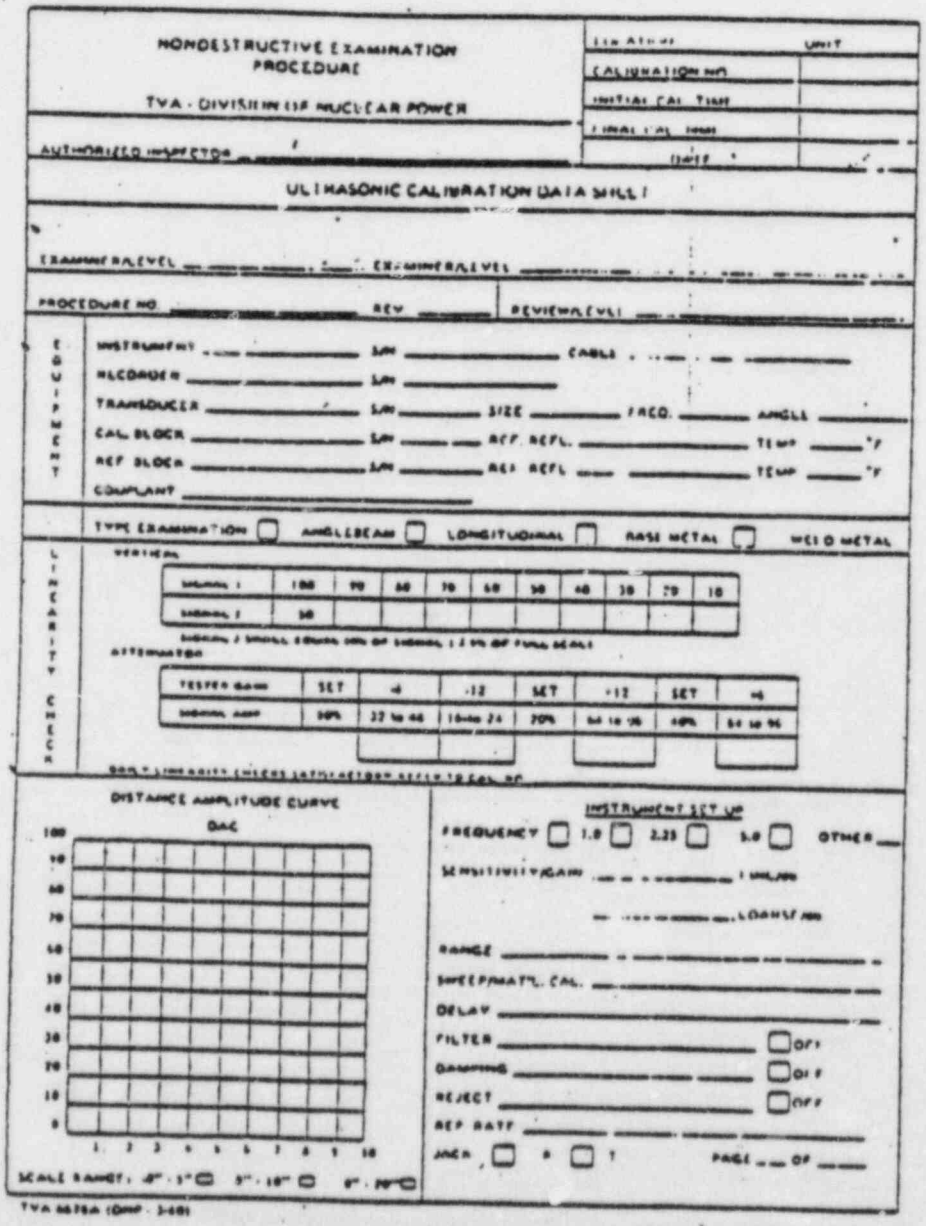
COMMENTS: _____

Results of the above examination:

OPERATOR _____ ACCEPTED _____ REJECTED _____

ASNT CERT. LEVEL _____

APPENDIX D



NONDESTRUCTIVE EXAMINATION PROCEDURE

TVA - DIVISION OF NUCLEAR POWER

AUTHORIZED INSPECTOR

UNIT

CALIBRATION NO

INITIAL CAL TIME

FINAL CAL TIME

DATE

ULTRASONIC CALIBRATION DATA SHEET

EXAMINER/LEVEL

EXAMINER/LEVEL

PROCEDURE NO REV REVIEW/LEVEL

EQUIPMENT

INSTRUMENT S/N CABLE

RECORDER S/N

TRANSDUCER S/N SIZE FREQ. ANGLE

CAL BLOCK S/N REF. REFL. TEMP °F

REF BLOCK S/N REF REFL TEMP °F

COUPLANT

TYPE EXAMINATION ☐ ANGLEBEAM ☐ LONGITUDINAL ☐ BASE METAL ☐ WELD METAL

LINEARITY CHECK

VERTICAL

	100	90	80	70	60	50	40	30	20	10
	50									

ATTENUATOR

	SET	-6	-12	SET	+12	SET	+6	
	50%	22 to 46	10 to 24	20%	44 to 96	40%	84 to 96	

DISTANCE AMPLITUDE CURVE

DAC

100 90 80 70 60 50 40 30 20 10 0

1 2 3 4 5 6 7 8 9 10

SCALE RANGE: 0" - 5" ☐ 5" - 10" ☐ 0" - 20" ☐

INSTRUMENT SET UP

FREQUENCY ☐ 1.0 ☐ 2.25 ☐ 5.0 ☐ OTHER

SENSITIVITY/GAIN

RANGE

SWEEP/MATL. CAL.

DELAY

FILTER ☐ OFF

DAMPING ☐ OFF

REJECT ☐ OFF

REP RATE

AREA ☐ A ☐ T PAGE OF

TVA 40788 (10-82) 3-481