GE Nuclear Energy

PROCEDURE: UT-BFN-702V1 REVISION NO.: 1

TITLE

PROCEDURE FOR GERIS 2000 ULTRASONIC OD
EXAMINATION OF RPV ASSEMBLY WELDS

THIS PROCEDURE IS APPROVED FOR USE AT BROWNS FERRY NUCLEAR AND IS CONTAINED IN GE NDE MANUAL 9.6 OF TVA'S DOCUMENT CONTROL SYSTEM

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1. SCOPE

1.1. This procedure defines the requirements for contact pulse-echo and pitch-catch ultrasonic examination of ASME Section XI, Category B-A and B-D, Reactor Vessel Assembly Welds using the GERIS 2000 OD remote automated ultrasonic examination system.

1.2. This procedure is applicable to materials from 2 to 12 inches in thickness. The materials may be either rolled plate or forging with nominal diameters equal to or greater than 120 inches.

1.3. The ultrasonic examination specified herein applies to the use of the GERIS 2000 OD automated contact pulse-echo and pitch-catch equipment for the ultrasonic examination of welds, heat affected zones, adjacent base metal, and base metal repairs. The examinations are to be performed from the outside surfaces of the vessel using a combination of 0° longitudinal; 45° shear wave; and 60° shear wave and 70° refracted longitudinal (RL) wave beam angles. Angles and modes of propagation are those required by contract.

1.4. This procedure meets the intent of ASME Section V, Article 4; and Section XI, Appendix I, Supplements 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11; as modified by USNRC Regulatory Guide 1.150, Rev. 1. When a conflict of requirements occurs, the requirements of USNRC Regulatory Guide 1.150 of paragraph 2.10 shall take precedence. Hence, this procedure is considered to be a qualified alternative examination method in accordance with Paragraph IWA-2240 of ASME Section XI.

1.5. The examination shall be performed in accordance with the applicable TVA work order per paragraph 2.10.

1.6. Administrative and program requirements of paragraph 2.10 shall be followed for the scope of this procedure.

2. REFERENCES

2.1. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section V and XI 1989 Edition, No Addenda.

2.2. General Electric document 386HA480, "Certification of Nondestructive Test Personnel".

2.3. General Electric Procedure GE-ADM-1002, "Procedure for the Review Process and Analysis of Recorded Indications" or equivalent site specific procedure.

2.4. General Electric procedure GE-ADM-1005, "Procedure for Zero Reference Location and Data Recording for Non-Destructive Examination" or equivalent site specific procedure.

2.5. General Electric Procedure GE-ADM-1006 "Procedure for Compliance with USNRC Reg. Guide 1.150" or equivalent site specific procedure.

2.6. General Electric procedure GE-ADM-1025, "Procedure for Training and Qualification of Personnel for GE-NE Specialized NDE Applications" or equivalent site specific procedure.

2.7. General Electric procedure GE-UT-706, "Procedure for RPV Flaw Sizing with the GERIS 2000 OD System" or equivalent site specific procedure.

2.8. USNRC Regulatory Guide 1.150, Rev. 1, February 1983, "Ultrasonic Testing of Reactor Vessel Welds During Preservice and Inservice Examinations", Alternate Method.

2.9. The following documents, which may be prepared by the vessel fabricator, must be available, but are not considered to be a part of this Procedure.

2.9.1. Reactor Vessel Fabrication Drawings, Nozzle Forging, and Nozzle Assembly Drawings.

2.9.2. Detailed nozzle identification plan.

2.10. TVA Surveillance Instructions as applicable 1-SI-4.6.G, 2-SI-4.6.G, and 3-SI-4.6.G, Latest Revision.

2.11. TVA Site Standard Practice SPP-3.1, Latest Revision.

2.12. TVA Site Standard Practice SSP-6.2, Latest Revision

3. PERSONNEL

3.1. Personnel performing examinations, reviewing and evaluating recorded data to this procedure shall be certified to at least Level II in accordance with paragraph 2.2 and shall have successfully completed additional training appropriate to their job function for GERIS 2000 OD Operator or Analyst as described in the document referenced in paragraph 2.6.

3.2. Personnel assisting in performing the ultrasonic examination, calibration and verification of calibration for the remote ultrasonic examination system shall be certified to at least a UT Level I-T Trainee. A Level I or I-T individual shall not independently evaluate or accept the results of the nondestructive examination. Level I or I-T individuals may only be allowed to participate in calibrations and examinations through equipment setup and data recording and only under the direct supervision of the responsible Level II. At least one person certified to a minimum of Level II shall directly supervise all calibrations and examinations.

3.3. The GERIS 2000 OD Operators shall be responsible for examination system setup and collection of data by following instructions from the GERIS 2000 OD Data Analyst. GERIS 2000 OD Data Analysis personnel shall be responsible for reviewing and accepting calibrations.

3.4. The GERIS 2000 OD Data Analysis shall be responsible for reviewing the acquired data and determining the presence or absence and sizing of flaw indications.

3.5. Any GERIS 2000 operator who has not operated the system for a period exceeding eighteen months is required to re-perform the proficiency demonstration prior to reassignment to GERIS 2000 work. A statement attesting to satisfactory completion of the demonstration shall be issued by GE Nuclear Energy, and shall become part of the employee's certification records.

3.6. Personnel whose job function consists of placing tracks, positioning the automated scanner, verifying transducer position, etc. need not be certified. However, they shall have received documented training in these job functions

3.7. When manual examination for verification is performed, the personnel shall be certified to at least a UT Level II in accordance with the document referenced in paragraph 2.2.

4. EQUIPMENT

4.1. Use of electronic simulators is not allowed by this procedure

4.2. Ultrasonic Equipment

4.2.1. The GERIS 2000 OD Data Acquisition System shall be used. The GERIS 2000 OD System is a computer controlled 16 channel multiplexed ultrasonic instrument. Each channel can be individually controlled through software e.g., instructions for gate length and position, sound velocity, sample rate and exam area pulsing limits. Real time C-scan and A-scan displays are provided for system monitoring by the operator. These displays need not be monitored for the effective performance of the examination. The complete RF output for each channel used during an examination is recorded on optical disks for off-line analysis.

4.3. The GERIS 2000 OD Digital Acquisition System pulses the transducers on position (POP). This means that each search unit is pulsed and data recorded once for each step position within its assigned examination area. Each step position is normally 0.250". Scanning speed is typically set to not exceed 3" per second. Pulse repetition rate is not variable and is hardware set for Pulse-on-Position (POP) where the system produces a single pulse for a given channel at programmed locations on the exam surface. The number and locations of POP's is determined by the trigger pattern and step sizes entered.

4.4. The ultrasonic system operates in the Pulse-Echo and Pitch-Catch modes and consists of the following electronic components:

a) GE Model PS-2 Ultrasonic Power Supply;
b) GE Model MX-1 Multiplexer;
c) GE Model PR-3 (Pulse-Echo) Pulsers;
d) GE Model RC-1 (Pulse-Echo) Receivers and RC-2 (Pitch Catch) Receivers;
e) GE Model LA-1 Logarithmic Amplifier;
f) LeCroy Model TR8818A Transient Recorder.

4.5. The GERIS 2000 vessel scanner or other scanning device shall be used for data acquisition. The GERIS 2000 scanner is a magnetically mounted, computer controlled, scanner. It is capable of positioning 1 search unit package containing multiple search units (system maximum of 16) each on the exam surface of the vessel.

4.6. The GERIS 2000 Data Analysis System which consists of an HPUX Work Station with the GERIS 2000 Software V5.23 installed, monitor, optical disk storage modules, mouse and keyboard shall be used. Previous or later revisions of software are considered acceptable when, the revision does not change the essential variables. The analysis system provides the Data Analyst with access to the entire recorded RF A-scan waveform, B-scan and C-scan displays for further detailed analysis. Final interpretation of the examination results is the responsibility of the Level II or Level III Data Analyst.

4.7. Search Units

4.7.1. The search units RF waveform and frequency amplitude information for each search unit shall be recorded prior to the initial calibration and after the final calibration. If the transducer is the type that requires an angle beam wedge, the pre and post RF waveform should be made with the same type wedge to minimize any variations of the wedge on the results of the information. The waveform and frequency amplitude information shall be recorded using GERIS 2000, PC-TES or other analysis equipment. The required data may be collected in an off-site location.

4.7.2. Zero degree (0°) Longitudinal search units shall be a ceramic type having a nominal frequency of 2.0 - 2.25 MHz. The search unit should be 1.0" in diameter. Where surface contours require, smaller search units may be used. On non-parallel surfaces, wedges may be used to obtain back surface reflections.

4.7.3. Angle beam examinations search units shall be a ceramic type having a nominal frequency of 1.0 thru 2.25 MHz. Search units must satisfactorily resolve the 2% of T notch in the basic calibration block. The search unit size shall range from 0.375" to 1.5" in dimension. Search units may be circular, elliptical, square or rectangular. The beam angles in the material shall be within ±3° of nominal. Alternate beam angles may be used with the approval of the cognizant Level III. All search units/wedge combination shall comply with reference 2.5.

Note: Transducers/wedges of other sizes, angles, modes of propagation or frequencies may be used when required by material characteristics, geometric configuration, or for the evaluation of indications, with the approval of the cognizant Level III. Such approval shall be documented.

4.7.4. For barrel nozzles Lucite wedges contoured for scanning from the OD blend radius surface may be used. The wedges are designed to produce 45° and 60° shear wave beam angles. Nozzle configuration may require examination from the OD blend radius surface to increase the amount of examination scan coverage.

4.7.5. Near surface examination shall be performed using a 70° RL, 2.0 MHz (nominal frequency) dual element transducer. This near surface examination is not performed on nozzle outer blend radius surfaces.

4.8. The couplant for calibration and examination shall be reactor grade water (de-ionized or de-mineralized). The ultrasonic couplant used shall be in sufficient quantities to maintain adequate acoustic contact between the search unit and component, and shall be approved by the Owner's chemistry program.

4.9. Basic calibration blocks should be accordance with ASME Section XI requirements. Basic calibration blocks shall be approved and/or provided by the Owner.

4.10. The basic calibration block or other reference block i.e. IIW or GE DSC block, may be used to verify system calibrations.

4.11. A thermometer calibrated and certified in accordance with the manufacturer's standards shall be used to measure the calibration block and examination component surface temperatures. Additionally, the serial number of the thermometer shall be recorded on the Calibration Data Sheet for reference.

4.12. Ultrasonic Cables

4.12.1. The search unit cable type, number of connectors and length shall be entered into the comments section in the search unit parameters menu for each search unit (reference Figure 1).

4.12.2. The maximum cable lengths and number of intermediate connectors (male-to-female) shall be:

4.12.2.1. A maximum length of 700 feet of preamp RF signal cable (Belden 9207 Twin Axial or equivalent) from the UT multiplexer to the UT console. The maximum number of intermediate connectors is 3.

4.12.2.2. A maximum length of 105 feet of coaxial cable (RG-174 or equivalent) from the UT multiplexer to the search unit. The maximum number of intermediate connectors is 1.

4.12.3. Other Cables

a) A maximum length of 2 feet of coaxial cable (RG-316/U or equivalent) from the mux power to the logarithmic Amplifier (Reference Figure 2). The use of intermediate connectors is not permitted.

b) A maximum length of 6 inches of coaxial cable (RG-316/U or equivalent) from the logarithmic amplifier to the LeCroy Transient Recorder, Digitizer (Reference Figure 2). The use of intermediate connectors is not permitted.

4.12.4. Separate calibration and examination cables maybe used provided the cables are of similar type, configuration, length and have similar UT responses (in both time and amplitude) all of which shall documented.

4.13. General Electric manufactured electronic equipment shall be identified by Model number designation. Modification of any electronic equipment shall require re-designation of the Model number. Reference Figure 2 for a system block diagram of the GERIS 2000 UT system.

4.14. Scanning Mechanisms

4.14.1. Vessel Scanner -A vessel scanner consisting of a magnetically attached motor-driven vehicle and a scanner assembly with ultrasonic transducers shall be used.

4.14.1.1. The vehicle is held to the RPV by magnetic wheels powered by small permanent magnet DC gear motors. Two absolute magnetic encoders on the vehicle give position and orientation information to the data processing and control unit. One encoder, driven by a caster wheel, reads out distance traveled. The second encoder has a pendulum suspended from its shaft to give vehicle orientation with respect to the vertical.

4.14.1.2. The scanner assembly mounted on the motor-driven vehicle consists of the transducer holder with multiple transducers, a ball screw or equivalent scanning drive assembly and stepping motor for providing scanning motion, and an encoder. The scanner is designed to give a transducer speed of less than six inches per second and provides search unit location readouts. The transducer holder provides passages for couplant and is held to the vessel wall by spring pressure. The transducer package contains a 0° straight beam with 45° and 60° shear wave and 70° refracted longitudinal (RL) angle beams and provides for scanning the weld or base metal in both parallel and transverse directions simultaneously.

4.14.1.3. A miniature TV camera is mounted on the vehicle. It permits the operator to visually track paint stripes or other marks placed on or near the center lines of weld seams. During examinations, it is also used for locating obstructions in the patn of the vehicle.

4.14.2. Nozzle Scanner -The magnetically attached nozzle scanner is a combination of a removable channel track surrounding the nozzle or safe end OD, a magnetically attached motor-driven unit for transporting the scanner assembly, and a scanner assembly with ultrasonic transducers.

4.14.2.1. The scanner is held in the circular steel track by magnetic wheels which are guided in a machined channel. Motive power is furnished by DC drive motors.

4.14.2.2. Positioning information for the scanner comes from a pendulum encoder. Azimuth orientation around the nozzle is given in degrees with 0° located at the 3 o'clock position, increasing in the clockwise direction as viewed facing the vessel. The transducer assembly is moved by a screw arrangement to a motor and position encoder. The transducer assembly provides passages for couplant and is held to the vessel wall with spring pressure.

4.15. Dynamic Calibration Fixture

4.15.1. The automated calibration equipment consists of a fixture for retaining the applicable vessel calibration block and a scanner mechanism for moving the search unit package over the calibration block. The scanner mechanism on the calibration equipment duplicates the scanner assembly in the vessel scanner vehicle, thereby allowing a dynamic calibration.

5. CALIBRATION

5.1. System setup

5.1.1. The GERIS 2000 system ultrasonic electronics shall be within their calibration due cycle and the certification of calibration on file.

5.1.2. The GERIS 2000 scanner shall be set up as required to permit scanning of the examination areas.

5.1.3. The GERIS 2000 Data Acquisition System Setup records should be completed in accordance with the GERIS 2000 Scan Plan. Operator deviation from the scan plan parameters is permitted due to obstructions or geometry configuration. These deviations shall be documented on the examination data sheet.

5.1.4. Software controlled gain shall be 14 dB. The dB per bit value shall be as determined from the Log Amplifier electronic certifications referenced in 5.1.1.

5.1.5. Pulse repetition rate is not variable and is hardware set for Pulse-on-Position (POP) where the system produces a single pulse for a given channel at programmed locations on the exam surface. The number and locations of POP's is determined by the trigger pattern and step sizes entered.

5.1.6. The sample rate shall be a minimum of 5 times the search unit nominal center frequency. The available sample rates are 6.25 MHz, 12.5 MHz, and 25 MHz.

5.1.7. The maximum scanner velocity shall be 3 inches / sec.

5.1.8. The maximum step size shall be 0.25 inches in both the 'X' and 'Y' axis. Search unit overap of 50% shall be maintained.

5.1.9. The nominal shear wave velocity is 0.128 in / μsec. The nominal longitudinal wave velocity is 0.233 in / μsec.

5.1.10. Gate settings are in μsec. using the nominal values for wall thickness (T), velocity (V) and angle (A) and must include the nominal wedge delay. The settings for the B-gate and C-gate may be changed at any time during analysis and are not mandatory. The formula for determining the Time-of-Flight (TOF) required for a given inspection depth (D) in μsec is:

$$(2 \times D) / (V \times \cos. A) + \text{wedge delay} = TOF\ \mu sec$$

5.2. General Requirements for Calibration

5.2.1. Calibration for the examination shall include the complete UT system. Any change in search units, couplants, UT instruments, or any other components of the system except as by this procedure, shall be cause for a calibration check for the particular channel or channels involved. Calibration for the examination shall be obtained on the basic calibration block applicable to the thickness of the material being examined. The temperature of the basic calibration block shall be within ±25° F of the component surface temperature The calibration block used shall be heated or cooled as necessary to meet the 25° F requirement. The identification of the temperature measuring device shall be entered on both the Calibration and Examination Data Sheets.

5.2.2. Calibrations and the establishment of the DAC should not be accomplished with the center line of the transducer housing closer than 1-1/2 inch to any edge of the calibration block if the block design allows.

5.2.3. Calibration is conducted on the basic calibration block to verify location and amplitude of signals from 1/4T, 1/2T, and 3/4T side-drilled holes. Other blocks or methods may be used with the approval of the cognizant GE Subject Matter Expert (SME) who are listed within the document referenced in paragraph 2.6.

5.2.3.1. For purpose of calibrations and calibration verification, separate cables between the UT transducer and the UT preamplifier may be used provided the cabling has been shown to give similar UT responses (in both time and amplitude) to the cabling used to perform the examination. If a difference is found in either time or amplitude between the two sets of cables, resultant values between the two cables shall be recorded. The examination cable shall have a greater signal response than the calibration cable. This process is an alternative technique in accordance with ASME Section XI IWA-2240 and may require demonstration to the Authorized Nuclear Inservice Inspector (ANII).

5.2.4. Calibration Verification

5.2.4.1. Calibration shall be verified at the start and finish of each series of examinations at intervals not to exceed twelve hours. Calibration may be verified on the calibration block or by means of a simulator such as the IIW-2 block. Any type of block may be used as a simulator provided that it contains sufficient reflectors so that at least two points on the sweep can be observed without changing the sweep range and delay controls from the calibration settings. If a simulator is used, the response must be recorded at the time of initial calibration, for reference at the time of verification.

5.2.4.2. If the amplitude of any reflector in the calibration verification has decreased by more than 2 dB, all data since the last acceptable verification shall be voided. The equipment shall be recalibrated and the voided areas re-examined.

5.2.4.3. If the amplitude of any reflector in the calibration verification has increased by more than 2 dB, the dB change shall be noted and all data since the last acceptable verification shall be corrected for the increase.

5.2.4.4. If the Time-of-Flight (metal path) of any reflector in the verification has changed by more than 10% of the initial reading, all data since the last acceptable verification shall be marked void. The equipment shall be re-calibrated and the voided areas re-examined.

5.3. Instrument Calibration

5.3.1. Instrument Linearity Checks - Instrument linearity verifications shall be performed as part of each initial and final calibration.

5.3.2. Amplitude Linearity Check - Obtain two signals from the reference block. Manipulate the search unit to set one signal to 80% FSH ±5%, and the other signal to 40% FSH ±5%. Without moving the search unit, adjust the gain to set the highest signal to approximately 100% FSH. Read the amplitude of the smaller signal. These amplitudes and the amplitudes at each succeeding step will be stored with the linearity file for each calibration. Reduce the gain in 2 dB steps until the larger signal is equal to or less than 20% FSH. Read the amplitudes of both signals, and verify the amplitude of the smaller signal is 50% of the larger signal ±5% FSH.

5.3.3. Amplitude Control Linearity Check - Obtain a signal from any convenient reflector. Set this signal as near as possible to 80% FSH. Using only the screen gain control, the dB changes indicated in Table 1 shall be made and the resultant amplitude compared with the allowable amplitude limits. Make the required changes adjusting the initial signal to 40% FSH, or as near as possible, and 20% FSH, or as near as possible. The system shall not be used if any signal exceeds the allowable limits.

5.3.4. Straight Beam Channel Time Delay Calibration - The straight beam time delay calibration shall be made using one of the following methods: (a) DSC style block; (b) IIW-2 block. Place the L-wave search unit on the block, obtain a peaked signal from the first reflector, and note the transit time. Set the time delay start position so the zero time position is at the scan surface. The adjustment is correct when the time to the first reflector is equal to one-half the time to the second reflector, ± 0.5 μsec. This must be performed once each calibration for each straight beam channel.

5.3.5. Angle Beam Channel Time Delay Calibration - The angle beam time delay calibration shall be made using one of the following methods: (a) DSC type block; (b) IIW-2 block. Place the shear wave search unit on the block, obtain a peaked signal from the first reflector, and note the transit time. Set the time delay start position so the zero time position is at the scan surface. The adjustment is correct when the time to the first reflector is equal to one-half the time to the second reflector, ± 1 μsec. This must be performed once each calibration for each angle beam channel.

5.3.6. Beam Angle Measurements

5.3.6.1. Beam angle measurements shall be made using the IIW-2 block. This need only be performed once for each search unit/wedge combination. The beam angle shall be measured whenever a change in either wedge or search units occur.

5.4. Material Velocity

5.4.1. The velocity for each mode of propagation must be entered. The nominal shear wave velocity is 0.128 in/μsec and the nominal longitudinal wave velocity is 0.230 in/μsec for SA-508, SA-533, or equivalent P3 material.

5.5. Dynamic Calibration

5.5.1. Position the search unit package to orient the required search units perpendicular to the appropriate calibration reflectors.

5.5.2. The calibration block shall be scanned using the GERIS 2000 calibration fixture. The calibration block should be oriented to allow the scanner access to the area of the block containing the calibration reflectors. A skirt may be required to allow a smooth transition over the edge of the block. The scan area must be large enough to allow all search units to examine the required reflectors. Each transducer orientation may require a separate scan.

5.6. Calibration For 0° Straight Beam, Base Metal Examination

5.6.1. The search unit for the base material examination should be set to trigger (as a minimum) in an area of the calibration block where no intermediate reflectors are present.

5.6.2. The A-gate start should be set at 0 μsec. The A-gate end shall be set to include all pertinent calibration reflectors.

5.6.3. The C-gate and Back-echo gate shall be set to include all pertinent calibration reflectors.

5.6.4. The threshold for the back echo gate should be set to 10%. Scan the area and record the data.

5.7. Calibration for 0° Straight Beam Weld Examination

5.7.1. The search unit for the weld metal exam should be set to trigger in the area of the calibration block required to view the 1/4T, 1/2T, and 3/4T offset side-drilled holes.

5.7.2. The A-gate start should be set at 0 μsec. The A-gate end shall be set to include all calibration reflectors.

5.7.3. Set the C-gate to include all calibration reflectors in the gate. Scan the area and record the data.

5.8. Calibration for the 45° and 60° Angle Beam Examination

5.8.1. With the search unit on the clad side of the applicable calibration block, determine the dB change in amplitude between the 3/4T to 5/4T positions. Record this dB change on the Calibration Data Sheet. This need only be performed once for each calibrated system/transducer/wedge combination.

5.8.2. The shear wave angle beam search units should be set to trigger in the area of the calibration block required to view the 1/4T, 1/2T, 3/4T side-drilled holes and the ID notch.

5.8.3. The A-gate start should be set at 0 μsec. The A-gate end shall be adjusted to include all calibration reflectors.

5.8.4. Set the C-gate to include all calibration reflectors in the gate. Scan the area and record the data.

5.8.5. Calibration for the examination from the OD blend radius shall be performed utilizing a standard 45° and 60° shear wave wedge, as per paragraphs 5.8.1, through 5.8.4. When calibration is completed, change to the radius wedge designed for the examination.

5.9. Calibration for Near Surface Examinations

5.9.1. Calibration utilizing the Basic Calibration Block

5.9.1.1. For calibration of the 70°beam, a 1 ½ inch deep minimum, 1/8 inch diameter maximum , side drilled hole, drilled parallel to the surface and located with the center at ¼ inch from the surface. At least 2 other additional 1/8 inch diameter maximum side drilled holes shall be installed at ½ inch maximum increments to establish metal path calibration.

5.9.1.2. The refracted longitudinal (RL) wave angle beam search units should be set to trigger in the area of the calibration block required to view the 1/4T side-drilled hole or 1" whichever is greater and the OD notch.

5.9.1.3. The A-gate start should be set at 0 μsec. The A-gate end shall be set to include all calibration reflectors.

5.9.1.4. Set the C-gate to include all calibration reflectors in the gate. Scan the area and record the data.

5.9.2. Calibration utilizing GE's Sizing Reference Block

5.9.2.1. Position the search unit on the Basic Calibration Block and obtain the maximum amplitude signal from the OD surface notch reflector.

5.9.2.2. Using the A-scan display record the Time-of-Flight (TOF) and amplitude of the calibration reflector.

5.9.2.3. Enter the TOF and amplitude information in the calibration DAC window.

5.9.2.4. Calibration is performed using a sizing reference block containing side-drilled-hole reflectors not to exceed 1/16" diameter. Repeat steps 5.9.2.2 and 5.9.2.3 for the reflectors required to include the examination range.

5.9.2.5. High angle RL transducers used for sizing require depth compensation due to varying effective beam angles at various depths.

a) Depth compensation may be performed by scanning a calibration block with multiple side drilled holes at known depths and recording the Time-of-Flight (TOF) at the maximized reflector positions.
b) Tables, graphs, or spreadsheets shall be constructed displaying TOF versus Depth.
c) The actual flaw depth shall be determined by interpolating the measured TOF into the recorded TOF vs. Depth position data. Extrapolation of depths greater than the maximum reflector depth is permitted but not recommended.

5.10. Beam Spread Determination

5.10.1. The beam spreads for each angle beam search unit will be determined by the GERIS 2000 as a part of the calibration. Beam spread shall be determined at the 50% and 20% DAC levels for each side-drilled-hole reflector. As a minimum, these checks shall be performed before the start of examination, every ninety days during the examination and after the examinations are completed. The beam spreads should be completed at the same time as the initial and final DAC calibrations. Manual beam spread determination for each search unit and calibration block may be used with the approval of the cognizant GE Subject Matter Expert (SME) who are listed within the document referenced in paragraph 2.6.

5.10.2. Beam spreads for the OD blend radius exams shall be determined per paragraph 5.10.1 utilizing standard 45° and 60° shear wave wedges.

5.10.3. Beam spread determination is not required when using search units listed in paragraph 4.7.5.

6. EXAMINATION

6.1. Prior to start of examination previous data shall be reviewed.

6.2. Pre-Examination Checks

6.2.1. Prior to examination, the welds shall be marked and identified in accordance with the applicable weld identification and marking plan.

6.2.2. All weld identification and other marking shall be the responsibility of the Owner.

6.2.3. The contact surface from which the examination is conducted must be clean and free of any weld spatter or other conditions which would interfere with free movement of the transducer or impair coupling to the material being examined. Unacceptable surface conditions shall be reported to the Owner.

6.2.4. Start the couplant flow and observe all ultrasonic channels separately to determine the ultrasonic operation. On the shear wave channels, look for clad metal response at the vessel ID. The back-echo signal from the L-wave transducers should also be observed.

6.2.5. All channels should be monitored to assure proper search unit contact and coupling. This monitoring is not required to be continuous for effective examination, as the entire RF waveform is being recorded for analysis.

6.2.6. Select a vehicle step size such that the increments between scans does not exceed 0.25" along the length of the flaw per paragraph 7.1.2. The maximum scanning speed selected shall not exceed 3" per second. The data acquisition rate for scanning shall be the same or less than the data acquisition rate for calibration.

6.2.7. The vessel shall be referenced to vessel "X" and "Y". Vessel position data may be in either inches or millimeters. Position data in "X" increases in the clockwise direction when viewing the vessel from above. Position data in "Y" elevation increases going up from vessel zero elevation.

6.3. Gate Settings

6.3.1. See Table 2 for A, B, C, Gate start and end setting requirements.

6.3.2. The A-gate should be set to start at 0 μsec. The A-gate end shall be set at a minimum 1.5T + nominal wedge delay for the 0°, 45°, and 60° search units and at 1/4T for the near surface calibration of paragraph 5.9. The A-gate end value should include the nominal value for the wedge delay for each transducer type.

6.3.3. The B-gate should be set to start at the wedge delay and stop at the end of the A-gate.

6.3.4. The C-gate start should be set to exclude surface noise for the 0°, 45° and 60° search units. The C-gate stop for the 45° and 60° search units shall be set to include a minimum of one-third of the clad roll. The C-gate stop for the 0° examination channels shall end at 0.9 T. The C-gate start shall be at the exam surface and the C-gate end shall be set at the end of the A-gate.

6.3.5. For the 0° base-metal channels, the Back-echo gate should be set to start at 0.75 T and end at 1.3 T.

6.3.6. The Analysis gate should be set the same as the C-gate in paragraph 6.3.4.

6.4. Examination Areas

6.4.1. Where RPV configuration permits, scan each weld for detection of defects that are parallel to the weld seam. Complete coverage of the weld requires scanning from both sides of the seam, in opposite directions and must include the weld and a minimum of 1/2T of base material on either side of the weld.

6.4.2. Where RPV configuration permits, scan each weld for detection of defects that are transverse to the weld seam. Complete coverage of the weld requires scanning on both sides of the seam, in opposite directions and must include the weld and a minimum of 1/2T of base material on either side of the weld.

6.4.3. When a near surface examination of the weld is required using the search units listed in paragraph 4.7.5 and where RPV configuration permits, scan each weld for detection of defects that are parallel to the weld seam. Complete coverage of the weld requires scanning from both sides of the seam, in opposite directions and must include the weld and a minimum of 1/2T of base material OD surface on either side of the weld.

6.4.4. When a near surface examination of the weld is required using the search units listed in paragraph 4.7.5 and where RPV configuration permits, scan each weld for detection of defects that are transverse to the weld seam. Complete coverage of the weld requires scanning on both sides of the seam, in opposite directions and must include the weld and a minimum of 1/2T of base material OD surface on either side of the weld.

6.4.5. If a base metal examination is required and where RPV configuration permits, the volume of base material, through which angle beams must travel shall be scanned. This exam is to detect laminar reflectors that could interfere with the examinations listed in 6.4.1, 6.4.2, 6.4.3 and 6.4.4.

6.4.6. For barrel type nozzles only, supplement coverage by examination from the OD blend radius. Scan each weld for detection of defects that are parallel to the weld seam. The scanning from the OD blend radius shall extend as far up the radius as mechanically possible.

6.5. Examination Limitations

6.5.1. Limited scans due to RPV configuration shall be documented on the Examination Data Sheet. Sketches showing the extent and nature of the interference shall be included with or on the Examination Data Sheet.

6.6. Data Integrity

6.6.1. Upon completion of the collection of the data, the Operator shall verify the integrity of the RF/AD data files by using the GERIS 2000 analysis utilities. If the integrity of the files can not be verified through use of the GERIS 2000 utilities, the examination area shall be re-scanned.

7. RECORDING

7.1. Straight and Angle Beam Examination Data

7.1.1. The entire RF waveform, which is contained within the A-gate, shall be recorded.

7.1.2. Indications will be recorded at scan intervals not greater than 1/4 inch to determine the 20% DAC end points and the through-wall dimension.

7.1.3. Record all inside surface reflectors that equal or exceed the amplitude of the ID notch established in Paragraph 5.8.2.

7.1.4. Record all near surface reflectors that are equal or exceed the amplitude of that which was established with the 1/4T hole calibration of paragraph 5.9.1.

7.1.5. Laminar reflectors are to be recorded to determine possible interference with angle beam examinations.

7.1.6. Laminar reflectors recorded for acceptance will be recorded when total loss of back reflection is accompanied by a continuous indication in the same plane parallel with the scanning surface, ±10%.

8. EVALUATION

8.1. For initial comparison with ASME Section XI, IWB-3500 acceptance standards, flaw indications shall be evaluated as shown below. Indications that are determined not to be flaws and flaw indications that meet these acceptance standards, using the criteria below, require no further evaluation. Indications that exceed these acceptance standards may be evaluated using alternate sizing methods as allowed by ASME Section V, Paragraphs T-451 and T-453. Reference paragraph 2.7 is one such method.

8.2. All flaw indications shall be reported to Site Engineering for disposition in accordance with paragraph 2.10.

8.3. Examinations which identify degraded conditions outside the recording requirements of this procedure shall be reported to the Owner in accordance with the requirements of paragraph 2.11.

8.4. Data requiring evaluation shall be reviewed and evaluated in accordance with reference 2.1, 2.3, and 2.7 when applicable. Data shall be evaluated by a Level II or Level III other than the one performing the examination. Data shall be evaluated in accordance with the requirements of the Contract.

8.5. The reported area of laminar indications is defined as 0.75 times the area of the square or rectangle that contains the detected area of the continuous loss of back reflection accompanied by continuous indications in the same plane.

8.6. Indication through-wall dimensions for reflectors exceeding 100% of DAC shall be determined using the limits recorded at the 1/2 of maximum amplitude positions.

8.7. Indication through-wall dimensions for reflectors exceeding 50% through 100% of DAC shall be determined using the limits recorded at the 50% of DAC positions.

8.8. Indication through wall dimensions for reflectors within the inner 1/4T examination volume exceeding 20% of DAC shall be determined using the limits recorded at the 20% of DAC positions corrected for beam spread. The 20% beam spread corrected dimensions shall be compared with the 50% DAC dimensions and the largest of the two flaw sizes used to determine acceptance.

8.9. Surface indications that are equal in amplitude to the calibration notch may be considered indicative of reflectors of equivalent depth.

8.10. The indication lengths shall be determined using the 50% DAC end points, or 20% DAC end points if the indication is less than 50% DAC.

8.11. Recordable indications caused by flaws will be reported to the Owner after evaluation by a Level III.

8.12. Evaluations of indications that are determined to be caused by geometric and metallurgical conditions shall include documentation of the basis for the determination. The following steps shall be taken, as a minimum, to classify an indication as geometric:

8.12.1. Interpret the area containing the reflector in accordance with the applicable examination procedure(s).

8.12.2. Plot and verify the reflector coordinates. Prepare a plot showing the reflector position and any surface discontinuities such as weld root, etc.

8.12.3. Review fabrication and/or weld preparation drawings.

8.12.4. Alternatively, other NDE methods or techniques may be used to classify an indication as geometric. These include, but are not limited to, alternate UT beam angles, radiography, and ID or OD profiling.

8.13. Evaluations of indications that are determined to be caused by flaws shall include the necessary calculations and comparisons with the ASME Section XI Acceptance Standards for the weld being evaluated as modified by USNRC Regulatory Guide 1.150, Rev. 1, February 1983.

8.14. Final disposition of indications is the responsibility of the Owner.

9. REPORTING

9.1. Examination reports and records are generated by the computer system after post processing and editing of the data. These examination records and reports will be turned over to the Owner after all necessary editing and post processing. Turnover shall be made in accordance with Contract requirements. A preliminary copy of all examination records shall be submitted to the customer prior to the original data leaving site.

9.2. Upon completion of the examination activities a final report containing as a minimum the examination data records, calibration records as applicable, disposition, personnel certifications, and material and equipment documentation applicable to the examinations shall be submitted to TVA site engineering for approval and record retention in accordance with the requirements of paragraph 2.10. The final report shall be signed by at least a Level II examiner.

9.3. The examination report(s) shall include specific instrument/ calibration information and examination information. The minimum Examination Report information is listed below. The use of Calibration Data Sheets or Examination Data Sheets may facilitate the Examination Report process, but need not be used provided the information listed below is documented.

9.3.1. The system calibration information shall include, as a minimum, the following:

9.3.1.1. Calibration sheet identification, date and time of calibration
9.3.1.2. Name(s) and NDE Level(s) of examination personnel
9.3.1.3. Examination procedure number and revision
9.3.1.4. Basic calibration block identification
9.3.1.5. Ultrasonic instrument identification and serial number
9.3.1.6. Beam angle in the material
9.3.1.7. Couplant
9.3.1.8. Search unit identification: serial number, frequency and size
9.3.1.9. Reviewer's signature, NDE Level and date
9.3.1.10. Search unit cable type and length
9.3.1.11. Times of initial calibration and subsequent and final calibration checks
9.3.1.12. Calibration reflector(s) and the instrument setting amplitudes, and sweep positions used to establish primary reference sensitivity
9.3.1.13. Thermometer serial number and calibration block temperature

9.3.2. Examinations shall be recorded and shall include as a minimum the following:

9.3.2.1. Data sheet identification, date and time of examinations
9.3.2.2. Name(s) and NDE Level(s) of examination personnel
9.3.2.3. Examination procedure and revision
9.3.2.4. Applicable calibration sheet identification
9.3.2.5. Weld identification
9.3.2.6. Computer Optical disk, File numbers and No. of inches scanned.
9.3.2.7. Scan identification, and scan limitations, if any
9.3.2.8. Examination surface temperature and thermometer serial number
9.3.2.9. Couplant and lot/batch number if applicable
9.3.2.10. Special equipment used, if any.
9.3.2.11. Beam spread measurements, as described in paragraph 5.10, shall be included in the calibration records as necessary.

9.4. Additional Supporting Data:

9.4.1. The search unit RF waveform and frequency amplitude information records described in reference 2.5.

9.4.2. The portion of the examination volume that has not been effectively examined shall be calculated. This calculation may be documented on the Examination Data Sheet or as an attachment and shall consider:

9.4.2.1. Near surface resolution
9.4.2.2. Interfaces between cladding and parent material
9.4.2.3. Volumes shadowed by laminar material defects
9.4.2.4. Volumes shadowed by part geometry
9.4.2.5. Volumes inaccessible to the transducer
9.4.2.6. Indication resolution sheets and plots showing the location of recorded indications shall be included with the examination records as necessary.

Table 1 - Signal Amplitude Gain Control Limits

Signal Amplitude (% FSH)	Gain Change	Limits (% FSH)
80	- 6 dB	32-48
80	-12 dB	16-24
40	+ 6 dB	64-96
20	+ 12 dB	64-96

Table 2 - Gate Settings in Depth (D)

ANGLE	A-GATE START	A-GATE END	B-GATE START	B-GATE END	C-GATE START	C-GATE END
0° Weld Metal	0 μsec	1.25 Tmax	Entry surface	1.25 Tmax	0.25 T	Tmin + 0.5"
0° Base Metal	0 μsec	1.25 Tmax	Entry surface	1.25 Tmax	0.25 T	Tmin + 0.5"
70° Long.	0 μsec	0.25 T max or 1" whichever is greater	Entry surface	0.25 T max or 1" whichever is greater	Entry surface	0.25 T max or 1" whichever is greater
45° Shear	0 μsec	1.5 Tmax	Entry surface	1.5 Tmax	1.0"	1.25 Tmax
60° Long.	0 μsec	1.5 Tmax	Entry surface	1.5 Tmax	1.0"	1.25 Tmax

Figure 1 - GERIS 2000 Ultrasonic Cabling

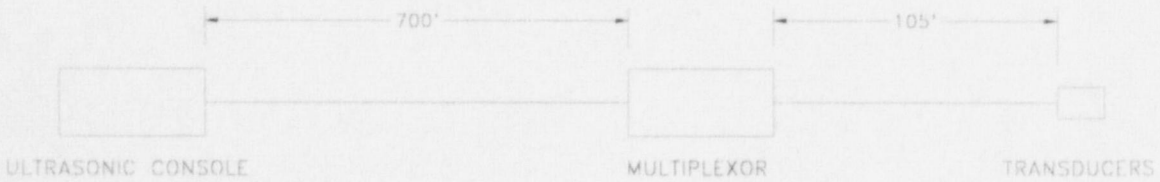

Figure 2 - GERIS 2000 System Block Diagram