



PRODUCT STANDARD

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Prod. Std. No. GT10184

REV. No. 01

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ULTRASONIC TESTING OF LOW ALLOY GAS TURBINE FORGINGSSCOPE

- 1.1 This specification describes the requirements for the ultrasonic testing of forged low alloy steel rotating gas turbine components and the associated acceptance standards.

1.2 Communication1.2.1 External Supplier

All communications, including questions or requests for additional information shall be submitted to GT Engineering

1.2.2 Internal Supplier

All communications, including questions or requests for additional information shall be submitted to GT Engineering

1.3 Request for Deviations

Requests for deviations to the requirements of this specification shall be submitted as follows:

- 1.3.1 External Supplier - Non conformance report (NCR)

- 1.3.2 Internal Supplier - Non conformance report (NCR)

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Ref. Doc.

PBC-AQ42
Rev. J

Revisions :

Refer to record of revisions

Prepared :

GSSR

Approved :

GSSR

Date :

19.9.98



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2. APPLICABLE DOCUMENTS

2.1 The following document shall form an integral part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue shall apply:

2.1.1

- | | |
|--------------|--|
| P28A-AL-0203 | Nondestructive Testing Supplier Qualification and Approval |
| P28A-AL-0204 | Nondestructive Testing Internal Supplier Qualification and Approval |
| P28A-AL-2100 | Calibration of Longitudinal Wave Contact Ultrasonic Test Transducers |

2.1.2 American Society for Nondestructive Testing

- | | |
|-----------|---|
| SNT-TC-1A | Personnel Qualification and Certification in Nondestructive Testing |
|-----------|---|

2.1.3 American Society for Testing and Materials

- | | |
|---------|---|
| E317-93 | Standard Practice for Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Systems Without the Use of Electronic Measurement Instruments |
| E428-92 | Standard Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Inspection |

3. DEFINITIONS

3.1 Personnel

3.1.1 Purchaser - BHEL

3.1.2 External Supplier - The corporation, company, partnership, sole proprietorship or individual engaged to perform the process covered by this Specification.

3.1.3 Internal Supplier - Any BHEL Manufacturing Department

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3.1.4 Supplier - As used herein, unless specifically designated, refers to both External and Internal Suppliers.

3.2 Specification Deviation Documents

3.2.1 Applicable to External Supplier

3.2.1.1 NCR (Non conformance report)

3.2.2 Applicable to Internal Supplier

3.2.2.1 NCR (Non conformance report)

3.3 Technical Terms

3.3.1 Acoustic Noise Level - Amplitude of peak noise associated with the material grain structure.

3.3.2 Closely Associated Indications - Two or more indications with peak amplitude positions located equal to or less than 1 inch (25.4 mm) apart after accounting for the positional data in the three orthogonal directions.

3.3.3 Equivalent Flat Bottom Hole (EFBH) - The diameter of a flat bottom hole that would reflect sufficient ultrasonic energy to produce the same signal amplitude as the indication being evaluated.

3.3.4 Flat Bottom Hole (FBH) - A cylindrical hole having a flat bottom that is perpendicular to the axis of the hole. The disc shaped hole bottom is typically used as a reference reflector.

3.3.5 Full Screen Height (FSH) - The maximum value of the vertical scale on the display screen of the ultrasonic test instrument representing 100% of the height of the scale.



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- 3.3.6 Holding Indication - An indication whose length, as measured by the distance a transducer is moved along the indication's longest dimension until its amplitude rises and falls to one-half its maximum amplitude, exceeds the appropriate line in Figure 1. These lines represent an indication length of approximately one inch after correction for sonic beam spread. This definition is only applicable to longitudinal wave axial tests and only for the axial direction in longitudinal wave radial tests. For longitudinal wave radial tests in the circumferential direction, a holding indication shall be defined as any indication that does not exhibit a normal decay pattern.
- 3.3.7 Indication - Any ultrasonic reflection that can be clearly differentiated from noise based on amplitude or echo dynamic pattern and is not caused by the shape of the test piece.
- 3.3.8 Indication Amplitude - The height of an indication from sweep line to peak usually expressed as a percentage of full screen height (FSH).
- 3.3.9 Indication Level - A condition where indications are too numerous to report individually.
- 3.3.10 Initial Pulse Length - The depth of metal obscured by the initial pulse during the ultrasonic test. With the instrument calibrated for test distance and sensitivity, the initial pulse length is the depth where the amplitude of the trailing edge of the initial pulse decreases to 5 percent of full screen height (FSH) or to the amplitude of the acoustic noise level of the material, whichever is higher.
- 3.3.11 Loss of Back Reflection - Any localized reduction of the bore or back reflection amplitude not attributed to coupling or variation in part geometry.
- 3.3.12 "0" Location - A "0" location will be used as the circumferential reference point for all nondestructive and mechanical tests. Measurement or indexing from the "0" location must be in the clockwise direction on the "radial circumferential" aft surface of the forging. The "0" location must be established at the time of manufacture when the forging is first tested nondestructively or when the first test material is removed. The "0" location must be maintained during manufacture and remain legible and available on the as-shipped forging.
- 3.3.13 Oriented Indication - Any indication whose position of maximum reflecting amplitude does not coincide with the position of minimum distance to the transducer.



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3.3.14 Scattered Indications - Indications which are located greater than 1 inch (25.4 mm) apart after accounting for the positional data in the three orthogonal directions.

3.3.15 Whipping - A sudden increase or decrease of the amplitude of the bore reflection which is followed by a reversal (decrease or increase) of the same bore reflection.

3.3.16 Reference Surface or End - The axial reference shall be the AFT surface or end of the forging. The GE drafting standard practice for rotating forgings is to assign the AFT surface or end of the forging to the right-hand side of the forging drawing.

3.3.17 Scan Plan - A summary of the individual scans to be performed on all forgings produced to a given GE forging drawing.

4. ENGINEERING REQUIREMENTS

4.1 Supplier Qualification - External Suppliers shall be qualified in accordance with P28A-AL-0203 and Internal Suppliers shall be qualified in accordance with P28A-AL-0204.

4.2 The ultrasonic examination requirements and instructions for each gas turbine rotor forging are detailed in either this specification or the applicable part process specification. These documents shall be used to prepare the ultrasonic examination scan plan that is required for each gas turbine rotor forging drawing.

4.3 The Supplier shall prepare and submit a test procedure for information to Materials and Processes Engineering - Nondestructive Test Engineering (MPE-NDTE). As a minimum the procedure shall include calibration procedures, examination methods, equipment used and a scan plan for each type of part tested. The procedure shall also completely describe the test and quality system used.

4.4 Inspector Certification

The tests shall be performed by personnel qualified and certified through an established program that incorporates all the recommended guidelines for qualification and certification of ultrasonic testing personnel provided in ASNT document SNT-TC-1A.



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4.5 Testing Coverage

4.5.1 Longitudinal wave tests shall be performed in the axial and radial direction from all accessible surfaces except from the bore surface. Tests from selected surfaces for forgings with unusual configurations may be waived if the respective forging scan plan has been submitted and approved by MPE-SME. Shear wave tests shall, when required, be performed from the outside diameter surfaces.

4.5.2 A scan plan shall be submitted for approval by MPE-SME that includes a sketch of the forging as examined and details for each scan. Specific data shall include the transducer size and frequency, evaluation sensitivity and the test distance covered.

4.6 Time Of Test

Ultrasonic inspection of forgings shall be performed after final heat treatment and in the forging configuration agreed upon between GE and the Supplier.

TEST REQUIREMENTS

5.1 General

5.1.1 Test Instrument

5.1.1.1 Pulse Repetition Frequency

The ultrasonic test instrument shall have a range of selectable pulse repetition frequencies. The minimum pulse repetition frequency (PRF) shall have a value of 31 Hz or less. If the minimum frequency of the existing test instrument is greater than this value, the instrument must be modified to lower the minimum PRF to this value.

5.1.1.2 Basic Instrument Qualification

Basic qualification of the ultrasonic test instrument shall be performed at intervals not to exceed twelve months or whenever maintenance is performed which effects the equipment function. The date of the last calibration and the date of the next required calibration shall be displayed on the ultrasonic test instrument.

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5.1.1.3 Calibration Verification

5.1.1.3.1 Calibration Block - A calibration or test block is needed to perform the following checks of the test instrument. This block shall give several non interfering multiple back reflections for the sweep range and other test conditions of interest. Any block having good ultrasonic transmittivity, flat parallel faces, and a thickness of about one tenth of the required sweep range should be adequate.

5.1.1.3.2 Vertical Linearity - An amplifier vertical linearity check of the test instrument shall be made prior to inspecting GE gas turbine forgings and then weekly during continuous periods in which these forgings are inspected. This linearity check shall be made by observing a multiple order pattern from a calibration block using a 2.0 or 2.25 MHz 1/2 inch (12.7 mm) diameter transducer. The first back reflection shall be set at 100 percent full screen height (FSH). The higher order back reflections 10 percent and higher in amplitude shall also be positioned on the screen and their amplitudes noted. The first back reflection shall be reduced to 50 percent and then 25 percent of FSH. The amplitudes of the higher order back reflections shall be noted at each step. The vertical linearity will be considered acceptable if the signal heights of the higher order reflections decrease in proportion to the decrease set for the first back reflection. The maximum acceptable error for the decrease of the higher order reflections is the greater of ± 5 percent of the expected back reflection height or ± 2 percent of FSH.

5.1.1.3.3 Gain Control Linearity - A gain control linearity check of the test instrument shall be made prior to inspecting GE gas turbine forgings and then weekly during continuous periods in which these forgings are inspected. Using the test set-up with the external step attenuator described in Section 5.6 of ASTM E317, set the back reflection from the calibration block at 100 percent FSH. Note the instrument gain control and external attenuator settings. Add 20 dB of external attenuation to decrease the back reflection by a factor of 10. Use the instrument gain control to increase the back reflection by factors of 2 (6 dB), 5 (14 dB), and 10 (20 dB). Note the signal amplitude in each case. Reset the instrument gain control to the initial recorded value. Increase the external attenuation by an additional 20 dB to reduce the original 100 percent back wall signal by a factor of 100.



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Use the instrument gain control to increase the back reflection by factors of 10 (20 dB), 20 (26 dB), 50 (34 dB) and 100 (40 dB). Note the signal amplitude in each case. Reset the gain control and the attenuator settings to the initial values so that the amplitude of the back reflection signal returns to 100 percent FSH. Use the instrument gain control to reduce the back reflection by factors of 2 (6 dB), 5 (14 dB), 10 (20 dB) and 20 (26 dB). Note the signal amplitude in each case.

The gain control linearity will be considered acceptable if the amplitude of the back reflection increases in proportion to the increase in gain control setting and decreases in proportion to the decrease in gain control setting. The maximum acceptable error for the back reflection amplitude during the linearity check is ± 5 percent of FSH.

5.1.1.3.4 Horizontal Linearity - The horizontal linearity of the test instrument shall be checked prior to inspecting GE gas turbine forgings and then weekly during continuous periods in which these forgings are inspected. The linearity shall be checked on a distance calibration bar using the multiple order technique with a 2.0 or 2.25 MHz 1/2 inch (12.7 mm) transducer. The linearity shall be such that the possible error involved in measuring over a distance equal to the maximum metal travel distance encountered in the forging shall not exceed ± 1 percent of the full screen width.

5.1.1.3.4.1 If the part has a thin section with parallel sides, the accuracy of the linearity shall be checked by ultrasonically verifying that thickness. If necessary, minor adjustments for differences between the calibration bar and the part shall then be made.

5.1.1.3.5 The results of the calibration checks shall be recorded and stored by the Supplier. Records covering a period of at least one year must be retained and shall be available for review by GE.

5.1.2 Transducers

5.1.2.1 Frequency - The transducers used shall have a rated frequency of 2.0 or 2.25 MHz. The measured frequency must be within ± 10 percent of the rated frequency.



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5.1.2.2 Size

5.1.2.2.1 Longitudinal Wave Tests - Tests are performed using either 1/2 inch (or 10 mm) diameter, 1 inch (or 24 mm) diameter, or 1/4 inch x 1 inch transducers depending upon the thickness and geometry of the part being tested. Transducer size requirements are specified in Para. 5.2.

5.1.2.2.2 Shear Wave Tests - All shear wave tests are performed using a 1/2 inch diameter (or 8 mm x 9 mm) transducer.

5.1.2.3 Protective Covering - Use of a protective covering over the transducer contact surface, such as nylon or electrical tape, is permitted. If such a protective covering will be used during testing, the reference signal, evaluation sensitivity and scanning sensitivity, as defined in Para. 5.2, must be established using the same protective covering. However, evaluation of indications shall be performed without any protective covering on the transducer. Consequently, to evaluate an indication the reference signal and evaluation sensitivity must be re-established without using the protective covering.

5.1.2.4 Basic Transducer Qualification - Basic qualification of the ultrasonic transducers shall be performed upon receipt of newly purchased transducers and then at intervals not exceeding 1 year. The qualification shall be performed in accordance with Process Specification P28A-AL-2100. Only measurement of transducer frequency, initial pulse length, sensitivity, and damping is required. A spectral analysis of the transducer may be used to evaluate the transducer frequency characteristics instead of the method described in P28A-AL-2100. The results of the transducer qualification shall be recorded and stored by the Supplier. The qualification results for the current year must be retained and shall be available for review by GE.

5.1.3 Test Surface - Test surfaces shall be clean and free from burrs, machining tears, dirt, grease, paint or other foreign matter that will interfere with performance of the test. A surface finish roughness not exceeding 250 micro inches AA (0.0064 mm) is required.



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- 5.1.4 Couplant - The viscosity of the couplant should not exceed the viscosity of SAE "20" oil in normal applications. SAE "30" oil is permissible if climatic conditions are a factor in examining or under certain examination conditions. Other couplants may be allowed after obtaining MPE-SME approval.
- 5.1.5 Type of Inspection - Either automated or manual inspections are permitted. The use of automated inspections require prior qualification and approval by MPE-NDTE.
- 5.1.6 Scan Speed - The scanning speed for all manual longitudinal and shear wave inspections shall not exceed 3 inches (76 mm) per second. Scanning speeds used with automated inspection systems shall be approved by MPE-NDTE.
- 5.1.7 Scan Index - The transducer shall not be moved/indexed a distance greater than 75 percent of the width of the transducer for each successive scanning pass.
- 5.1.8 Distance Calibration Markers - For test instruments using distance calibration markers (electronically generated), the markers shall only be positioned on the screen when measuring distance and shall be off when recording amplitudes of signals during testing.
- 5.1.9 Sensitivity Calibration Check - Sensitivity calibration of the test system is performed at the beginning of the test on each test surface by establishing the required scanning sensitivity based on the reference signal from the backwall or bore for longitudinal wave tests and from calibration notches shear wave tests as discussed in Para. 5.2. The test system includes the test instrument (pulser, receiver, amplifier, gate circuitry) transducer, and transducer cable. The sensitivity calibration shall be checked whenever a component of the test system is changed and at the end of the test from each test surface. The reference signal shall be used to check the sensitivity calibration. To perform the calibration check, reduce the instrument gain to the original gain setting used to establish the 100 percent FSH reference signal. If the amplitude of the reference signal is 85 percent FSH or lower when checked, adjust the gain setting to produce a 100 percent FSH reference signal and repeat the test of that surface at the proper scanning sensitivity. If the amplitude of the reference signal is 115 percent FSH or higher when checked, it is not necessary to repeat the inspection. However, if an indication was found during the test, it must be evaluated at the correct evaluation sensitivity.

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5.1.10 Unattenuated Sound Check - If after establishing the scanning sensitivity in accordance with Paras. 5.2.1 or 5.2.2 the presentation on the instrument display contains a high noise level or numerous apparent indications, the forging shall be checked for the presence of unattenuated sound before scanning commences. The preferred method of checking for unattenuated sound is to adjust the delay control of the ultrasonic test instrument to move the initial pulse as far to the right on the display screen as possible. Any signals appearing on the screen before the initial pulse indicate unattenuated sound is present in the material. If this condition exists, the test shall be performed after the pulse repetition frequency (PRF) has been reduced to the value that eliminates these signals. If the signals cannot be completely eliminated even at the lowest PRF, use the lowest PRF to achieve the maximum reduction in the amplitude of these signals. Report the presence of unattenuated sound in the comments column of the test report form in Figure 7 for the particular test surface involved.

5.2 Method of Test

5.2.1 Longitudinal Wave Radial Test

5.2.1.1 Transducer - Tests shall be performed from the peripheral surfaces using a transducer having a single rectangular element with the dimensions 1/4 inch x 1 inch. The frequency of the transducer shall be 2.0 or 2.25 MHz. The test shall be performed with the major axis of the transducer oriented parallel to the forging axis.

5.2.1.1.1 On forgings where the examined thickness is less than 6 inch (152 mm), a 1/2 inch (or 10 mm) diameter, 2.0 or 2.25 MHz transducer shall be used.

5.2.1.1.2 On bored forgings with a ratio of ID/OD less than 0.1 and solid forging diameters larger than 30 inches (762 mm), a 1 inch (or 24 mm) diameter transducer may be used.

5.2.1.2 Reference Signal - The reference signal shall be the signal reflected from the diametrically opposed surface for solid (unbored) forgings and from the bore surface of bored forgings. The signal amplitude shall be set to 100% FSH while scanning in a indication-free area.

5.2.1.3 Evaluation Sensitivity - The required evaluation sensitivity shall be obtained by increasing the 100 percent FSH reference signal by the appropriate multiplication factor calculated below. The multiplication factor when converted to a dB value is defined as the evaluation sensitivity. Add this value to the instrument gain setting that produces the 100 percent FSH reference signal.



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5.2.1.3.1 Bored Forgings

$$M = (0.92) \cdot \frac{(D_o - D_b)}{f} \cdot \sqrt{\frac{D_b}{D_o}}$$

Where,

M = reference multiplication factor

D_o = forging outside diameter (inches)D_b = bore diameter (inches)

f = frequency (MHz)

- 5.2.1.3.1.1 At the corresponding evaluation sensitivity the reflection from a 1/16 inch (1.6 mm) diameter FBH located at the bore surface will produce a signal having an amplitude of 5 percent FSH.

5.2.1.3.2 Solid Forgings (No Bore)

$$M = (0.46) \frac{D_o}{f}$$

- 5.2.1.3.2.1 At the corresponding evaluation sensitivity the reflection from a 1/16 inch (1.6 mm) diameter FBH located at the center will produce a signal having an amplitude of 5 percent FSH.

- 5.2.1.4 Scanning Sensitivity - For scanning, the multiplication factor shall never be less than one and the instrument gain shall be increased by 6 dB for ultrasonic instruments with linear screen presentations. The value in dB obtained by adding 6 dB to the evaluation sensitivity is defined as the scanning sensitivity.
- 5.2.1.5 The location of all indications, regardless of their amplitudes, shall be marked on the forging for subsequent evaluation during scanning.
- 5.2.1.6 All indications detected at 6 inches (152 mm) or less from the test surface with a 1 inch (or 24 mm) diameter or a 1/4 inch x 1 inch transducer shall be verified with a 1/2 inch (or 10 mm) diameter 2.0 or 2.25 MHz transducer using the same multiplication factor.



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- 5.2.1.7 Tapered Sections - For forgings with tapered sections (non-parallel walls), the reference reflection shall be obtained from a flat and parallel wall thickness on the forging closest to the maximum dimension of the tapered section or obtained on a calibrated block as described in Para. 5.2.2.8.1. The sensitivity obtained from the closest dimension shall be adjusted as specified in Para. 5.2.2.3.
- 5.2.1.8 Contoured Wheels - For contoured compressor wheel forgings, the radial testing of the dovetail section shall be only performed from the outermost diameter over its entire axial length using a 1/2 inch (or 10 mm) diameter, 2.0 or 2.25 MHz transducer. The evaluation sensitivity and length of the sweep for this test shall be the same as that used to perform the axial test on the bolt hole section of the wheel.
- 5.2.1.9 Thin Sections - For components having thin axial thicknesses and for which a radial inspection of this section is required, perform the inspection as follows:

5.2.1.9.1 Radial Sections > 6 Inches

- 5.2.1.9.1.1 If a 1/4 inch x 1 inch transducer is being used and the ratio $L/W \geq 6.2$,

or,

if a 1 inch (or 24 mm) diameter transducer is being used and the ratio $L/W \geq 5.3$,

where,

L = total radial thickness of the section, $\left(\frac{D_o - D_b}{2} \right)$, for bored

forgings or D_o for solid forgings;

W = minimum axial thickness in the section;



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the reference reflection shall be obtained from a flat and parallel wall thickness on the forging that is closest in value to the radial test distance. Then use Para. 5.2.2.3.1 to determine the multiplication factor for the inspection. For calculating the multiplication factor, T will be the thickness on which the reference reflection is established and t will be $\left(\frac{D_o - D_b}{2}\right)$ for

bored forgings and $\frac{D_o}{2}$ for solid forgings.

5.2.1.9.1.2 If the ratio $L/W < 6.2$ for a 1/4 inch x 1 inch transducer,

or,

if the ratio $L/W < 5.3$ for a 1 inch (or 24 mm) diameter transducer,

perform the inspection in accordance with the standard radial longitudinal wave inspection requirements.

5.2.1.9.2 Radial Sections ≤ 6 Inches

5.2.1.9.2.1 If the ratio $L/W \geq 2.6$,

where,

L = total radial thickness of the section, $\left(\frac{D_o - D_b}{2}\right)$, for bored

forgings or D_o for solid forgings;

W = minimum axial thickness in the section;



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the reference reflection shall be obtained from a flat and parallel wall thickness on the forging closest in value to the radial test distance. Then use Paragraph 5.2.2.3.1 to determine the multiplication factor for the inspection. For calculating the multiplication factor, T will be the thickness on which the reference reflection is established and t will be

$$\left(\frac{D_o - D_o}{2} \right) \text{ for bored forgings and } \frac{D_o}{2} \text{ for solid forgings.}$$

5.2.1.9.2.2 If the ratio $L/W < 2.6$,

perform the inspection in accordance with the standard radial longitudinal wave inspection requirements.

5.2.2 Longitudinal Wave Axial Test

5.2.2.1 Transducer - A 1/2 inch (or 10 mm) diameter, 2.0 or 2.25 MHz transducer shall be used for the axial testing from all accessible surfaces whose thickness is 15 inches (381 mm) or less.

5.2.2.1.1 A 1 inch (or 24 mm) diameter, 2.0 or 2.25 MHz transducer shall be used for thicknesses greater than 15 inches (381 mm).

5.2.2.2 Reference Signal - The reference signal shall be the signal reflected from the opposite surface of the section being examined. The signal amplitude shall be set to 100% FSH while scanning in an indication-free area.

5.2.2.3 Evaluation Sensitivity - The required evaluation sensitivity shall be obtained by increasing the 100 percent FSH reference signal by multiplication factors calculated below. The multiplication factor converted to a dB value is the evaluation sensitivity. Add this value to the instrument gain setting that produces the 100 percent FSH reference signal.

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5.2.2.3.1 Parallel Sides

$$M = (1.83) \frac{T}{f} \left(\frac{t}{T} \right)^2$$

Where,

M = reference multiplication factor

T = thickness on which sensitivity is established (inches)

t = thickness to be tested (inches)

f = frequency (MHz)

5.2.2.3.1.1 At the corresponding evaluation sensitivity the reflection from a 1/16 inch (1.6 mm) diameter FBH located at the backwall of the forging will produce a signal having an amplitude of 5 percent FSH.

5.2.2.3.1.2 Axial sections greater than 30 inches (762 mm) shall be tested using the adjusted sensitivity specified in Para. 5.2.2.3 that is established on any smaller axial thickness, T, of the forging and where t is one half the total length of the axial section to be tested. However, the sweep length of the test instrument shall be adjusted to monitor the total length of the axial section.

5.2.2.4 Scanning Sensitivity - For scanning, the multiplication factor shall never be less than one and the instrument gain shall be increased 6 dB for ultrasonic instruments with linear screen presentations. The value in dB obtained by adding 6 dB to the evaluation sensitivity is defined as the scanning sensitivity.

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5.2.2.5 In sections of thickness less than 1.25 inches (31.75 mm) use a 1/2 inch (or 10 mm) diameter, 2.0 or 2.25 MHz transducer. Adjust the sweep length to display the first two backwall signals. Use the first backwall signal as the reference signal. Set the sensitivity as described in Paras. 5.2.2.2 through 5.2.2.4. During scanning, observe the sweep between the initial pulse, the first backwall signal and second backwall signal. For an indication appearing only between the first and second backwall signals, use the distance from the first backwall signal to the indication plus the section thickness as the distance to the indication for evaluation of indication size. The actual location of this indication would be reported as the distance from the first backwall signal to the indication.

5.2.2.6 Tapered Sections - For forgings with tapered sections (non-parallel sides), the reference reflection shall be obtained from a flat and parallel wall thickness on the forging closest to the maximum dimension of the tapered section or obtained on a calibrated block as described in Para. 5.2.2.8.1. The sensitivity obtained from the closest dimension shall be adjusted as specified in Para. 5.2.2.3.

5.2.2.7 The location of all indications regardless of amplitude, shall be marked on the forging during scanning for subsequent evaluation.

5.2.2.8 All indications detected at 6 inches (152 mm) or less from the test surface with a 1 inch (or 24 mm) diameter transducer shall be verified with a 2.0 or 2.25 MHz 1/2 inch (or 10 mm) diameter transducer after setting the sensitivity on a portion of the forging whose parallel side wall thickness is approximately 6 inches (152 mm) or on a calibration block fabricated in accordance with ASTM-E428.

5.2.2.8.1 When using a calibration block:

5.2.2.8.1.1 The sensitivity shall be calibrated on a low alloy 4-0600 calibration block.

5.2.2.8.1.2 The reflection from the 1/16 inch (1.6 mm) diameter flat bottom hole located 6 inches (152 mm) deep shall be adjusted to 20 percent FSH.



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5.2.2.8.1.3 The EFBH size of the indication shall be reported and calculated in accordance with the following:

$$EFBH = (0.0233)d\sqrt{I}$$

d = distance to indication

I = Indication amplitude in decimal form (i.e., 15% FSH = 0.15)

5.2.2.9 Thin Sections - For components such as load couplings, distance pieces, etc., having thin wall thicknesses and for which an axial longitudinal wave inspection of this thin section is required, perform the inspection as follows:

5.2.2.9.1 Axial Sections > 15 Inches

5.2.2.9.1.1 If the ratio $L/W \geq 5.3$,

where,

L = total axial length of the section to be inspected;

W = minimum radial thickness in the axial section;

and the component has a flange, use the axial flange thickness to establish the reference signal and perform the inspection to an axial distance equal to twice the axial flange thickness using the formula in Para. 5.2.2.3.1 to determine the multiplication factor for the inspection. In the equation for the multiplication factor, T will be equal to the flange thickness and t will be equal to twice the flange thickness. Repeat this inspection from the opposite surface of the component whenever possible. If this surface also has a flange, use this flange to establish the reference signal and multiplication factor for the inspection from this surface. If it does not have a flange, use the same setup as for the initial surface.



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If the component doesn't have flanges, the reference reflection shall be obtained from a flat and parallel thickness on the forging closest in value to the axial test distance. Perform the inspection to an axial distance equal to one half the axial length of the component using the formula in Para. 5.2.2.3.1 to determine the multiplication factor for the inspection. In the equation for the multiplication factor, T will be equal to the thickness on which the reference reflection is established and t will be equal to one half the axial length of the component. Repeat this inspection from the opposite surface of the component whenever possible

5.2.2.9.1.2 If the ratio $L/W < 5.3$,

perform the inspection in accordance with the standard axial longitudinal wave inspection requirements.

5.2.2.9.2 Axial Sections ≤ 15 Inches

5.2.2.9.2.1 If the ratio $L/W \geq 2.6$,

where,

L = total axial length of the section to be inspected;

W = minimum wall thickness in the axial section;

and the component has a flange, use the axial flange thickness to establish the reference signal and perform the inspection to an axial distance equal to twice the axial flange thickness using the formula in Para. 5.2.2.3.1 to determine the multiplication factor for the inspection. In the equation for the multiplication factor, T will be equal to the flange thickness and t will be equal to twice the flange thickness. Repeat this inspection from the opposite surface of the component whenever possible. If this surface has a flange, use this flange to establish the reference signal and multiplication factor for the inspection from this surface. If it does not have a flange, use the same setup as for the initial surface.



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If the component doesn't have flanges, the reference reflection shall be obtained from a flat and parallel thickness on the forging closest in value to the axial test distance. Perform the inspection to an axial distance equal to one half the axial length of the component using the formula in Para. 5.2.2.3.1 to determine the multiplication factor for the inspection. In the equation for the multiplication factor, T will be equal to the thickness on which the reference reflection is established and t will be equal to one half the axial length of the component. Repeat this inspection from the opposite surface of the component whenever possible

5.2.2.9.2.2 If the ratio $L/W < 2.6$,

perform the inspection in accordance with the standard axial longitudinal wave inspection requirements.

5.2.3 Shear Wave Tests

5.2.3.1 General

5.2.3.1.1 Shear wave tests shall be performed from the periphery:

5.2.3.1.1.1 In both circumferential directions on bored rotors where ratio of the OD/ID is 1.35 or less.

5.2.3.1.1.2 In both axial directions in addition to Para. 5.2.3.1.1.1 on tapered sides on rotors such as MS7001E and MS9001E Forward and Aft Turbine Stub shafts.

5.2.3.2 Bored Rotors With a Uniform Wall Thickness (Distance Piece)

5.2.3.2.1 Test Direction - Shear wave tests shall be performed from the periphery in both circumferential directions on bored uniform wall thicknesses whose ratio of the OD/ID is 1.35 or less.

5.2.3.2.2 Transducer - A 2.0 or 2.25 MHz 1/2 inch diameter (or 8 mm x 9 mm) 45° shear wave transducer shall be used. The transducer may be modified by use of a Plexiglas shoe which is ground to the curvature of the part.

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5.2.3.2.3 Calibration - The sensitivity shall be calibrated on an axial notch measuring 1/2 inch (12.7 mm) in length with a 0.030 inch (0.762 mm) depth provided there is sufficient forging stock available to be able to remove all evidence of the notch at the forging's final machined state. All axial notches (major axis of the notch and the forging axis are parallel) shall be a "V" type, with a 60-degree included angle and it shall be metal stamped into the periphery of the part. All upset metal and burrs adjacent to the notch shall be removed prior to measuring the notch depth and prior to adjusting the sensitivity.

5.2.3.2.3.1 When the part cannot be notched, an external reference standard having the same geometry, material composition and surface finish as specified on the part drawing may be used. This external reference standard shall be maintained permanently by the Supplier.

5.2.3.2.4 To assure the area of the notch is flaw free, it should be scanned prior to notching.

5.2.3.2.5 Evaluation Sensitivity - The sensitivity calibration is made by placing the shear wave transducer on the periphery of the part and maximizing the reflection from the notch on either the first or second full bounce, whichever is more suitable. The sensitivity shall be adjusted so that the reflection from the calibration notch is set to 100 percent of FSH. Once the reflection is adjusted to this amplitude, the sensitivity adjustment shall not be changed.

5.2.3.2.6 The position of the reflection from the notch shall be marked on the oscilloscope screen for reference. Indication amplitudes shall be maximized and read as close to this position as possible.

5.2.3.2.7 The oscilloscope screen shall be calibrated to measure the depth to the indications as follows: Move the transducer away from the reference notch and mark the screen where the next successive full bounce reflection appears. The distance between the two marked positions is proportional to twice the wall thickness. By sub-dividing this distance, a close approximation for the depths of the indications can be made.

5.2.3.2.8 The position of adjacent bounce shall also be marked on the screen to locate indications within the part.

5.2.3.2.9 The locations of the indications shall be marked on the forging as they occur.



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5.2.3.3 Rotors With Tapered Sides Such as MS7001E and MS9001E Forward and Aft Turbine Stub Shafts

5.2.3.3.1 Test Direction - Shear wave examinations shall be performed from the periphery with the beam directed in the axial and circumferential directions. In each case the examination shall be conducted in both directions.

5.2.3.3.2 Transducer - Shear wave tests shall be performed using 2.0 or 2.25 MHz 1/2 inch diameter (or 8 mm x 9 mm) 45° shear wave transducer.

5.2.3.3.3 Calibration - The sensitivity shall be established by calibrating on a circumferential notch measuring 1/2 inch (12.7 mm) in length with a 0.030 inch (0.762 mm) depth provided there is sufficient forging stock available to be able to remove all evidence of the notch at the forging's final machined state. The circumferential notch (major axis of the notch oriented in the circumferential direction) shall be a "V" type, with a 60° included angle and shall be metal stamped. The notch shall be placed in an area of the part having the thickest section, or as close as practical to the thickest section. All upset metal and burrs adjacent to the notch shall be removed prior to measuring the notch depth and prior to adjusting the sensitivity.

5.2.3.3.3.1 When the part cannot be notched, an external reference standard having the same geometry, material composition and surface finish as specified on the part drawing may be used. This external reference standard shall be maintained permanently by the supplier.

5.2.3.3.3.2 When indications are located in sections where the wall thickness has more than 1/2 inch (12.7 mm) variance from the calibration notch section, a new calibration notch shall be established for that specific wall thickness.

5.2.3.3.4 To assure the area of the notch is flaw free, it should be scanned prior to notching.

5.2.3.3.5 Evaluation Sensitivity - The sensitivity calibration is made by placing the shear wave transducer on the periphery of the part and maximizing the reflection from the notch on either the first or second full bounce, whichever is more suitable. The sensitivity shall be adjusted so that the reflection from the calibration notch is set to 100 percent of FSH. Once the reflection is adjusted to this amplitude, the sensitivity adjustment shall not be changed. The same sensitivity shall be used for the axial and circumferential tests.



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- 5.2.3.3.6 The position of the reflection from the notch shall be marked on the oscilloscope screen for reference. Indication amplitudes shall be maximized and read as close to this position as possible.
- 5.2.3.3.7 The position of next successive full bounce shall also be marked on the screen to locate indications within the part.
- 5.2.3.3.8 The locations of the indications shall be marked on the forging as they occur.
- 5.2.3.3.9 The sweep length shall be adjusted such that the first outside bounce signal is visible within the first half of the sweep so that a minimum of a 2-bounce signal can be seen on the oscilloscope screen. Special shaped parts with a relatively short axial dimension might only allow a 1-bounce signal. The test report must state whether a 1 or 2-bounce signal was used.
- 5.2.3.3.10 The same sensitivity used for the axial shear wave test shall be used for the circumferential test. The transducer, at the axial scanning sensitivity, shall be rotated 90° to continue testing.

5.2.4 Special Longitudinal and Shear Wave Sensitivity Testing

Figures 2 through 5 show atypical forgings that require special sensitivity or testing in specific sections as shown. The adjusted longitudinal wave evaluation sensitivity is specified in Para. 5.2.2.3, where the test thickness is different than the reference thickness.

- 5.2.4.1 Figure 2 - Section A shall be used to establish the reference signal. The evaluation sensitivity required for Section AA shall then be determined using the formula in Para. 5.2.2.3.1.
- 5.2.4.2 Figure 3 - Section A shall be used to establish the reference signal for the axial test of Section AA. The evaluation sensitivity required for Section AA shall be determined using the formula in Para. 5.2.2.3.1. Section B shall be used to establish the reference signal for the axial test of Section BB. The evaluation sensitivity required for Section BB shall be determined using the formula in Para. 5.2.2.3.1. Section A or B shall be used to establish the reference signal for the radial test of Section CC. The evaluation sensitivity required for Section CC shall be determined using the formula in Para. 5.2.2.3.1.



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5.2.4.3 Figure 4 - Section A shall be used to establish the reference signal for the axial test of Section AA. The evaluation sensitivity required for Section AA shall be determined using the formula in Para. 5.2.2.3.1. Section B shall be used to establish the reference signal for the axial test of Section BB. The evaluation sensitivity required for Section BB shall be determined using the formula in Para. 5.2.2.3.1.

5.2.4.4 Figure 5 - Additional shear wave tests are required as shown for Distance Pieces such as the MS7001F and MS9001F.

5.2.4.4.1 Transducer - A 2.0 or 2.25 MHz 1/2 inch diameter (or 8 mm x 9 mm) 45° shear wave transducer shall be used. The transducer may be modified by use of a Plexiglas shoe which is ground to the curvature of the part.

5.2.4.4.2 Calibration - The sensitivity shall be established by calibrating on a notch in the flange as shown in Figure 5. The notch shall measure 1/2 inch (12.7 mm) in length with a 0.030 inch (0.762 mm) depth provided there is sufficient forging stock available to be able to remove all evidence of the notch at the forging's final machined state. The notch (major axis of the notch oriented in the circumferential direction of the flange) shall be a "V" type, with a 60° included angle and shall be metal stamped. All upset metal and burrs adjacent to the notch shall be removed prior to measuring the notch depth and prior to adjusting the sensitivity.

5.2.4.4.2.1 When the part cannot be notched, an external reference standard having the same geometry, material composition and surface finish as specified on the part drawing may be used. This external reference standard shall be maintained permanently by the supplier.

5.2.4.4.3 Evaluation Sensitivity - The sensitivity calibration is made by placing the shear wave transducer on the flange face with the beam directed radially outward to the notch. The reflection from the notch shall be maximized. The sensitivity shall then be adjusted so that the reflection from the calibration notch is set to 100 percent of FSH. Once the reflection is adjusted to this amplitude, the sensitivity adjustment shall not be changed.

5.2.4.4.5 The position of the reflection from the notch shall be marked on the oscilloscope screen for reference. Indication amplitudes shall be maximized and read as close to this position as possible.



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5.2.4.4.6 The oscilloscope screen shall be calibrated to measure the depth to the indications.

5.2.4.4.7 Scanning Direction - The tapered section adjacent to the flange shall be scanned in both axial directions. From the flange face the beam shall be directed radially inward and scanning shall extend from the periphery of the flange face to the mid-radius position.

5.2.4.4.8 The locations of the indications shall be marked on the forging as they occur.

5.3 Evaluating and Reporting Indications

5.3.1 General

5.3.1.1 All scattered indications that are detected by more than one test (radial, axial or shear wave) shall be correlated on the test report. A comment shall be made identifying the matching indications(s) for each test.

5.3.1.2 If any indications are suspected of being unattenuated sound, first verify that unattenuated sound is present by repeating the instructions in Para. 5.1.10. If unattenuated sound is not present, proceed with evaluating the indication according to the requirements of this section. If unattenuated sound is present and the amplitude of an indication is significantly reduced by lowering the instrument's pulse repetition frequency, the indication is not considered real and should not be reported as a flaw indication. If the amplitude of the indication is not affected by lowering the pulse repetition frequency, evaluate it according to the requirements of this section.

5.3.1.3 Unusual Conditions - Any unusual conditions detected during the ultrasonic test shall be reported on the test report. A description of this unusual condition and its location shall be included in the test report. For example, a region in a forging having a high density of nonreportable indications is considered an unusual condition and must be reported. Even though the indications by themselves are nonreportable, the localized nature and population of these indications makes this condition unusual.

5.3.1.4 All indications found in the scan plan configuration which meet the following reporting criteria shall be reported on the test report even though these indications should be removed in the final forging dimensions.



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5.3.2 Longitudinal Wave Test - Evaluation and reporting of indications shall be performed with respect to the required quality level. Two quality levels, Quality Level A and Quality Level B, are defined by their acceptance criteria in Section 5.4.

5.3.2.1 Evaluation Sensitivity - All indications and the acoustic noise level shall be evaluated at the evaluation sensitivity as defined in Paras. 5.2.1.3 and 5.2.2.3.

5.3.2.2 Indication Amplitude - Indication amplitude shall be measured as a percentage of FSH. The percentages reported shall be rounded up to the nearest whole percent. The evaluation sensitivity shall be adjusted while the forging is stationary in an indication-free position of the respective diameter.

5.3.2.3 Initial Pulse Length - The initial pulse length of the transducer at the scanning sensitivity shall be reported from each test surface.

5.3.2.4 All indications located while rotating the part shall be re-checked while the forging is stationary. The amplitude and location as determined while the rotor is stationary shall be reported.

5.3.2.5 Scattered Indications - The following information shall be recorded and reported for each individual (scattered) indication equal to or greater than 75% of the allowable amplitudes per line "B" for Quality Level A or line "C" for Quality Level B in Figure 6.

5.3.2.5.1 Maximum amplitude

5.3.2.5.2 The indication's location at the position of maximum indication amplitude:

5.3.2.5.2.1 Radial tests - the radial depth to the indication with respect to the surface being tested and axial distance to the indication with respect to the reference end.

5.3.2.5.2.2 Axial tests - the axial depth to the indication with respect to the surface being tested and the radial distance to the indication with respect to the outside diameter.

5.3.2.5.2.3 The circumferential location with respect to the "0" location looking from the reference end of the forging.



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5.3.2.5.2.4 Areas where loss of back reflection are noted or suspect because of changes in sweep conditions (width of back wall envelope or noise level) shall be re-checked with the back wall adjusted to 100 percent FSH. Any areas re-checked which show 50 percent or more loss of back reflection at this sensitivity shall be reported.

5.3.2.5.2.5 Whipping of the bore reflection shall be recorded by giving the amplitude of the whipping and its axial and circumferential location. The report shall state whether the whipping is or is not associated with an indication. Whipping is measured by reducing the normal reference reflection to 50 percent FSH, then scanning over the area of whipping. Note the maximum and minimum amplitude of the reference reflection as a percentage of 100 percent. The difference between the minimum and maximum amplitude of the reference reflection is the percent of whipping that is reported.

5.3.2.6 Holding Indications

5.3.2.6.1 Axial Test or Radial Test in Axial Direction - Figure 1 and Para. 3.3.6 shall be used in evaluating indications found during the axial test or the radial test in the axial direction to determine if these indications are holding indications. For holding indications having amplitudes equal to or exceeding line "A" for Quality Level A or line "B" for Quality Level B in Figure 6, the information described in Paras. 5.3.2.5.1 and 5.3.2.5.2 shall be recorded and reported. In addition, the following information shall be reported:

5.3.2.6.1.1 The transducer positions along the longest holding dimension of the indication at the one-half amplitude points and at the locations where the indication amplitude is just distinguishable from the noise level.

5.3.2.6.1.2 The length of the holding indication (longest dimension) as measured between the transducer positions at the one-half amplitude points and at the minimum distinguishable amplitude positions as described in Para. 5.3.2.6.1.

5.3.2.6.1.3 The width of the holding indication (perpendicular to the longest holding dimension) as measured between the transducer positions at the one-half amplitude points and at the minimum distinguishable amplitude positions.



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5.3.2.6.2 Radial Test in Circumferential Direction - If during a radial test in the circumferential direction an indication is detected for which the transducer travel exceeds the length requirement for holding at that depth as defined for an axial test in Figure 1, record on the test report all the information required in Paras. 5.3.2.6.1.1 to 5.3.2.6.1.3 and in the "Comment" column write "suspected circ. holding".

5.3.2.7 Oriented Indications - For oriented indications having maximum amplitudes equal to or exceeding line "A" for Quality Level A or line "B" for Quality Level B in Figure 6, the information described in Paras. 5.3.2.5.1 and 5.3.2.5.2 shall be recorded and reported. In addition, the minimum distance position and associated amplitude shall be reported.

5.3.2.8 Closely Associated Indications - For closely associated indications having amplitudes equal to or exceeding line "A" for Quality Level A or line "B" for Quality Level B in Figure 6, the information described in Paras. 5.3.2.5.1 and 5.3.2.5.2 shall be recorded and reported.

5.3.2.9 Indication levels - For indication levels in which one or more indications have amplitudes equal to or exceeding line "A" for Quality Level A or line "B" for Quality Level B in Figure 6, record and report the following information:

5.3.2.9.1 The maximum, minimum and general amplitudes of the levels. The location of each indication level shall be reported as:

Radial, axial and circumferential boundaries outlining the volume of materials containing the indications.

5.3.2.9.2 Any noticeable non-uniformity of the indication levels shall be described in detail. Examples of non-uniformities are:

5.3.2.9.2.1 Eccentric radial distribution.

5.3.2.9.2.2 Concentration of higher amplitude indications within a general level.

5.3.2.9.2.3 Variation in the concentration of indications within the level.

5.3.2.10 Acoustic Noise Level - Report the noise level in the last one third of the sweep as a percentage of FSH.



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5.3.3 Shear Wave Test

5.3.3.1 Indication Amplitude - Indication amplitude shall be measured as a percentage of FSH. The percentages reported and recorded shall be rounded up to the nearest whole percent. The evaluation sensitivity shall be adjusted while the forging is stationary in an indication-free position of the respective diameter.

5.3.3.2 The amplitude of all indications shall be recorded when they are maximized on the screen nearest to the marked position of the test notch reflection. The indications shall be checked from two circumferential and two axial directions.

5.3.3.3 The following information shall be recorded and reported for each individual (scattered) indication 5 percent FSH or greater:

5.3.3.3.1 The maximum amplitude.

5.3.3.3.2 The indication's location for the position of maximum indication amplitude:

5.3.3.3.2.1 The radial location, e.g. inside diameter, outside diameter or mid-wall location.

5.3.3.3.2.2 The axial distance from the reference end of the forging.

5.3.3.3.2.3 The circumferential location with respect to the "O" location looking from the reference end of the forging.

5.4 Acceptance Standards

5.4.1 Conditions that do not meet the following acceptance criteria require submittal of the appropriate request for deviation document (SDR or QCR) in accordance with Para. 1.3.

5.4.2 The appropriate request for deviation document (SDR or QCR) must be submitted for all indications found in the forging scan plan configuration that do not meet the following acceptance criteria, even though these indications should be removed in the final forging dimensions.

5.4.3 Longitudinal Wave Tests - Acceptance criteria are provided for two quality levels, Quality Level A and Quality Level B. Quality Level B acceptance requirements shall apply unless otherwise specified in the piece parts specification.

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5.4.3.1 Quality Level A Criteria

- 5.4.3.1.1 Scattered Indications - Any scattered indications that have a peak amplitude that is less than line "B" in Figure 6 are acceptable.
- 5.4.3.1.2 Acoustic Noise Level - The amplitude of the ultrasonic noise level in the last third of the sweep, as measured to the bore or backwall, during the scanning examination is acceptable if it does not exceed line "A" on Figure 6.
- 5.4.3.1.3 Holding, Oriented, Closely Associated and Levels of Indications - Any of these indications having amplitudes equal to or exceeding line "A" in Figure 6 shall require submittal of the appropriate request for deviation document (SDR or QCR) in accordance with Para 1.3.
- 5.4.3.1.4 Whipping - Whipping of the bore reflection that is less than 10 percent of the bore reflection amplitude shall be acceptable.
- 5.4.3.1.5 Loss of Back Reflection - Loss of back reflection less than 50 percent of the reference reflector shall be acceptable.

5.4.3.2 Quality Level B Criteria

- 5.4.3.2.1 Scattered Indications - Any scattered indications that have a peak amplitude that is less than line "C" in Figure 6 are acceptable.
- 5.4.3.2.2 Acoustic Noise Level - The amplitude of the ultrasonic noise level in the last third of the sweep, as measured to the bore or backwall, during the scanning examination is acceptable if it does not exceed line "B" on Figure 6.
- 5.4.3.2.3 Holding, Oriented, Closely Associated and Levels of Indications - Any of these indications having amplitudes equal to or exceeding line "B" in Figure 6 shall require submittal of the appropriate request for deviation document (SDR or QCR) in accordance with Para 1.3.
- 5.4.3.2.4 Whipping - Whipping of the bore reflection that is less than 10 percent of the bore reflection amplitude shall be acceptable.



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5.4.3.2.5 Loss of Back Reflection - Loss of back reflection less than 50 percent of the reference reflector shall be acceptable.

5.4.4 Shear Wave Test

5.4.4.1 Indications less than 50 percent of the standard calibration notch signal shall be acceptable.

5.4.5 Unusual Conditions - Any unusual conditions encountered shall require submittal of the appropriate request for deviation document in accordance with Para. 1.3. For example, a region in a forging having a high density of nonreportable indications is considered an unusual condition. Such a condition must be reported through an SDR or QCR, whichever is appropriate.

5.5 Record of Test

5.5.1 Copies of the ultrasonic test report for each component inspected shall be submitted as part of the Certificate of Test.

5.5.1.1 Approved request for deviation documents shall be attached and submitted with the Certificate of Test.

5.5.2 The test report sheets shown in Figures 7 and 8 must be used to report the ultrasonic test results.

6. NOTES

None

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LENGTH REQUIREMENTS FOR HOLDING INDICATIONS

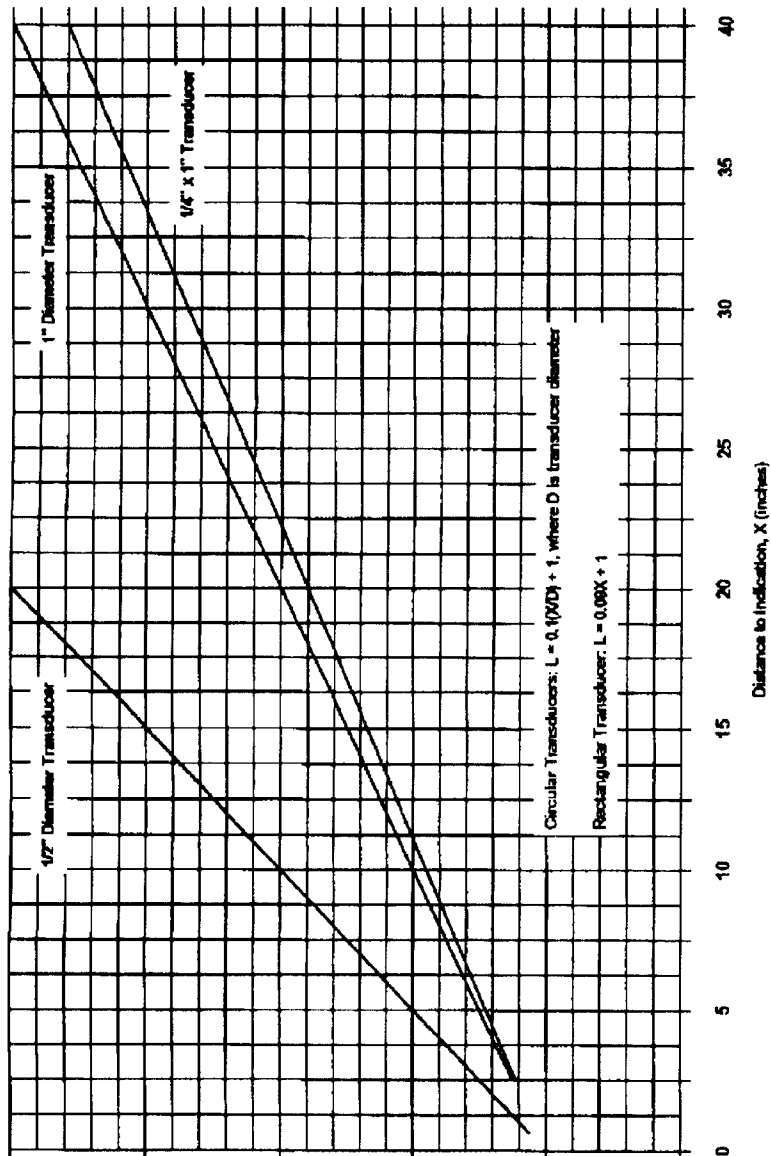


FIGURE 1



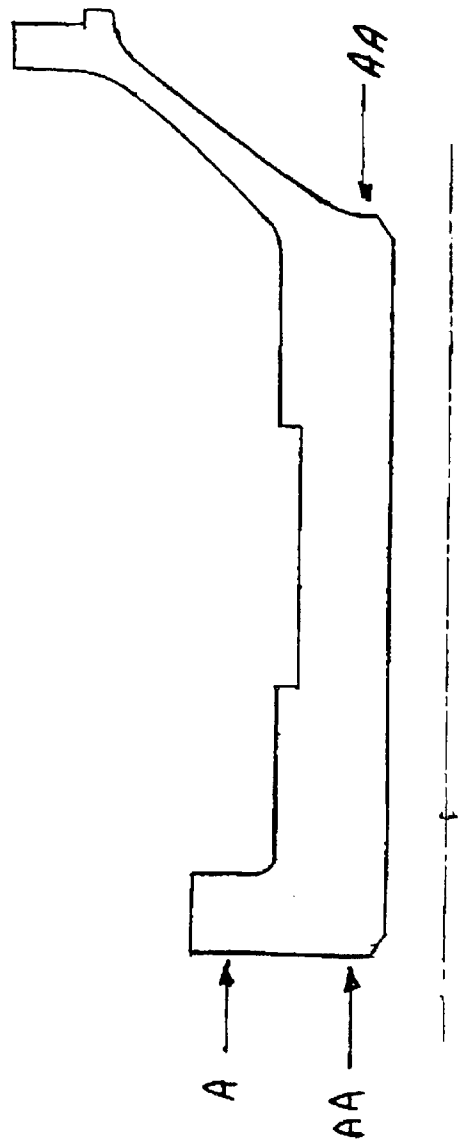
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Aft Shaft



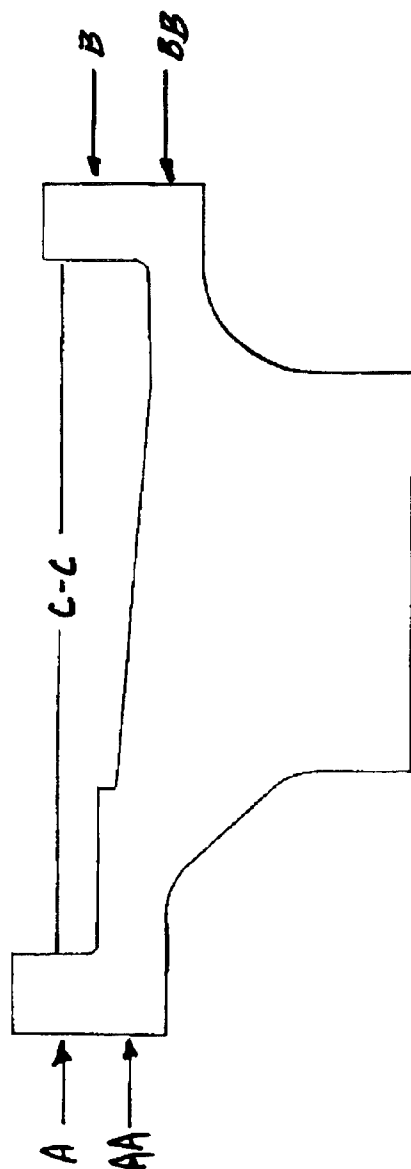
Sensitivity set at A and adjusted as specified in Paragraph 5.2.2.3 to test at AA

FIGURE 2



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1. Sensitivity set at A/B and adjusted as specified in Paragraph 5.2.2.3 to test AA/BB.
2. Sensitivity set at A or B and adjusted as specified in Paragraph 5.2.2.3 to test radially in section C-C.

FIGURE 3



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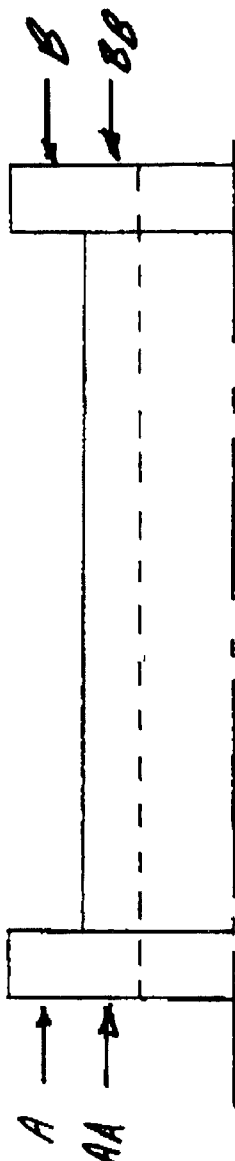
35

OF

40

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Distance Piece

1. Sensitivity set at A and adjusted as specified in Paragraph 5.2.2.3 to test at AA.

2. Sensitivity set at B and adjusted as specified in Paragraph 5.2.2.3 to test at BB.

FIGURE 4



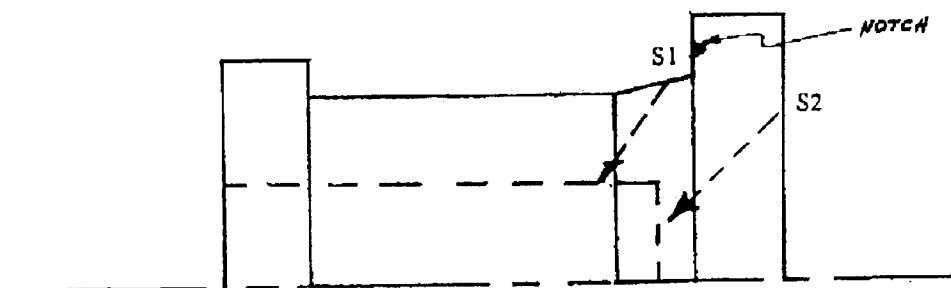
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Distance Piece

Additional shear wave tests required:

1. S1 in both axial directions.
2. S2 from the flange face.

FIGURE 5

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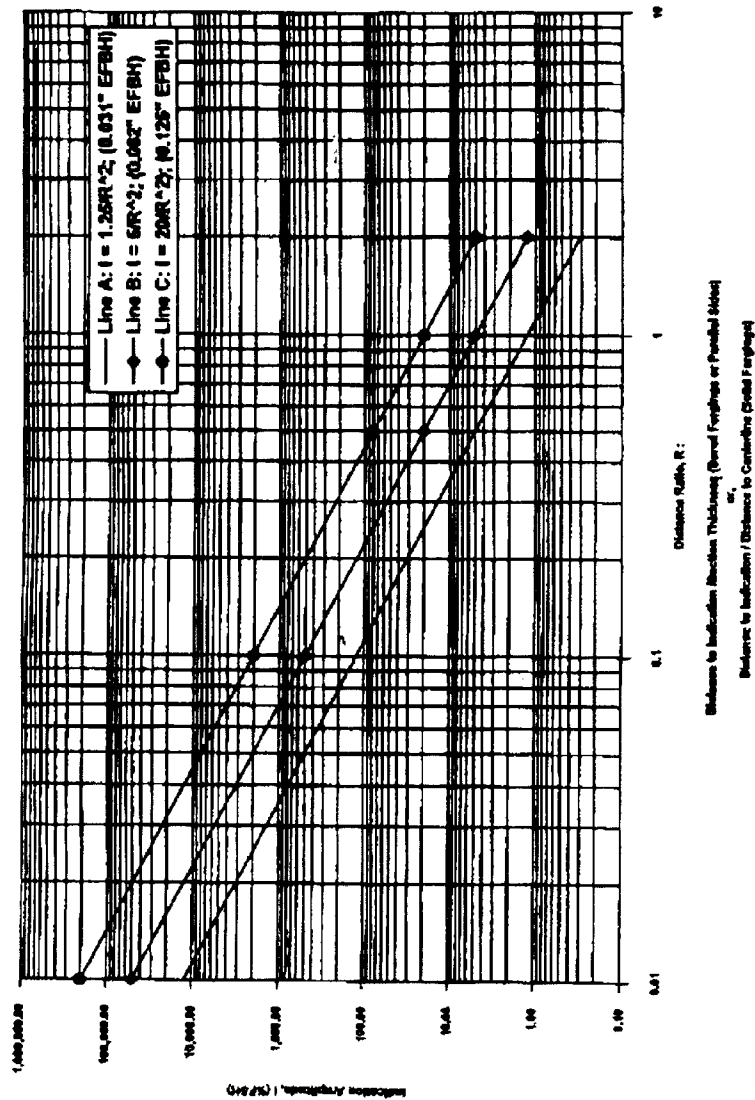
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INDICATION AMPLITUDE VS. DISTANCE RATIO

*Changed



* FIGURE 6



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FIGURE 7

ULTRASONIC TEST REPORT
P3C-AG42 REVISION J

Sheet 1 of 1

PART TYPE: _____

GE SERIAL NO.: _____

FORGING DWG. NO.: _____

MACHINING DWG. NO.: _____

PURCHASE ORDER NO.: _____

SHOP ORDER NO.: _____

FRAME SIZE: _____

TEST METHOD: _____

TEST DATE: _____

INSPECTOR:

TEST SITE: _____

UT. UNIT I.D. NO. _____

TRANSDUCER SERIAL NO.

COUPLANT _____

SURFACE REFERENCE SKETCH

(Include dimensions and surface codes)

[illegible]

NOTE 1: Axial Long. Wave - LWA; Radial Long. Wave - LWR; Axial Shear Wave - SWA; Circ. Shear Wave - SWC

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FIGURE 8

ULTRASONIC TEST INDICATION REPORT
P3C-AG42 REVISION J

Sheet ____ of ____

PART TYPE: _____

GE SERIAL NO.: _____

FORGING DWG. NO.: _____

MACHINING DWG. NO.:

TEST DATE: _____

TEST SITE: _____

INSPECTOR _____

[illegible]

NOTE 1: MEASURED IN % FSH AT THE EVALUATION SENSITIVITY

NOTE 2: DEPTH FROM TEST SURFACE FOR AXIAL TEST or, DISTANCE FROM REFERENCE END FOR RADIAL TEST.

NOTE 3: DISTANCE FROM OUTSIDE DIAMETER SURFACE FOR AXIAL TEST or, DEPTH FROM TEST SURFACE FOR RADIAL TEST or, APPROXIMATE DEPTH FOR SHEAR WAVE TESTS.

NOTE 4: IN DEGREES FROM THE "0" LOCATION AS VIEWED FROM THE REFERENCE END

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RECORD OF REVISIONS

[illegible]