



GE
Aviation

Specification No. P3TF15
Issue No. S16
Date January 13, 2020
Page 1 of 42
CAGE Code 07482

General Electric Company
Cincinnati, OH 45215

Supersedes P3TF15-S15

GE PROPRIETARY INFORMATION

The information contained in this document is GE proprietary information and is disclosed in confidence. It is the property of GE and shall not be used, disclosed to others or reproduced without the express written consent of GE, including, but without limitation, it is not to be used in the creation, manufacture, development, or derivation of any repairs, modifications, spare parts, designs, or configuration changes or to obtain FAA or any other government or regulatory approval to do so. If consent is given for reproduction in whole or in part, this notice and the notice set forth on each page of this document shall appear in any such reproduction in whole or in part.

This technical data is considered ITAR and/or EAR controlled pursuant to 22 CFR Part 120/130 and 15 CFR Parts 730-774, respectively. Transfer of this data by any means to a Non-US Person, whether in the United States or abroad, without the proper U.S. Government authorization (e.g., License, exemption, NLR) is strictly prohibited.

SPECIFICATION

ULTRASONIC INSPECTION OF BILLET - IMMERSION

1. SCOPE

1.1 Scope. This specification describes methods for detecting and evaluating discontinuities in round billet by ultrasonic inspection using the longitudinal mode, and establishes acceptance standards for such inspection.

1.1.1 Classification. This specification contains the following class(es). Unless otherwise specified, the requirements herein apply to all classes.

- CLASS A: General Applications-Coarse Grain
- CLASS B: Titanium Alloys, Zoned Inspection With Digital Data Acquisition
- CLASS C: Fine Grain nickel Alloys, Zoned Inspection With Digital Data Acquisition

GENERAL REVISION

PREPARED NW Betcher	REVIEWED	APPROVED <input checked="" type="checkbox"/> EVENDALE
APPROVED G.E. Best	DISTRIBUTION 10A	<input checked="" type="checkbox"/> LYNN

CLASS D: Rene'95 (Inactive for new design, use P3TF31 CL-A)
CLASS E: General Application-High Sensitivity
CLASS F: Titanium Alloys, Non-Premium

1.2 Definitions. For the purpose of this specification, further definitions of terminology shall provide for common language and understanding. Whereas, it is impractical to list all definitions in this specification, the order of precedence where differences are observed shall be (1) those terms herein defined, and (2) ASTM E 1316.

Alarm Threshold/Evaluation Limit - The signal amplitude which, when exceeded, requires further evaluation.

Assisted Indication Evaluation (AIE) - AIE is a computer-based image-processing tool that identifies signals in a C-scan image, and defines the relevant noise region surrounding that signal to be used in the signal-to-noise ratio (SNR) calculation.

Billet - Material having a nominal diameter greater than 4.5 inches (114 mm).

Capability - The words "shall be capable of" or "capability test" indicate characteristics or properties required in the product but for which testing of each lot is not required. However, if such testing is performed by the Purchaser, material not conforming to the requirements shall be subject to rejection.

Certifying Agent - Representative of the Purchaser's technical organization with authority for approving Technical Plans, inspection equipment, inspection procedures and operator training programs and requirements.

Effective Beam Width (EBW) - Portion of the beam used to inspect required volumes of material. Measured at the focal point of the transducer in units of length, at thresholds measured in decibels or percent.

-6dB EBW - The beam diameter at which the signal amplitude is reduced by a factor of 2.00 (i.e., from 80 percent FSH to 40 percent FSH).

-5dB EBW - The beam diameter at which the signal amplitude is reduced by a factor of 1.78 (i.e., from 80 percent FSH to 45 percent FSH).

-4dB EBW - The beam diameter at which the signal amplitude is reduced by a factor of 1.60 (i.e., from 80 percent FSH to 50 percent FSH).

-3db EBW - The beam diameter at which the signal amplitude is reduced by a factor of 1.40 (i.e., from 80 percent FSH to 57 percent FSH).

-2dB EBW - The beam diameter at which the signal amplitude is reduced by a factor of 1.27 (i.e., from 80 percent FSH to 63 percent FSH).

Full Screen Height (FSH) - Term to define magnitude of ultrasonic signals as a percentage of the A-scan display of an ultrasonic instrument where the range is 0 to 100 percent for linear amplifiers. Logarithmic ranges typically exceed 100 percent for full screen height, therefore, amplitudes are directly read from the scale on the screen.

Indication - The ultrasonic signal generated from a surface or internal condition.

Inspection Plan - A written and pictorial description of a billet to be inspected which identifies inspection requirements and limitations as they apply to the billet.

Material Noise - Noise caused by reflections from within the material being tested.

Pulse-on-Position (POP) - Control circuit which causes the ultrasonic instrument to pulse the transducer at a time based on position of the transducer relative to the billet being inspected.

Purchaser - The procuring activity of GE Aviation that issued the procurement document invoking this specification. When this specification is invoked by a U. S. Government purchasing activity (or such activity's designee) the Purchaser shall mean such activity or designee as the case may be.

Supplier - Source who provides material, parts or services, for incorporation into GE Aviation products (The term Supplier may also refer to an organizational unit of GE).

Technical Plan - The controlling document that defines how the supplier meets the requirements of this specification.

Time-of-Flight - A C-scan image showing the relative depth of the highest amplitude signal within the gated area for each pixel.

1.3 EHS Regulated Materials. The requirements of P2TF1, CL-A, shall be complied with. The material(s) shown below were referenced in this specification and P2TF1, CL-A, as of the date of this specification issue. The list below does not include all materials which are referenced in sub-tier documents.

There are no referenced materials.

2. APPLICABLE DOCUMENTS

2.1 Issues Of Documents. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS

- ASTM E 127 Fabrication and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks
- ASTM E 1065 Standard Guide for Evaluating Characteristics of Ultrasonic Search Units
- ASTM E 1316 Standard Terminology for Nondestructive Examinations

NATIONAL AEROSPACE STANDARD

- NAS 410 NAS Certification and Qualification of Nondestructive Test Personnel

GE AVIATION SPECIFICATIONS

- P2TF1 Regulated Materials, Environmental, Health and Safety
- P3TF45 Types of Records to be Retained for NDE (Nondestructive Evaluation)

2.2 Order of Precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 General

3.1.1 Qualification. Ultrasonic inspection shall only be performed with personnel, equipment and methods which meet the requirements of this specification. The qualification method shall emphasize applicable procedures on billets representative of the product to be inspected. The procedures for qualification, retest and maintenance of acceptability shall be approved in the Technical Plan.

3.1.2 Personnel Qualification. Personnel performing inspections to this specification shall be qualified and certified in accordance with NAS 410, a minimum Level I or better. Foreign procedures which are, at

minimum, equal to NAS 410 may be used with prior approval of the Certifying Agent.

3.1.3 Inspection Sources. CLASS B: Ultrasonic inspection shall be performed by sources and with equipment approved by the Purchaser (see 4.2).

3.1.4 Alternative Inspection Procedures. Ultrasonic inspection may be performed in accordance with an alternative procedure(s) to this specification, if the procedure(s) is approved by the Certifying Agent (see 4.4). Once established, an approved alternative inspection procedure shall not be changed without prior written concurrence by the Certifying Agent.

3.2 Material Control

3.2.1 Technical Plan. The Supplier shall inspect billets to a Technical Plan approved by the Certifying Agent. The plan shall be in a Supplier controlled document and meet all the requirements of this specification. As a minimum the plan shall include the following information:

- (a) Inspection plan
- (b) Operator certification procedure
- (c) Equipment certification & maintenance procedures
- (d) Functional system checkout procedure(s)
- (e) Calibration standard control procedure(s)
- (f) Calibration results records
- (g) Disposition of hardware procedures
- (h) Software Quality Assurance (SQA) plan (where applicable)

3.2.2 Inspection Plan. The Supplier shall inspect billet to an Inspection Plan approved by the Certifying Agent. The plan, associated work instructions and records shall include the following:

- (a) Billet identification and diameter
- (b) Material designation (Alloy)
- (c) P3TF15 Classification A, B, C, D, E and F
- (d) Instrument pulse repetition rate for each inspection zone expressed as pulses per second (internally triggered system) or pulses per revolution (Pulse-on Position)
- (e) Inspection rotational speed

- (f) Amplitudes for calibration, alarm threshold/evaluation limit, rejection.
- (g) Minimum effective beam width
- (h) Maximum scanning index
- (i) Calibration standard serial number, material, size and correction factors
- (j) Outline of the inspection configuration and dimension with inspection zones labeled and near-surface resolution obtained
- (k) Type of recording
- (l) Gating: gate delay and length per zone
- (m) This GE specification number and all procedure numbers controlling the inspection
- (n) Purchaser controlling specification number
- (o) Inspection requirements (including accept/reject criteria)
- (p) Data recording requirement
- (q) Cross-section of billet
- (r) Billet number and name
- (s) Equipment used

3.2.3 Surface Requirement. Surfaces shall be prepared by a process approved by the Certifying Agent and shall have a surface texture adequate to meet the inspection requirements specified herein. A surface texture of 125 microinches or better will normally ensure inspectability.

3.2.3.1 Cleanliness. Surfaces shall be clean and free from machining or grinding particles, oil, grease, cutting compounds or other foreign material, which could adversely affect ultrasound transmission characteristics of the setup.

3.2.3.2 Unacceptable Surfaces. When surface discontinuities (e.g., grind-outs or machining discontinuities) prevent inspection to this specification, the section of the billet affected shall be removed from further processing and the removal shall be indicated on the inspection report.

3.2.3.3 Acceptance Of Billet For Inspection. The facility required to perform the inspection shall examine each billet, before inspection, for surface characteristics obviously incompatible with the inspection required. Billet with such surfaces shall not be accepted for inspection.

3.3 Equipment

3.3.1 Ultrasonic Instrument. The ultrasonic instrument shall consist of a display device and pulser(s), receiver(s), amplifier(s) and gate(s).

3.3.1.1 Functional System Checkout. The Supplier shall describe in the Technical Plan, procedures and schedules for functional system checkout and method of control to assure that required equipment performance is maintained. The Certifying Agent shall approve the Technical Plan (including control of interchange of equipment components) and schedules and shall review the equipment performance test results.

3.3.1.2 Multiple Channels. CLASSES B and C: The instrument shall have a number of channels no less than the number of zones for the largest diameter of billet to be inspected. If a multiplexed system is used, the gain, gate settings and Distance Amplitude Correction (DAC) shall be independently controllable on each channel.

3.3.1.3 Receivers and Amplifiers. Amplifiers shall be capable of operating over a minimum frequency range of 2.25 to 10 MHz. The bandwidth of all amplifiers shall be greater than the bandwidth of transducers used for inspection. Bandwidth may be obtained from the manufacturer's specification. Amplifiers shall be provided with an incrementally adjustable gain or attenuation control providing a range of at least 50 dB adjustable in 1 dB steps.

3.3.1.4 Gates. The time interval of the gates and delay from the front surface echo shall be adjustable. The output from the gates shall be capable of operating a suitable alarm, stop-on-indication or recording device.

3.3.2 Alarm, Recording and Data Acquisition Systems.

CLASSES A, D, E, and F: An alarm system or a recorder or a digital data acquisition system shall be used (alternative methods such as stop-on-indication systems are also permitted if approved by the Certifying Agent).

CLASSES B and C: A digital data acquisition system with AIE module shall be used to record the data. The system shall consist of encoders for axial and circumferential positions, an analog-to-digital (A/D) signal conversion device, a computer, color display monitor, long term storage method and applicable software.

3.3.2.1 Position Encoding and Data Acquisition. CLASSES B and C: The system shall be able to collect image data synchronized with the circumferential and axial position for each billet zone. This requires data acquisition based on the output of axial and circumferential position encoders. Encoders shall have resolution of at least 2048 pulses per revolution (circumferential) and 1000 pulses per inch (axial) and shall be designed to provide accurate position information despite any billet slip on the rollers. Encoders with less resolution may be used with prior approval of the Certifying Agent if they provide the required data acquisition

spacing specified in 3.6.6.3. Attachment of the circumferential encoder to the billet end is preferred.

3.3.2.2 A/D (Analog-to-Digital) Conversion. CLASSES B and C: For each pulse, the peak ultrasonic amplitude in the gated region of each inspection zone shall be digitized to a minimum resolution of 8 bits over the range of 0 to 100 percent full scale. The A/D converter shall be calibrated and adjusted using procedures recommended by the manufacturer and shall meet the linearity requirements defined in 3.3.8.

CLASS C: For each pulse, Time-of-Flight data shall be captured in the gated region.

3.3.2.3 Digital Data Storage. CLASSES B and C: Digital amplitudes and the corresponding encoder positions shall be stored in Network Common Data Form (netCDF) file format, version 2.3.2 or higher or ASTM DICONDE format. For each ultrasonic amplitude the corresponding encoder locations shall be accessible. Alternative file formats may be used with Certifying Agent approval.

3.3.2.4 Digital Data Archiving. CLASSES B and C: All inspection data files shall be archived on media approved by the Certifying Agent.

3.3.2.5 Analysis of Digital Data. CLASSES B and C: Software to analyze the digital data shall perform the following functions as a minimum:

- (a) Display location and amplitude, select Region of Interest (ROI), calculate mean, minimum, maximum and standard deviation in ROI; provide rapid identification of values above evaluation limit.
- (b) Equipment to be qualified for inspection shall have the capability to perform AIE on the stored C-Scan data.
- (c) The Purchaser maintains a database of test images and correct SNR responses. AIE shall return the number of indications and their respective SNRs rounded to the nearest tenth for comparison to the database.

3.3.3 Search Units. Search units shall meet the following requirements.

- (a) Search units used to perform inspection to this specification shall be tested with a qualified pulser-receiver used for inspection and with approved calibration standards.
- (b) The Technical Plan, procedure and schedule for maintenance tests to assure search unit performance shall be approved by the Certifying Agent.

- (c) Phased array transducers where used, shall test the array using each phase delay configuration proposed for use in the inspection process.
- (d) Transducers recommended for CLASS B are listed in Appendix B.

3.3.3.1 Transverse beam profile. Search units shall be tested to determine the transverse profile in the axial and circumferential directions. If circumferential profile cannot be measured, axial beam diameter shall be used for calculation of scan speed and index.

3.3.3.2 Peak Frequency. Search unit frequency shall meet the following requirements.

- (a) The frequency response, peak frequency and bandwidth shall be determined in accordance with ASTM E 1065.
- (b) Measurements provided by the transducer manufacturer are acceptable provided they are performed in accordance with ASTM E 1065.
- (c) The peak frequency of the search units used shall be no less than 4.50 MHz for billet nominal diameters 10 inches (255 mm) and under and not less than 2.25 MHz for billet nominal diameters above 10 inches (255 mm) when excited by a broadband pulse.
- (d) Alternative minimum peak frequencies may be used for specific applications with prior approval of the Certifying Agent.

3.3.4 Couplant. The couplant shall be water, free from particles which could interfere with ultrasonic inspection. Rust inhibitors, softeners, wetting agents, and other additives when approved by the Certifying Agent may be added to the couplant.

3.3.5 Waterpath. The search unit operating waterpath shall be established for each system. The system shall be capable of maintaining this waterpath within ± 0.125 inch (± 3.2 mm) for all calibrations and inspections unless conditions require a different tolerance which shall be defined in the approved Inspection Plan.

3.3.6 Other Equipment. Tanks, bridges, rotators, manipulators and other equipment shall meet the following requirements and shall be checked annually.

- (a) The tank shall be of sufficient size to permit submersion of the material to be inspected with proper placement of the search unit at working waterpaths.
- (b) An automated scanning and indexing system shall be used.

- (c) The axial (index) motion accuracy shall be within ± 10 percent of the minimum proposed index distance.
- (d) The rotational surface speed shall be accurate to within ± 10 percent of indicated values over the range of proposed inspection speeds.

3.3.7 Instrument Control. The instrument shall be provided with regulated line voltage controlled within plus or minus three percent of the nominal value specified by the instrument Supplier.

3.3.8 Amplifier and Attenuator Accuracy Verification. Attenuator accuracy and amplifier linearity shall be verified by method (a) or method (b) below and shall on a schedule approved by the Certifying Agent but not to exceed one year.

Table I - Response-Percent Amplitude

HOLE DIAMETER				ATTENUATION DIFFERENCE-dB			
NO.	64'S	INCHES	(mm)	0	6	12	18
#5	5/64	0.078	(1.98)	80% FSH	40% FSH	20% FSH	10% FSH
#4	4/64	0.062	(1.59)	51% FSH	--	--	--
#3	3/64	0.047	(1.19)	28% FSH	--	--	--
#2	2/64	0.031	(0.79)	13% FSH	--	--	--

3.3.8.1 Method (a). Attenuator accuracy and amplifier linearity shall be verified by method (a) and shall meet the following:

- (a) Using a method approved by the Certifying Agent and aluminum ultrasonic standard reference (flat bottom holes (FBH)) blocks fabricated and checked in accordance with ASTM E 127, with 2/64 inch through 5/64 inch holes at a three inch (76 mm) depth, and using a suitable transducer, the Supplier shall prove that the complete ultrasonic system used for inspection to this specification has a linear area/amplitude relationship at the frequency used for inspection.
- (b) The required linearity shall be proven if the amplitude response for the system is within ± 2 percent full screen height (FSH) of the values shown in Table I.
- (c) Flat bottom holes at less than three inches (76 mm) depth may be used for sharp focus transducers required for specialized inspections with prior approval of the Certifying Agent.

3.3.8.2 Method (b)

3.3.8.2.1 Equipment for Linear Amplifier Verification. Equipment used for amplifier linearity verification by method (b) shall meet the following:

- (a) The verification shall be performed using the equipment configuration shown in Figure 3.
- (b) The external attenuator shall have accuracy (in accordance with manufacturer's specification) of better than ± 1.0 dB over the attenuation range 0 to 80 dB at DC to 50 MHz frequency, adjustable in 1 dB steps with 50 ohms impedance.

3.3.8.2.2 Linear Amplifier Verification Procedure. Amplifier linearity verification by method (b) shall be performed as follows:

- (a) With equipment configured as in Figure 3, adjust the signal amplitude to 80 percent FSH.
- (b) Adjust the external attenuator in steps as shown in the Table II below and note the signal amplitude on the screen.
- (c) The signal amplitude shall be within ± 2 percent FSH of the values in the table. Electronic measurement of signal amplitude may be used as an alternative to screen height.

Table II - Linearity Response (Method b)

<u>Attenuator Setting</u>	<u>Signal Amplitude</u>
0 dB	80% FSH
3 dB	57% FSH
6 dB	40% FSH
9 dB	28% FSH
12 dB	20% FSH
18 dB	10% FSH
24 dB	5% FSH

3.3.8.2.3 Instrument Attenuator Accuracy Verification. Instrument attenuator verification by method (b) shall be performed as follows:

- (a) Set the external attenuator to 0 dB (no attenuation) and use the instrument controls to set the signal to 50 percent FSH.
- (b) Increase the external attenuator setting by 10 dB and increase the instrument calibrated gain control by 10 dB.
- (c) Record the signal amplitude.
- (d) Repeat in 10 dB steps to a total of the full scale ranges of the instrument.

- (e) The attenuator accuracy is acceptable if the displayed signal is in the range of 40 to 63 percent FSH (50 percent FSH ± 2 dB) at each step in the full range of the instrument.
- (f) Electronic measurement of signal amplitude may be used as an alternative to screen height.

3.3.9 Equipment. CLASS B: Ultrasonic instruments, recorders and transducers used to perform inspections shall be approved by the Purchaser. (See 4.2)

3.4 Calibration Standards

3.4.1 Calibration Standard Material. Calibration standard material shall meet the following requirements.

- (a) Standards shall be fabricated from material of the same base alloy type and shall be subjected to thermomechanical processing that is consistent with the billet to be inspected.
- (b) Standards fabricated from Ti6-4 alloy may be used when inspecting billet made from Ti6-2-4-2 or Ti17 alloys.
- (c) The standard shall have the same diameter, acoustic transmission and surface texture as the billet to be inspected.

3.4.1.1 Indications - Noise. The standard test block material shall be free from ultrasonic indications and shall have a material noise amplitude similar to the material to be inspected.

3.4.1.2 Attenuation. The test block material shall have ultrasonic attenuation similar to the material to be inspected and verified by the following process.

- (a) This is to be verified by comparison of the first back-surface reflection in the standard (away from any edge in the test block) to the first back surface reflection from similar regions (away from any edge) in a number of samples of typical production billet material.
- (b) Back surface echoes averaged over a region of 1 inch (25 mm) length by 360 degrees circumferential shall be within ± 6 dB.
- (c) If the sound transmission characteristics vary more than 6 dB, either a new standard more closely representative of the material being inspected shall be fabricated or the sensitivity shall be increased to compensate for the difference between the standard and material being inspected.
- (d) The correction factors or differences shall be recorded on the inspection report.

3.4.1.3 Control of Calibration Standards. Calibration standards that are used to establish inspection sensitivities shall be controlled in accordance with procedure approved by the Certifying Agent.

3.4.2 Calibration Standard Diameter. CLASSES A, C, D, E, and F: The reference standards shall be within 10 percent of the billet nominal diameter, up to a maximum difference of 1 inch (25 mm).

CLASS B: The reference standards shall be within ± 0.5 inch (13 mm) of the billet nominal diameter except that a 13 inch (330 mm) diameter standard may be used for calibration to test 12 ± 0.25 inch (305 ± 6.4 mm) diameter billet.

3.4.3 Calibration Standard Entry Surfaces. The surface of the calibration standard shall have surface texture comparable to the billet to be inspected.

3.4.4 Calibration Standard Holes. CLASSES A, C, D, E, and F: The calibration standard test block holes shall be in accordance with Figure 1.

CLASS B: The calibration standard shall contain a minimum of one hole at the shallow and deep depths of each inspection zone. Recommended configurations are shown in Appendix A.

3.4.5 Calibration Standard Certification. CLASS B: Only calibration standards certified by the Certifying Agent shall be used by the Supplier for inspection to CLASS B. Correction factors provided with the certification shall be used for inspection.

3.5 Calibration

3.5.1 Equipment Preparation. Instruments shall be warmed up for not less than 10 minutes before being used.

3.5.2 Instrument Settings. The instrument settings shall be consistent with the frequency of the transducers being used during calibration.

3.5.3 Calibration Hole Amplitude. During calibration, the amplitude from each specified hole shall be peaked and recorded at the established waterpath.

CLASSES A, C, D, E and F: The waterpath shall be adjusted to assure the inspection is no more than -3dB into the near field. The near field limit can be determined by peaking the response from the shallow hole in the X, rotation and Z axis and setting the response to 80 percent FSH. Reduce the waterpath while maintaining the peak until the signal is at 57 percent FSH. This is the minimum waterpath that may be used for that zone.

CLASS B: The waterpath shall be set as specified in Appendix A.

3.5.3.1 Inspection Zones. CLASSES A, D, E and F: Inspections may be performed with multiple zones using the holes within each zone to establish inspection sensitivity.

CLASS B: Recommended inspection zones are listed in Appendix A.

CLASS C: Inspections shall be performed using the zones below, where B = Near Surface Hole and T = Billet Diameter. See Calibration Standard, Figure 1.

- (a) Nominal Diameters 7 inches (178 mm) or less.
Zone 1 - Near surface FBH B to T/4.
Zone 2 - T/4 to T/2 + 0.5 inch (13 mm).
- (b) Nominal Diameters greater than 7 inches (178 mm).
Zone 1 - Near surface FBH B to T/8.
Zone 2 - T/8 to T/4.
Zone 3 - T/4 to T/2 + 0.5 inch (13 mm).

3.5.3.2 Calibration Gain. Calibration gain shall be established in accordance with the following process.

- (a) The amplitude of the reflection from the flat-bottom hole producing the lowest amplitude in the inspection zone shall be adjusted to an amplitude of at least 80 percent FSH on the display, with appropriate corrections, and with DAC applied if used for the inspection.
- (b) As an alternative to using displayed signal amplitude, the calibration and reject levels may be based on a numerical representation of the signal amplitude, for example a digital voltmeter showing gated peak amplitude. If this method is used, the linearity of the numerical display shall be demonstrated and the reject and threshold/evaluation levels shall be shown to be equal to or more sensitive than the values shown in Figure 1 (Continued).

3.5.3.2.1 Entry Surface Resolution. During calibration the signal from the front surface shall have returned to the horizontal sweep line before the signal from the closest calibration hole appears on the horizontal swepline to obtain inspection resolution.

3.5.3.2.2 Distance Amplitude Correction. DAC (Distance Amplitude Correction) corrections if used shall be established using the calibration standard holes for the various depths. In the case of multiplexed instruments, DAC may be used within a focusing zone but may not be used to compensate for differences between zones.

CLASSES A, B, C, E, and F: Distance Amplitude Correction Optional

CLASS D: Distance Amplitude Correction Required

3.5.3.3 Dynamic Calibration Capability. The ability to detect calibration holes or similar small reflectors at the operating scanning speed shall be established in accordance with procedures approved by the Certifying Agent.

3.5.3.3.1 Alarm and Stop-on-Indication Systems. The ability to alarm or stop-on-indication consistently shall be demonstrated at the planned operating speed.

3.5.3.3.2 Recording Systems and Data Acquisition Systems. The ability to record or identify indications shall be demonstrated at the maximum planned operating speeds to be used for the system. Indications of all applicable holes in the standard shall be identified at the planned inspection operating speed.

3.5.3.4 Recording System Linearity. The linearity of any analog or digital recording systems used shall be demonstrated to be within ± 2 percent FSH with respect to signal amplitude displayed on the A-Scan display. Where numerical readings of instrument analog or digital output are used for calibration or evaluation, the numerical display shall be demonstrated to be linear with respect to displayed signal amplitude within ± 2 percent FSH.

3.6 Inspection

3.6.1 Calibration Schedule. The calibration schedule shall meet the following requirements.

- (a) A calibration shall be made before and after each inspection lot or at the least, startup and end of each shift.
- (b) A calibration at the beginning of the immediately following shift may be substituted for the end of shift calibration.
- (c) Calibration frequency may be decreased to once per day when calibration records indicate that the required instrument gain varies no more than ± 10 percent from that registered at the previous calibration.
- (d) The calibration intervals may be further extended with approval of the Certifying Agent based on documented calibration consistency over an extended period of time.
- (e) Calibration may be dynamic provided the signal amplitudes from the flat-bottom holes are consistent with requirements described in 3.6.6.

3.6.1.1 Re-inspection. Re-inspection of material when the post inspection calibration is outside of the limits is required in accordance with the following:

- (a) If the magnitude of the calibration hole response from the post-test calibration is lower by 10 percent FSH or more from the pre-test calibration indication, all material inspected since the pre-test calibration shall be reinspected.
- (b) When recording devices are used, the recording may be evaluated in lieu of re-inspection at a corrected threshold corresponding to the post calibration error when the pre and post calibration values are within $\pm 3\text{dB}$.

3.6.2 Normalization. The sound beam entry angle shall be normalized for longitudinal mode (straight beam) before inspection by maximizing the back surface reflection.

3.6.2.1 Entry Angle. During inspection, the entry angle shall not vary more than plus or minus two degrees from the established beam entry angle.

3.6.3 Frequency. The frequency used during inspection shall be that used during calibration.

3.6.4 Waterpath. For all inspections, the water path shall not vary more than 0.125 inch (3.2 mm) from that established during calibration.

3.6.5 Attenuation Adjustment. The acoustic similarity of the part under inspection to the calibration standard shall be determined in accordance with the following process.

- (a) The acoustic similarity (calibration standard/billet) shall be determined before inspection by comparing the back surface reflections averaged over a 1 inch (25 mm) length by 360 degrees circumferential.
- (b) The measurement shall be made and recorded at both ends and the middle of each billet.
- (c) If the back reflection amplitude from the material being inspected varies by more than $\pm 6\text{dB}$ from that recorded from the calibration standard, no inspection shall be performed until a test standard of more similar acoustic response is obtained or an attenuation correction procedure is established.
- (d) CLASS B inspections require attenuation correction for variation greater than 1dB.

3.6.6 Scan Parameters. The scanning of the billet shall consider the following parameters:

- (a) Beam width
- (b) Pulse repetition rate

- (c) Scan index
- (d) Surface speed
- (e) Alarm threshold/evaluation limit.

The parameters shall be chosen such that a reflector producing an indication equal to the reject level will always produce an indication above the alarm threshold/evaluation limit. (See Figure 1 (Continued))

3.6.6.1 Beam Width Determination. Beam width shall be determined in accordance with the following requirements. (See Figure 1 (Continued))

- (a) The beam width is the minimum dimension of the ultrasonic beam measured on each flat bottom hole through the depth of metal being inspected with that transducer at the water path to be used (See Figure 5).
- (b) Both axial and circumferential dimensions should be measured.
- (c) If circumferential measurement cannot be made, then axial measurement shall be used for all calculations.
- (d) The measurements shall be made at various EBW's which may be employed during the inspection, but not less than -2dB EBW nor greater than -6dB EBW.
- (e) The peak amplitude from each hole used to determine the EBW shall be set at 80 percent FSH and the distance determined by the amount of travel across the hole as the signal changes. For example: from 57 to 80 to 57 percent FSH for -3dB EBW and 40 to 80 to 40 percent FSH for -6dB EBW (See Table III).
- (f) For CLASS B inspection, only -3dB EBW or less beam widths will be measured and used.

Table III - Amplitude Change

EBW	Scope Amplitude Change
-2dB	63% FSH to 80% FSH to 63% FSH
-3dB	57% FSH to 80% FSH to 57% FSH
-4dB	50% FSH to 80% FSH to 50% FSH
-5dB	45% FSH to 80% FSH to 45% FSH
-6dB	40% FSH to 80% FSH to 40% FSH

3.6.6.2 Pulse Repetition Rate. The instrument shall be pulsed at a rate which permits the greatest scanning speeds but avoids "ghost" signals caused by unattenuated energy or multiples from the water path.

3.6.6.3 Scan Index. The maximum nominal axial scanning index (ASI) intervals shall provide a spacing no greater than that illustrated in Figures 4a and 4b. Figure 4c illustrates unacceptable inspection coverage because there is a gap in the center of the circles which represents the EBW. This considers the axial EBW, the pulse repetition rate - data acquisition spacing (DAS), the surface speed and the alarm level. The linear motion accuracy shall be within ± 10 percent. Follow the steps below to determine the correct ASI and DAS.

- (a) Determine the EBW to be used for inspection based on anticipated noise levels. See 3.6.10.1 for noise and evaluation requirements.
- (b) Determine the axial scanning index based on the percentage of the EBW to be used for inspection. The axial scanning index shall be 43 percent or greater, up to and including 90 percent of the EBW.
- (c) Determine the Data Acquisition Spacing using the formula: Maximum Data Acquisition Spacing = $\sqrt{(EBW^2 - ASI^2)}$.
- (d) Rep rate = (Surface speed/DAS) X 1.1 for non-Pulse-on-Position equipment or strip chart recording.
- (e) Revolutions/Minute (RPM) = $60 / (\text{Circumference} / \text{Surface Speed})$.

3.6.6.4 Surface Speed. The maximum nominal scanning speed shall provide a spacing no greater than that shown in Figure 4 taking into account the circumferential EBW, the pulse repetition rate, the scan index rate and the alarm level.

3.6.7 Inspection Coverage. Billet shall be inspected over 100 percent of the circumferential surface. The depth of the longitudinal mode inspection shall cover all material between the minimum and maximum calibration hole depths (See Figure 1).

3.6.8 Instrument Gate Position. CLASSES A, C, D, E, and F: The gate(s) shall cover at least the range between the minimum and maximum calibration hole depths for that zone. If more than one zone is used, a 0.25 inch (6.4 mm) minimum overlap is required between zones.

CLASS B: The gate in the near-surface zone shall cover from the minimum calibration hole depth to the center of the adjacent zone as a minimum. All other gates shall cover the appropriate zone with an additional overlap not less than one half a zone at each end. A backwall gate shall be provided on one channel or on a dedicated channel with a separate transducer. See Appendix A for recommended CLASS B zones and gating.

3.6.9 Inspection Gain Level. Material shall be inspected at the gain established during calibration with attenuation corrections.

3.6.10 Alarm Systems. During inspection with an alarm system, the alarm system shall be set at "hold" or "manual reset". Alarm system shall be connected with scanning mechanism so that axial motion stops when alarm threshold is exceeded.

3.6.10.1 Alarm Threshold. The inspection system alarm threshold shall be set as low as possible. The dB difference between the alarm threshold setting and the reject criteria establishes the maximum EBW to be used for the inspection. Any indication equal to or greater than the following shall be evaluated.

- (a) 80 percent of the rejection limit using a -2dB EBW,
- (b) 71 percent of the rejection limit using a -3dB EBW,
- (c) 63 percent of the rejection limit using a -4dB EBW,
- (d) 56 percent of the rejection limit using a -5dB EBW,
- (e) 50 percent of the rejection limit using a -6dB EBW.

Parts with noise equal to or greater than 3.6.10.1(a) through 3.6.10.1(e) shall be re-inspected using a narrow EBW. Parts with noise levels exceeding -2dB EBW limits shall be rejected.

3.6.11 Control Settings. The instrument control settings and test parameters established during calibration shall not be changed during inspection of the material with the exception of gate settings which may have been adjusted to eliminate backwall echoes during dynamic calibration checks.

3.6.12 Reference Points. Each billet shall be marked with a reference point from which all sonic indications can be located axially on the billet.

3.7 Billet Evaluation And Acceptance Criteria

3.7.1 Use of DAC (Distance Amplitude Correction). Indications may be evaluated with DAC provided the DAC is demonstrated to provide sensitivity between calibration reflectors that are at least equal to a linear interpolation between the reflectors.

3.7.2 Indications. Indications shall be evaluated in accordance with the following requirements.

3.7.2.1 Indication Peaking. Indications which, during scanning, exceed the alarm threshold shall be peaked to determine the actual amplitude in comparison to the reference hole at the same or deeper depth.

3.7.2.2 Translation and Angulation. The peaking is accomplished by translating and angulating in both axial and circumferential directions.

For CLASS B, peaking is accomplished by axial and circumferential translation only.

3.7.2.3 Indication Limits. Indications shall conform to the limits specified in the specification or drawing invoking this specification.

3.7.2.4 Unspecified Limits. If limits are not specified, billets shall conform to the following:

- (a) Any indication greater than the rejection level shown in Figure 1 (Continued) is unacceptable.
- (b) Areas exhibiting a loss of the established back reflection pattern greater than 1/2 of the normal pattern from the billet under inspection, when accompanied by signals between front and back surfaces of at least double the normal background noise level, are unacceptable.
- (c) CLASS B Surface Zone 1 Indications: Surface related callouts do not require documentation on the ultrasonic inspection certificates or to be included in the data submitted if they meet the following criteria:
 - (1) The ultrasonic response for the indication is seen in Zone 1 only.
 - (2) The indication is caused by a non-linear surface feature visible to the eye or a scratch where the bottom is clearly visible.
 - (3) The indication does not affect the inspection results of any Zones other than the surface zone by more than 6 dB.
 - (4) The nature of the indication is annotated on the C-scan or recorded on supporting documentation.
 - (5) Linear indications are not acceptable and all such indications are required to be either removed from the billet by mechanical polishing and removal verified by a Nondestructive Evaluation (NDE) method approved by the Certifying Agent or the section containing linear indications shall be removed from the billet.
- (d) Where reject level is expressed in terms of signal-to-noise ratio (SNR) the SNR shall be calculated as:

$$SNR = \frac{(Signal - Mean)}{(Peak - Mean)}$$

Where Signal is the highest amplitude obtained from the suspected indication, Mean is the mean value of noise in a region surrounding or

adjacent to the indication, and Peak is the median of the five highest amplitudes in the same region. Alternative methods of calculating SNR may be used with Certifying Agent approval. SNR criteria for CLASS C does not apply to indications less than 15 percent FSH.

- (e) Additional CLASS B and C requirements: Assisted Indication Evaluation software shall be used for all C-scan image indications requiring evaluation. The operator shall review the image and AIE result when making the indication accept or reject decision.
- (f) Additional CLASS C requirements: Indications with a Time-of-Flight length greater than 0.5 inch (13 mm) in any direction are rejectable regardless of amplitude.
- (g) All rejectable indications shall be removed from the billet.

3.7.3 Billet Map. All rejectable indications and all repeatable indications which are not rejectable, but which exceed the alarm threshold/evaluation limit amplitude on Figure 1 (Continued), shall be reported on a billet map or alternative documentation approved by a Certifying Agent.

3.8 Inspection Records. Inspection records shall be maintained in accordance with the following requirements.

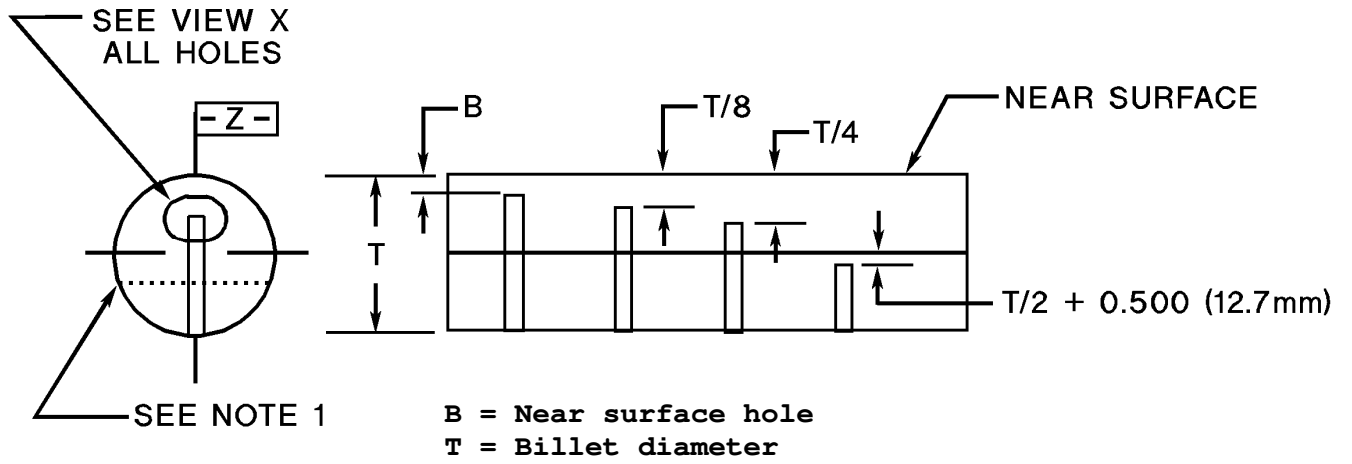
- (a) Complete inspection records, including the billet location of each rejectable indication, ultrasonic response for all rejectable indications, results of any metallographic evaluation of indications, and calibration sheets for each billet shall be maintained and made available to the Purchaser upon request.
- (b) Records shall be kept for a period acceptable to the Purchaser.
- (c) The Supplier shall submit or keep on file for review by the Purchaser a report of the ultrasonic inspection results.
- (d) The report shall include a record of transducer, instrument, calibration standard, and all evaluated indications delineated with respect to a reference point on the material and the identification number, the depth of the indications from the surface and the magnitude of the indications in percent amplitude.
- (e) The record shall include all strip chart or digital data recordings which were made of the inspection.
- (f) Typical noise level of each billet or billet lot shall be reported.
- (g) Record retention shall be in accordance with P3TF45 CL-A.

3.9 Equipment Control And Maintenance. Records of maintenance showing the results and any corrective action shall be available to the Purchaser upon request.

3.10 Certificate Of Inspection. The material Supplier shall furnish with each shipment a certificate of inspection showing the numerical results of all required tests and inspections on each billet in the shipment. The certificate shall show that the results are in accordance with the requirements of this specification. The certificate of inspection shall also contain the following.

- (a) Purchase order number
- (b) The inspection plan number and issue
- (c) Material description, including material specification, heat and billet identification
- (d) The number of items inspected, disposition and date
- (e) All information on the equipment, its calibration, transducer, etc., shall be either kept on file for review by the Purchaser or submitted as part of the certificate of test performed
- (f) Signature of designated personnel
- (g) Average noise level
- (h) Billet map
- (i) This GE specification number, class and issue number

3.11 Marking. Material which has satisfactorily met the ultrasonic inspection requirements shall be identified by a unique symbol. Where it is not practical to mark the material, the symbol may be marked on the identifying paperwork or container. Identification of the Supplier's symbol shall be submitted to the Purchaser. The plan for marking shall require approval of the Purchaser.



\perp	Z	0.0015 (0.038 mm)
\square		0.0015 (0.038 mm)

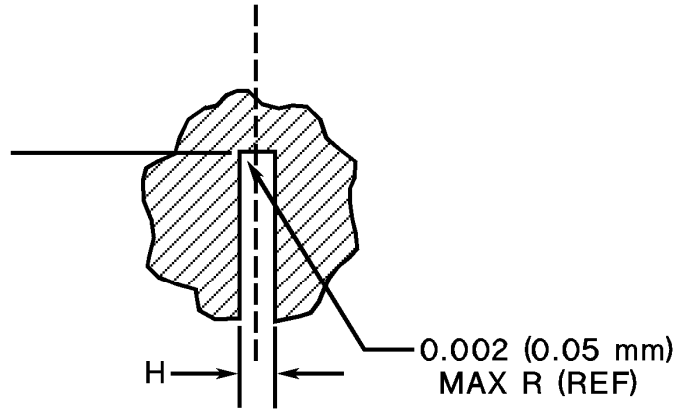


Figure 1 - Calibration Standard

P3TF15-S16

CLASS	TYPICAL MATERIALS	"T" BILLET NOMINAL DIAMETER INCH (mm)	"B" NEAR SURFACE HOLE In. (mm)	"H" HOLE DIAMETER				CALIB. AMP., % FSH	REJECT AMPLITUDE, % FSH	ALARM THRESH/ EVAL LIMIT, % FSH (SEE NOTE 2)
				NO.	64's	INCH	(mm)			
A	GENERAL	4.5 to 9 (114 to 229)	0.50 (12.7)	3	3/64	0.047	(1.19)	80	40	20
	APPLICATIONS - COARSE	Over 9 to 12 (229 to 305)	0.50 (12.7)	4	4/64	0.062	(1.57)			
	GRAIN MATERIALS	OVER 12 (305)	0.75 (19.0)	5	5/64	0.078	(1.98)			
B	TITANIUM ALLOYS - ZONED INSPECTION	4.5 to 10 (114 to 254)	0.2 (5.1)	2	2/64	0.031	(0.79)	80	70	50
		Over 10 (254)	0.2 (5.1)	3	3/64	0.047	(1.19)	80	40 (0.2 to 4 inches depth)	28
									60 (Over 4 inches depth)	42
		All							Any signal over 2.5 SNR	
C	FINE GRAIN Nickel Alloys	4.5 to 12 (114 to 305)	0.25 (6.35)	2	2/64	0.031	(0.79)	80	40	20
		OVER 12 (305)							60	30
		All							Any signal over 2.5 SNR	
D	RENE '95	4.5 to 12 (114 to 305)	0.50 (12.7)	1	1/64	0.016	(0.40)	80	15	10
E	GENERAL APPLICATION	10 and under (254)	0.50 (12.7)	2	2/64	0.031	(0.79)	80	60	30
	SENSITIVITY INSPECTION	OVER 10 (254)		3	3/64	0.047	(1.19)			
F	TITANIUM ALLOYS NON-PREMIUM	4.5 to 5.0 (114 to 127)	0.25 (6.35)	3	3/64	0.047	(1.19)	80	50	25
		Over 5 to 10 (127 to 254)	0.375 (9.53)	3	3/64	0.047	(1.19)	80	55	27
		Over 10 to 13 (254 to 330)	0.50 (12.7)	3	3/64	0.047	(1.19)	80	60	30
		Over 13 (330)	0.62 (15.7)	3	3/64	0.047	(1.19)	80	65	32

NOTE 1: Typical standard variations may be approved by the Certifying Agent.

NOTE 2: CLASSES A, C, E, and F: Based on -6dB EBW and scan speed. Alarm threshold and evaluation limit may be increased along with changes in index and scan speed in accordance with 3.6.6 and Table III.
 CLASS B: Based on -3dB EBW and scan speed.
 CLASS D: Maximum scan index shall be 50% of the -6dB EBW.

Figure 1 - Calibration Standard - Continued

Figure 2 - Deleted

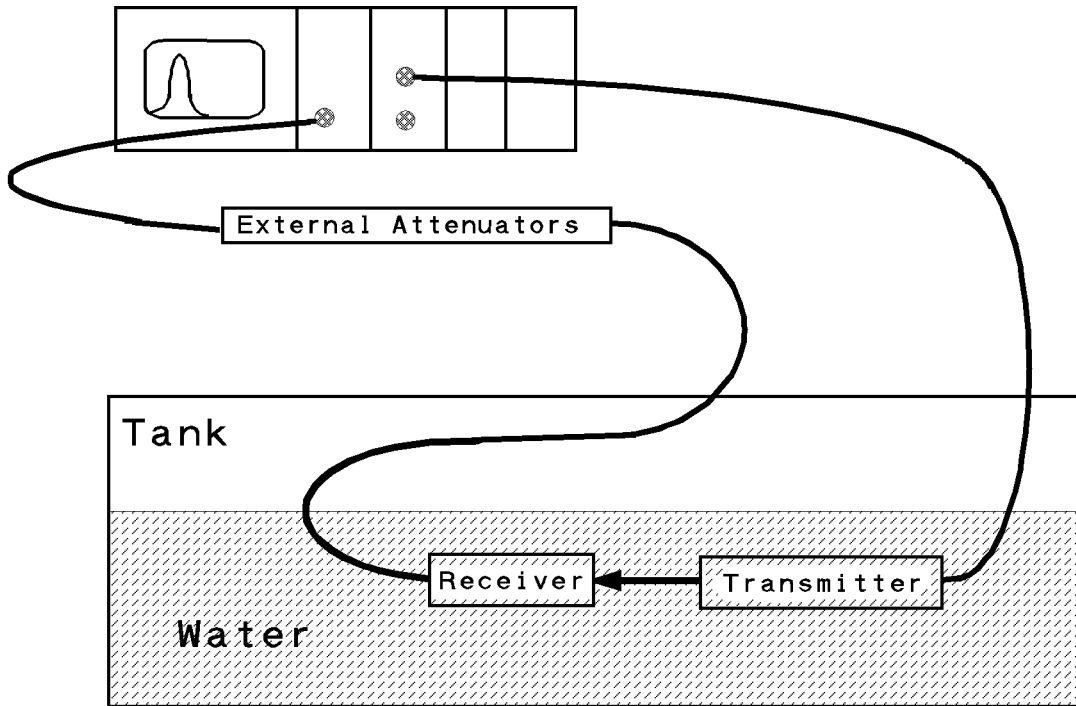


Figure 3 - Through Transmission Setup with External Attenuators

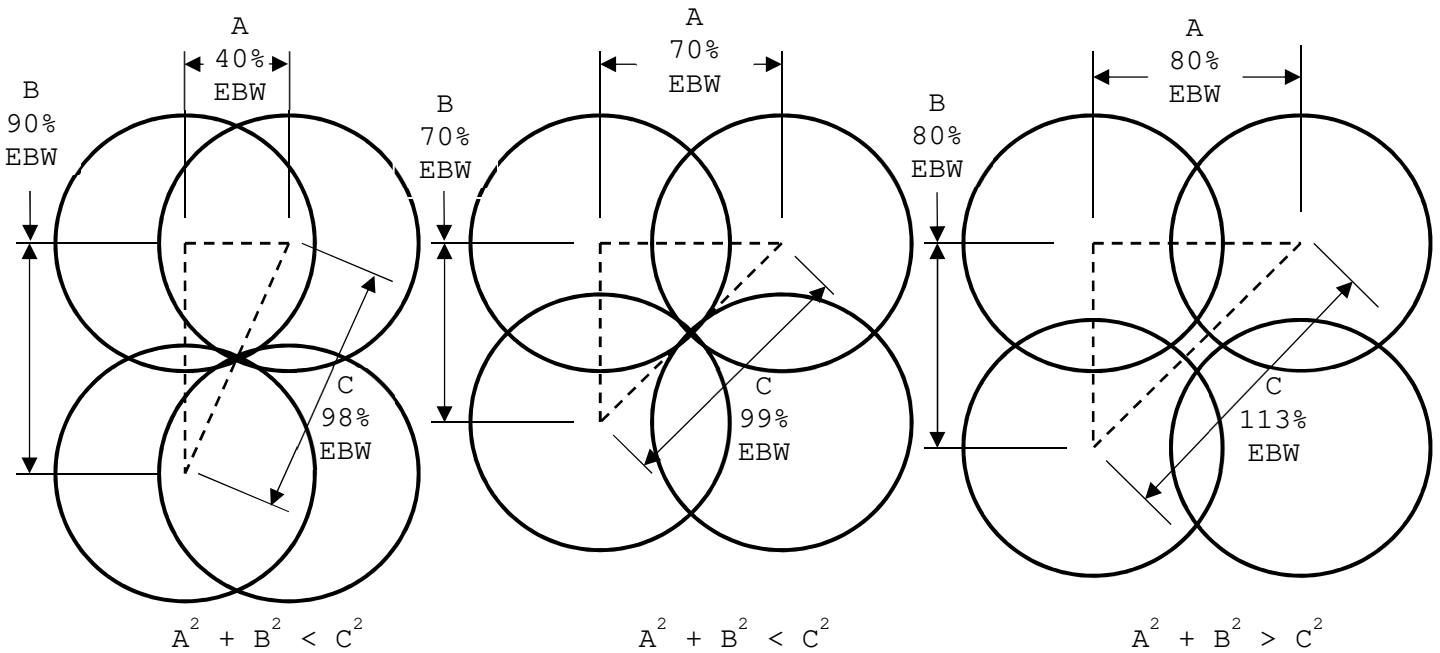


Figure 4a - Acceptable Spacing

Figure 4b - Acceptable Spacing

Figure 4c - Unacceptable Beam Spacing

Figure 4 - Spacing

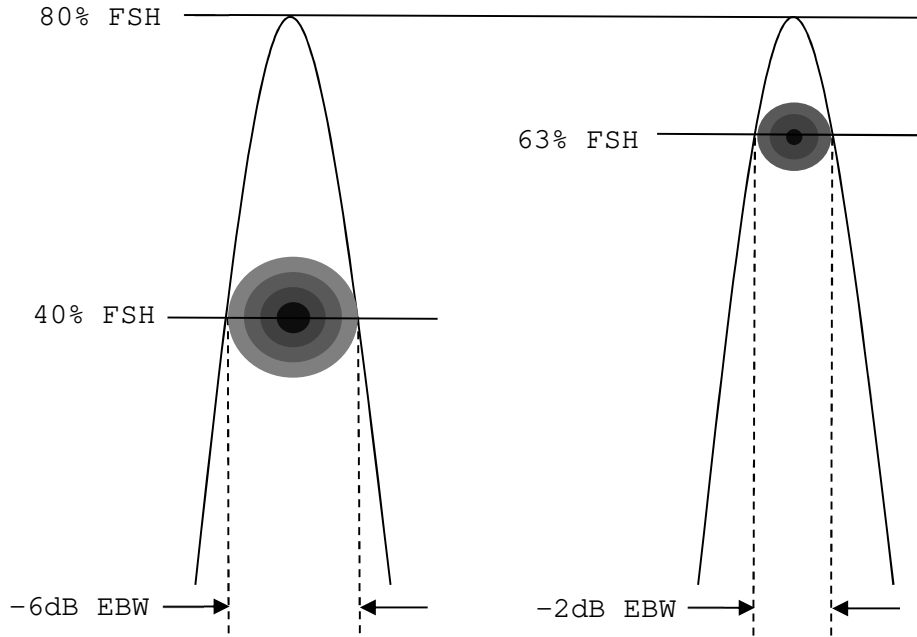


Figure 5 - EBW

4. NOTES

4.1 Purpose. This section contains information of a general nature, which may be helpful, but is not mandatory. It does not contain any requirements.

4.2 Data For Ordering (DFO) Sheet. CLASS B: DFO-P3TF15, lists approved inspection sources and equipment (see 3.1.3).

4.3 Deleted

4.4 Alternative Inspection Procedures. The approval of alternative inspection procedures is based upon the Certifying Agent approving the procedure as being equal to or better than the ultrasonic inspection requirements of this specification. The alternative procedures may allow variances in processing details; but are still required to meet the technical requirements specified for the billet(s).

4.5 Etching After Indication Removal. Aggressive mechanical polishing processes can smear titanium alloy material and degrade the effectiveness of penetrant inspection to detect cracks. When aggressive mechanical polishing processes are used to remove billet surface indications, penetrant inspection to confirm complete indication removal should be preceded by an appropriate etching process to remove smeared metal.

APPENDIX A

CLASS B TITANIUM ALLOYS ZONED INSPECTION

RECOMMENDED PRACTICE

A.1 CLASS B - TITANIUM ALLOYS ZONED INSPECTION - RECOMMENDED PRACTICE

A.1.1 Billet Diameter 5 inch (127 mm). Use transducers for 5 - 6 inch (127 - 152 mm) diameter with 3.5 inches (89 mm) waterpath.

Zone	Zone Start inches (mm)	Zone End inches (mm)	Gate Start	Gate End	Pulses per Rev.
1	0.2 (5.1)	0.75 (19)	0.2 (5.1)	1.15 (29)	1024
2	0.75 (19)	1.5 (38)	0.35 (8.9)	1.9 (48)	512
3	1.5 (38)	2.25 (57)	1.1 (28)	2.65 (67)	512
4	2.25 (57)	3.0 (76)	1.85 (47)	3.5 (89)	256

A.1.2 Billet Diameter 6 inch (152 mm). Use transducers for 5 - 6 inch (127 - 152 mm) diameter with 3.0 inches (76 mm) waterpath.

Zone	Zone Start inches (mm)	Zone End inches (mm)	Gate Start	Gate End	Pulses per Rev.
1	0.2 (5.1)	0.8 (20)	0.2 (5.1)	1.25 (32)	1024
2	0.8 (20)	1.7 (43)	0.4 (10)	2.15 (55)	1024
3	1.7 (43)	2.6 (66)	1.25 (32)	3.05 (77)	512
4	2.6 (66)	3.5 (89)	2.15 (55)	3.95 (100)	256

A.1.3 Billet Diameter 7 inch (178 mm). Use transducers for 7 - 8 inch (178 - 203 mm) diameter with 3.5 inches (89 mm) waterpath.

Zone	Zone Start inches (mm)	Zone End inches (mm)	Gate Start	Gate End	Pulses per Rev.
1	0.2 (5.1)	0.8 (20)	0.2 (5.1)	1.2 (31)	1024
2	0.8 (20)	1.6 (41)	0.4 (10)	2.0 (51)	1024
3	1.6 (41)	2.4 (61)	1.2 (31)	2.8 (71)	512
4	2.4 (61)	3.2 (81)	2.0 (51)	3.6 (91)	512
5	3.2 (81)	4.0 (102)	2.8 (71)	4.4 (112)	256

A.1.4 Billet Diameter 8 inch (203 mm). Use transducers for 7 - 8 inch (178 - 203 mm) diameter with 3.0 inches (76 mm) waterpath.

Zone	Zone Start inches (mm)	Zone End inches (mm)	Gate Start	Gate End	Pulses per Rev.
1	0.2 (5.1)	0.9 (23)	0.2 (5.1)	1.35 (34)	1024
2	0.9 (23)	1.8 (46)	0.45 (11)	2.25 (57)	1024
3	1.8 (46)	2.7 (69)	1.35 (34)	3.15 (80)	512
4	2.7 (69)	3.6 (91)	2.25 (57)	4.05 (103)	512
5	3.6 (91)	4.5 (114)	3.15 (80)	4.95 (126)	256

A.1.5 Billet Diameter 9 inch (229 mm). Use transducers for 9 - 10 inch (229 - 254 mm) diameter with 3.5 inches (89 mm) waterpath.

Zone	Zone Start inches (mm)	Zone End inches (mm)	Gate Start	Gate End	Pulses per Rev.
1	0.2 (5.1)	0.8 (20)	0.2 (5.1)	1.2 (31)	1024
2	0.8 (20)	1.6 (41)	0.4 (10)	2.0 (51)	1024
3	1.6 (41)	2.4 (61)	1.2 (31)	2.8 (71)	1024
4	2.4 (61)	3.2 (81)	2.0 (51)	3.6 (91)	512
5	3.2 (81)	4.1 (104)	2.8 (71)	4.5 (114)	512
6	4.1 (104)	5.0 (127)	3.7 (94)	5.4 (137)	256

A.1.6 Billet Diameter 10 inch (254 mm). Use transducers for 9 - 10 inch (229 - 254 mm) diameter with 3.0 inches (76 mm) waterpath.

Zone	Zone Start inches (mm)	Zone End inches (mm)	Gate Start	Gate End	Pulses per Rev.
1	0.2 (5.1)	0.9 (23)	0.2 (5.1)	1.35 (34)	1024
2	0.9 (23)	1.8 (46)	0.45 (11)	2.25 (57)	1024
3	1.8 (46)	2.7 (69)	1.35 (34)	3.15 (80)	1024
4	2.7 (69)	3.6 (91)	2.25 (57)	4.05 (103)	512
5	3.6 (91)	4.5 (114)	3.15 (80)	4.95 (126)	512
6	4.5 (114)	5.5 (140)	4.05 (103)	5.95 (151)	256

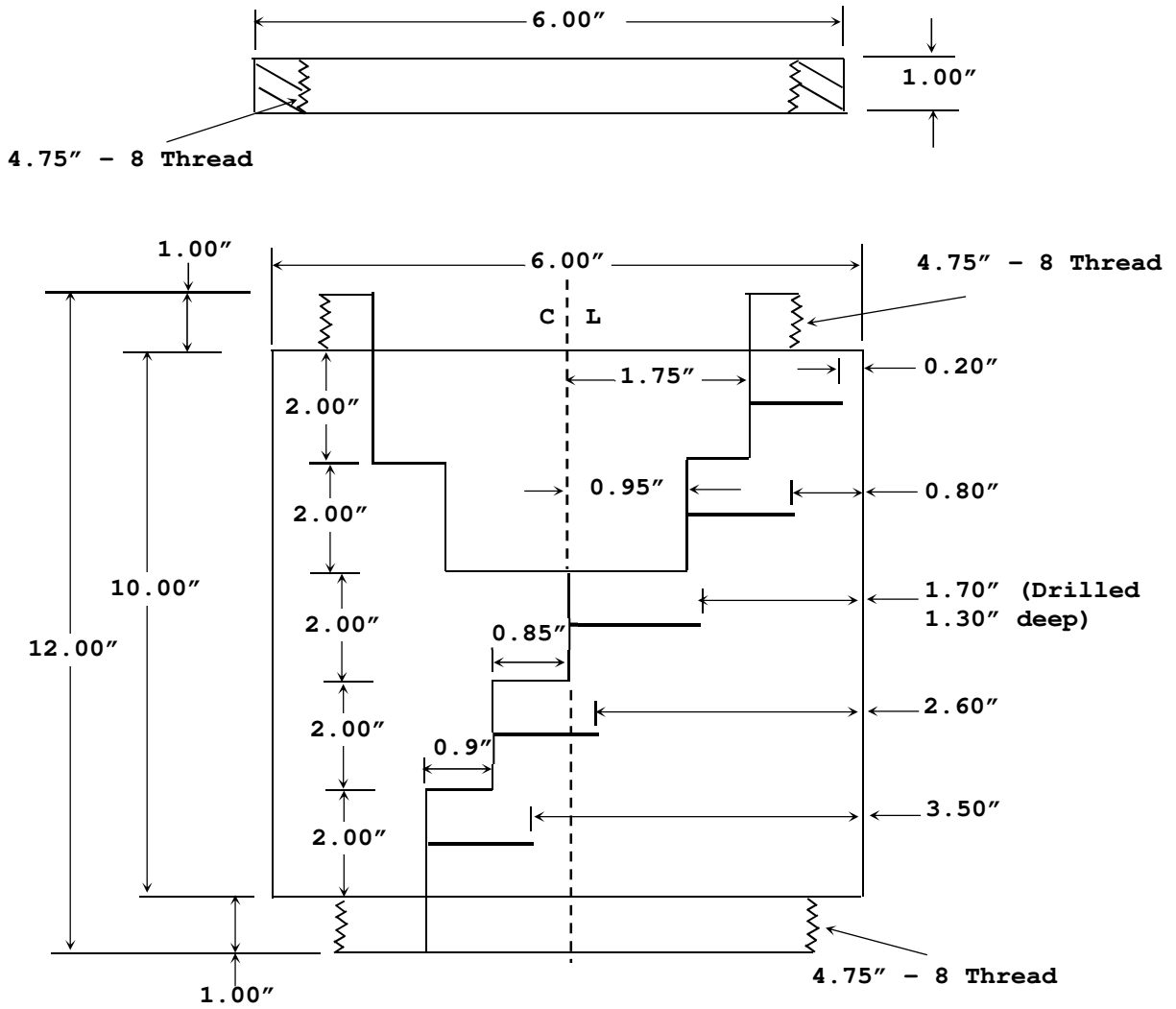
A.1.7 Billet Diameter 12 inch (305 mm). Use transducers for 12 - 13 inch (305 - 330 mm) diameter with 4.0 inches (102 mm) waterpath.

Zone	Zone Start inches (mm)	Zone End inches (mm)	Gate Start	Gate End	Pulses per Rev.
1	0.2 (5.1)	0.9 (23)	0.2 (5.1)	1.35 (34)	1024
2	0.9 (23)	1.8 (46)	0.45 (11)	2.25 (57)	1024
3	1.8 (46)	2.7 (69)	1.35 (34)	3.15 (80)	1024
4	2.7 (69)	3.6 (91)	2.25 (57)	4.05 (103)	1024
5	3.6 (91)	4.5 (114)	3.15 (80)	4.95 (126)	512
6	4.5 (114)	5.5 (140)	4.05 (103)	5.95 (151)	512
7	5.5 (140)	6.5 (165)	5.05 (128)	6.95 (177)	256

A.1.8 Billet Diameter 13 inch (330 mm). Use transducers for 12 - 13 inch (305 - 330 mm) diameter with 3.5 inches (89 mm) waterpath.

Zone	Zone Start inches (mm)	Zone End inches (mm)	Gate Start	Gate End	Pulses per Rev.
1	0.2 (5.1)	1.0 (25)	0.2 (5.1)	1.5 (38)	1024
2	1.0 (25)	2.0 (51)	0.5 (13)	2.5 (63)	1024
3	2.0 (51)	3.0 (76)	1.5 (38)	3.5 (89)	1024
4	3.9 (76)	4.0 (102)	2.5 (63)	4.5 (114)	1024
5	4.0 (102)	5.0 (127)	3.5 (89)	5.5 (140)	512
6	5.0 (127)	6.0 (152)	4.5 (114)	6.5 (165)	512
7	6.0 (152)	7.0 (178)	5.5 (140)	7.5 (191)	256

P3TF15-S16



Holes are $1/32$ " diameter Flat Bottom 1.25" deep except hole .200" from O.D. (1.050" deep) and hole 1.70" from O.D. (1.300" deep)

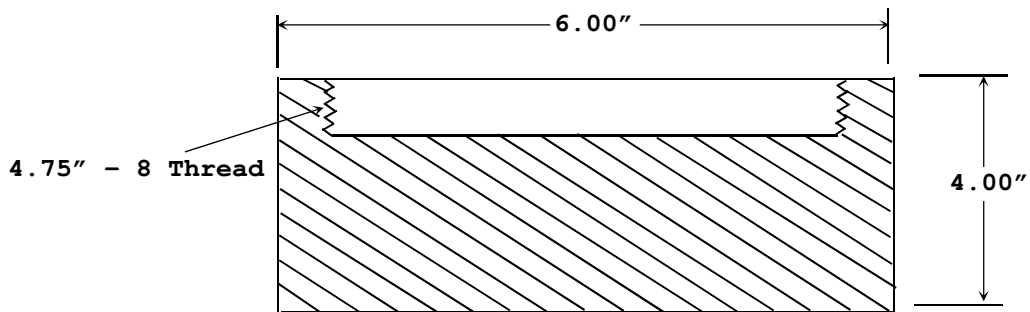


Figure A-2
Titanium Calibration Standard, 6 inch (152 mm) diameter - P3TF15, CL-B

P3TF15-S16

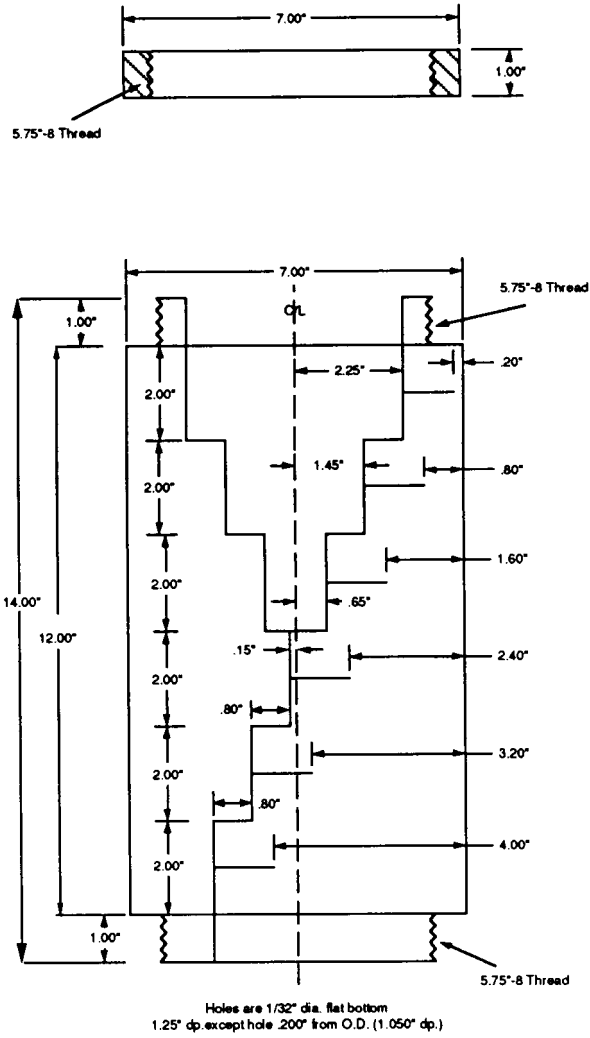


Figure A-3
Titanium Calibration Standard, 7 inch (178 mm) diameter - P3TF15, CL-B

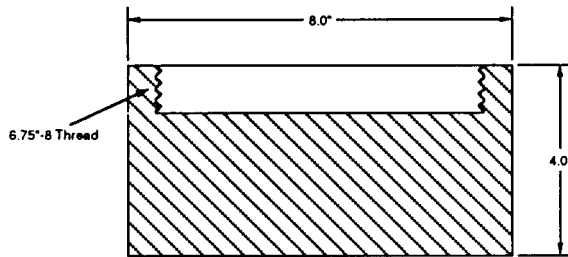
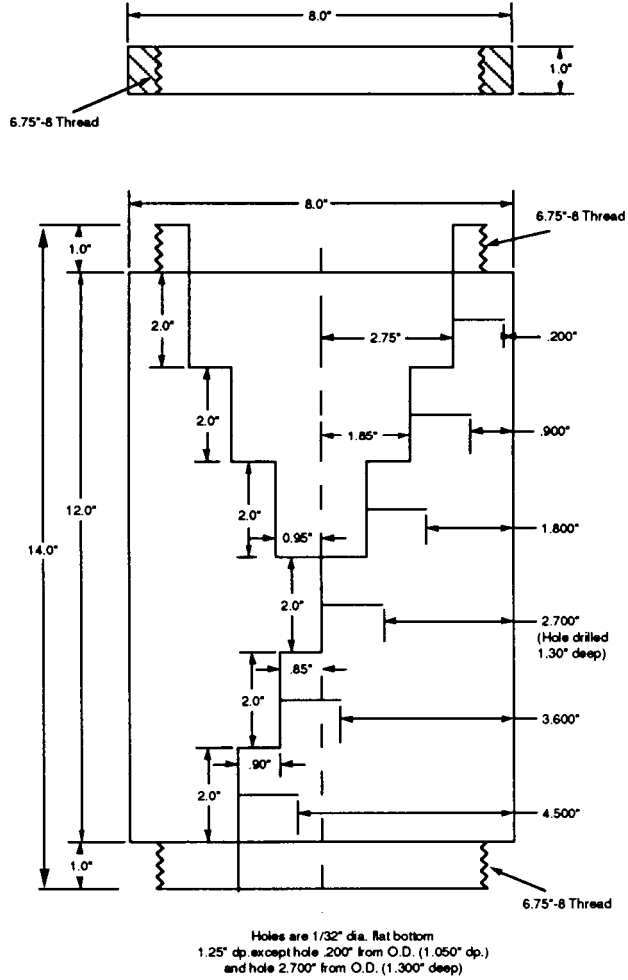


Figure A-4
 Titanium Calibration Standard, 8 inch (203 mm) Diameter - P3TF15, CL-B

P3TF15-S16

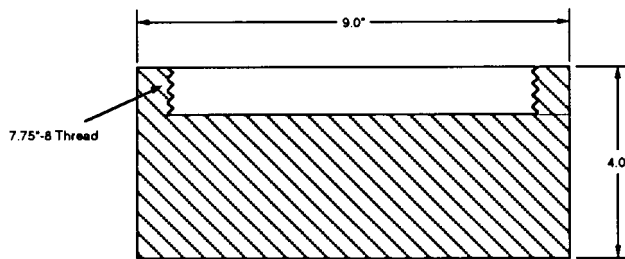
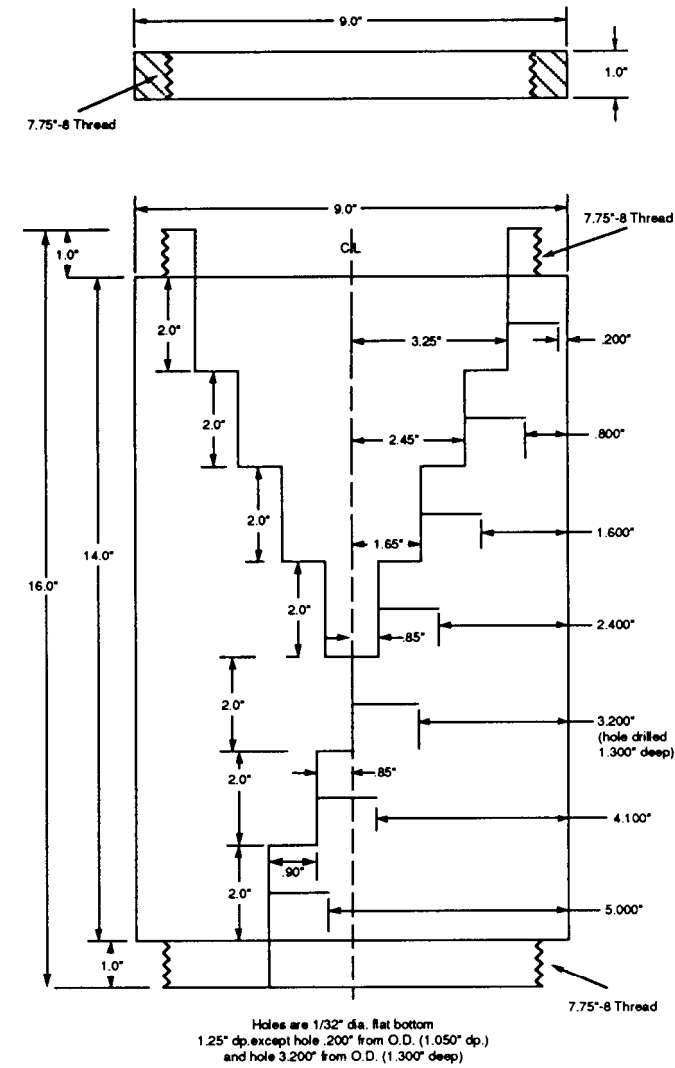
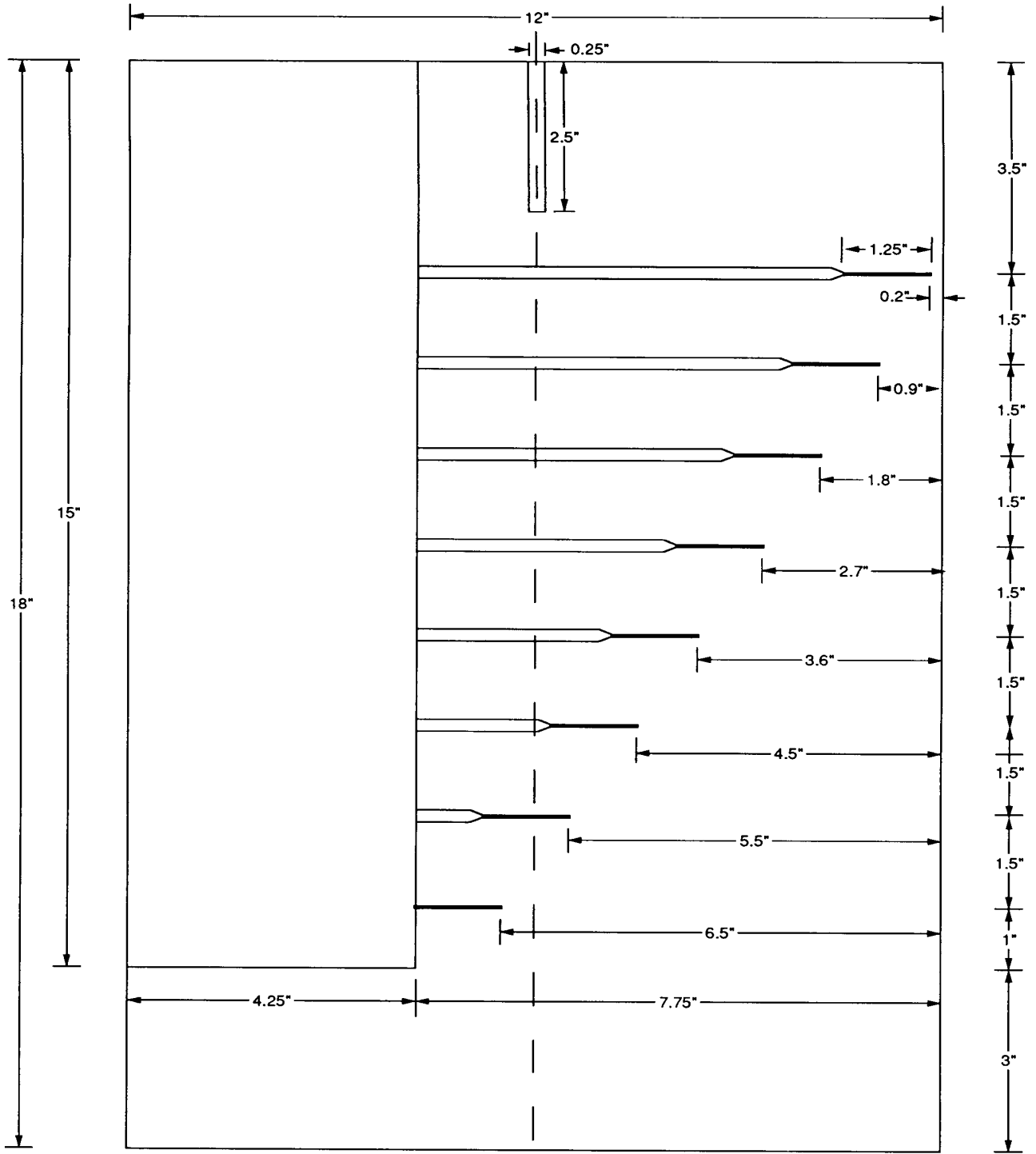


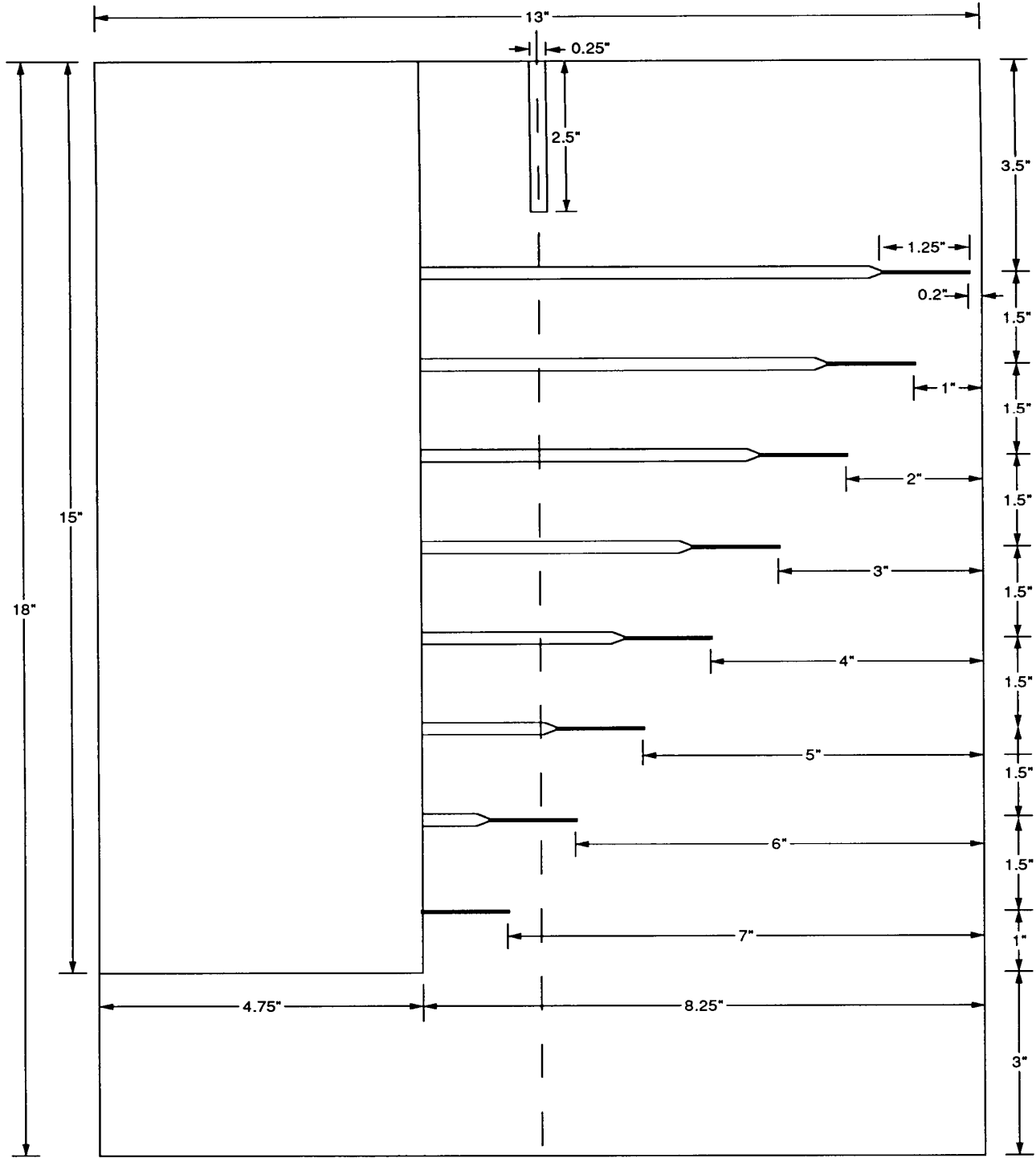
Figure A-5
 Titanium Calibration Standard, 9 inch (229 mm) diameter - P3TF15, CL-B



CL

Holes are 3/64" dia., flat bottom, 1.25" deep from 3/16" dia. counterbore except where noted.

Figure A-7
 Titanium Calibration Standard, 12 inch (305 mm) diameter - P3TF15, CL-B



CL

Holes are 3/64" dia., flat bottom, 1.25" deep from 3/16" dia. counterbore except where noted.

Figure A-8
 Titanium Calibration Standard, 13 inch (330 mm) diameter - P3TF15, CL-B

APPENDIX B

CLASS B TITANIUM ALLOYS ZONED INSPECTION

RECOMMENDED TRANSDUCERS

B.1 CLASS B - TITANIUM ALLOYS ZONED INSPECTION - RECOMMENDED TRANSDUCERS
FOR 5 TO 13 INCH (127 TO 330 MM) BILLETB.1.1 Recommended Transducers for 5 - 6 Inch (127 - 152 mm) Diameter.

Zone	Diameter inches (mm)	Focal Len. Axial inches (mm)	Focal Len. Circum. inches (mm)	Focal Depth inches (mm)
1	0.75 (19)	4.5 (114)	4.5 (114)	0.4 (10)
2	1.0 (25)	8.0 (203)	5.2 (132)	1.2 (31)
3	1.375 (35)	11.8 (300)	5.7 (145)	2.1 (53)
4	1.75 (45)	15.5 (394)	6.0 (152)	3.0 (76)

B.1.2 Recommended Transducers for 7 - 8 Inch (178 - 203 mm) Diameter.

Zone	Diameter inches (mm)	Focal Len. Axial inches (mm)	Focal Len. Circum. inches (mm)	Focal Depth inches (mm)
1	0.75 (19)	4.5 (114)	4.5 (114)	0.4 (10)
2	1.0 (25)	8.4 (213)	5.7 (145)	1.3 (33)
3	1.375 (35)	12.2 (310)	6.3 (160)	2.2 (56)
4	1.75 (45)	15.9 (404)	6.7 (170)	3.1 (79)
5	2.35 (60)	19.7 (500)	7.0 (178)	4.0 (102)

B.1.3 Recommended Transducers for 9 - 10 Inch (229 - 254 mm) Diameter.

Zone	Diameter inches (mm)	Focal Len. Axial inches (mm)	Focal Len. Circum. inches (mm)	Focal Depth inches (mm)
1	0.75 (19)	4.5 (114)	4.5 (114)	0.4 (10)
2	1.25 (32)	8.6 (218)	6.0 (152)	1.3 (33)
3	1.5 (38)	12.3 (312)	6.9 (175)	2.2 (56)
4	1.75 (45)	16.1 (409)	7.4 (188)	3.1 (79)
5	2.0 (51)	19.8 (503)	7.7 (196)	4.0 (102)
6	2.35 (60)	23.5 (597)	8.0 (203)	5.0 (127)

B.1.4 Recommended Transducers for 12 - 13 Inch (305 - 330 mm) Diameter.

Zone	Diameter inches (mm)	Focal Len. Axial inches (mm)	Focal Len. Circum. inches (mm)	Focal Depth inches (mm)
1	0.75 (19)	5.4 (137)	5.4 (137)	0.4 (10)
2	1.0 (25)	9.8 (249)	7.0 (178)	1.5 (38)
3	1.375 (35)	13.9 (353)	8.1 (206)	2.5 (64)
4	1.75 (45)	18.1 (460)	8.9 (226)	3.5 (89)
5	2.35 (60)	22.3 (566)	9.3 (236)	4.5 (114)
6	2.35 (60)	26.4 (671)	9.7 (246)	5.5 (140)
7	2.35 (60)	30.6 (777)	10.0 (254)	6.5 (165)

REVISION HISTORY

P3TF15-S1	INITIAL ISSUE	05-06-82
-S2	DCID 34856	05-17-82
-S3	CID 74958	02-14-86
-S4	CID 75228	03-30-87
-S5	CID 075827	05-30-89
-S6	CID 076676	04-19-90
-S7	CID 076791	10-15-90
Amend 1	CID 076701	01-08-91
-S8	CID 077665	04-13-93
-S9	CID 077786	09-01-93
-S10	CID 078075	12-16-94
-S11	CID 078180	06-03-95
-S12	CID 078259	10-23-95
Amend 1	CID 078341	02-12-96
-S13	CID 078509	04-16-97
-S14	CID 078898	07-24-00
-S15	CID 558187	01-31-11
-S16	CID 558929	01-13-20

* DENOTES LATEST REVISION