Summary:

This document defines the procedures for the ultrasonic testing of forgings, hipped parts, bar stock, and mill shapes in accordance with API 6A / 17D.

Reviewed By:

Ed Briggs

September 15, 2015

ASNT Level III, #1522
# Table of Contents

1.0 SCOPE ........................................................................................................... 4  
2.0 PERSONNEL .................................................................................................. 4  
3.0 REFERENCED DOCUMENTS ......................................................................... 5  
4.0 GENERAL ....................................................................................................... 6  
5.0 ULTRASONIC EQUIPMENT .......................................................................... 6  
6.0 MATERIAL CONDITION ............................................................................... 10  
7.0 CALIBRATION ............................................................................................. 11  
8.0 TRANSFER CORRECTION .......................................................................... 12  
9.0 RECALIBRATION ........................................................................................ 14  
10.0 EXAMINATION PROCEDURE .................................................................... 15  
11.0 GENERAL ACCEPTANCE CRITERIA for FORGINGS, BARSTOCK, MILL SHAPES .................................................................................... 19  
12.0 SPECIFIC ACCEPTANCE CRITERIA for FORGINGS, BAR STOCK, AND MILL SHAPES .................................................................................... 19  
13.0 REPORTING ................................................................................................ 20
List of Figures

Figure 1: Transfer Correction – Straight Beam ................................................................. 12
Figure 2: Transfer Correction – Angle Beam ................................................................. 13
Figure 3: Scan Plan for Barstock and Solid Rounds .................................................... 16
Figure 4: Scan Plan for Tubing and ID/OD Rounds .................................................... 17
Figure 5: Scan Plan for Squares and Rectangles ......................................................... 17
Figure 6: Scan Plan for Valve Bodies ......................................................................... 18
Figure 7: Scan Plan for Heads and Spools .................................................................. 18
1.0 SCOPE

1.1 Suppliers shall work to the latest revision of this procedure and be responsible for training personnel in the use of the procedure and maintaining records of the training. If the supplier prefers to use his own procedure that is fully compliant to the FMC specification, he shall submit this to FMC for written approval prior to use on a specific application basis.

1.2 The NDE provider shall perform ultrasonic examination of raw material (forgings, hipped parts, bar stock, and mill shapes) in accordance with API 6A / 17D. API 6A will reference ASTM A388 and mandates the flat bottom hole technique; the back reflection technique shall not be employed on production components.

NOTE: In the balance of this procedure, the term "forging" shall include open and closed die forgings, ring roll forgings, hipped parts, bar stock, and mill shapes when this procedure is employed.

1.3 Refer to the Part Report (Data Base Information (DBI), quality matrix or engineering drawing to identify the applicable industry standard, API Product Specification (API 6A, 16A or 17D) or NORSOK. For API Product Specifications, refer to the Part Report (DBI) to determine quality level (PSL 1, PSL 2, PSL 3 or PSL 4) in order to determine the appropriate scope of examination.

1.4 For Part Reports (DBIs) which indicate "NA" for the Product Specification, utilize API 6A. For API 6A DBIs which indicate a PSL range, select the highest PSL. If the DBI indicates "NA" for the quality level, utilize PSL 1.

1.5 For final certification purposes, the material shall be inspected after completion of heat treatment.

1.6 For shapes where scanning from both sides is not possible over a region of the material (reference figures 3 through 7), the supplier shall submit a scan plan to identify how this area will be scanned and the dead zone kept to 1/4" (6.35 mm) or less. This scan plan shall be submitted to FMC and approved in writing prior to conducting the inspection. This is on an FMC part number basis and once approved will remain approved regardless of the part revision level.

2.0 PERSONNEL

2.1 NDE personnel responsible for NDE activities shall be nationally certified to Level III in the applicable NDE test method in accordance with ASNT or ISO 9712 requirements.

2.2 Personnel performing inspections and interpreting results shall be certified to a minimum Level II by an independent certification body or authorized qualifying body (ISO 9712, ASNT ACCP), or SNT-TC-1A certification validated by FMC designated certification organization.
FMC is developing a major revision of our technician certification requirements that will be worked in collaboration with the approved NDE service suppliers on our Global Special Process Supplier List and aligned with customers' requirements. Until a new agreement of requirements is achieved with Petrobras, the requirement noted below shall apply to all FMC Brazil purchase orders.

"All parts manufactured for FMC Brazil purchase orders shall be inspected by NDE personnel qualified to a primary nationally accredited entity (ASNT, ACCP, EN-ISO 9712, CGSB, or equivalent). Technicians qualified and certified in accordance with SNT-TC-1A are not acceptable for performing NDE methods of testing on parts manufactured for FMC Brazil.

2.3 Level I personnel may perform inspections under the direct supervision of Level II or Level III personnel.

3.0 REFERENCED DOCUMENTS

Ultrasonic examinations shall be performed in accordance with a written procedure which shall, as a minimum, contain the requirements listed in this document, and the applicable industry specification(s) referenced. The written procedure(s) shall establish a single value, or range of values, for each requirement.

The supplier procedures shall be submitted to and approved in writing by the appropriate FMC Subject Matter Expert (SME) personnel prior to use in production work.

The latest revision of the following associated specifications shall be utilized, where applicable, as a part of the requirements of this specification.

<table>
<thead>
<tr>
<th>FMC Procedure / Specification</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q02310</td>
<td>FMC Specification for Referencing Other Ultrasonic Testing Specifications and Procedures (Bridging Document)</td>
</tr>
<tr>
<td>FMC Q02200</td>
<td>Nondestructive Examination Personnel Qualification and Certification (Written Practice)</td>
</tr>
<tr>
<td>FMC Q00100</td>
<td>Edition / Revision Levels of FMC Technologies Referenced Specifications</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Industry Specification</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>API Spec 17D</td>
<td>Specification for Subsea Wellhead and Christmas Tree Equipment</td>
</tr>
<tr>
<td>API 6A</td>
<td>Specification for Wellhead and Christmas Tree Equipment</td>
</tr>
<tr>
<td>ASME BPVC Section V</td>
<td>Nondestructive Examination, Article 5, Ultrasonic Examination Methods for Materials</td>
</tr>
<tr>
<td>SNT-TC-1A</td>
<td>ASNT Recommended Practice for the Qualification and Certification for Nondestructive Testing Personnel</td>
</tr>
<tr>
<td>EN-473 / ISO 9712</td>
<td>Nondestructive Testing – Qualification and Certification of NDT Personnel</td>
</tr>
<tr>
<td>ASTM A388</td>
<td>Standard Practice for Ultrasonic Examination of Steel Forgings</td>
</tr>
<tr>
<td>ASTM E114</td>
<td>Standard Practice for Ultrasonic Pulse-Echo Straight-Beam Examination by the Contact Method</td>
</tr>
<tr>
<td>ASTM E428</td>
<td>Standard Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Testing</td>
</tr>
<tr>
<td>ASTM E587</td>
<td>Standard Practice for Ultrasonic Angle Beam Examination by the Contact Method</td>
</tr>
<tr>
<td>ASTM E2375</td>
<td>Standard Practice for Ultrasonic Testing of Wrought Products</td>
</tr>
</tbody>
</table>

4.0 **GENERAL**

The following information contains acceptable ultrasonic procedures for inspection of API equipment, and shall be adhered to for such equipment. API equipment shall be indicated as such on the Part Report (DBI) or engineering documents.

4.1 As far as practical, subject the entire volume of each item to ultrasonic examination in the required number of perpendicular directions. For Scan Plans of typical shapes, refer to Figures 3 thru 7.

4.2 If, due to configuration, the item cannot be 100% volumetrically examined in the required number of perpendicular directions using the straight beam technique, use angle beam examination as necessary to effect 100% of maximum feasible coverage. When the configuration does not allow 100% volumetric examination, the report shall include a description of the area where UT is not performed.

5.0 **ULTRASONIC EQUIPMENT**

5.1 Instrument

5.1.1 A pulse-echo ultrasonic instrument capable of generating frequencies from 1 MHz to 10 MHz will be utilized for all examinations. The
instrument will have a linear presentation (within 5%) for at least 75% of the screen height. Linearity will be verified per ASTM E317. The ultrasonic instrument will utilize a calibrated amplitude control, accurate over its useful range to +10% of the nominal amplitude ratio, to allow measurement of indications beyond the linear range of the vertical display on the instrument CRT.

5.1.2 Controls that affect instrument linearity will be in the OFF position during calibration, calibration check and examination.

5.1.3 Alarms will be clearly audible or visible to the examiner, when used.

5.1.4 Recording equipment will produce a clear, unambiguous inspection record, when used.

5.2 Search Unit

5.2.1 Straight beam scanning will be performed with a search unit having a maximum active area of 1 sq. in. (645 sq. mm) with 3/4 inch (19.05mm) minimum and 1-1/8 inch (28.6mm) maximum dimensions. The preferred search unit frequency is 2.25 to 5 MHz. For austenitic materials or other course gained material, a lower frequency transducer may be used down to 1 MHz.

5.2.2 A smaller sized search unit may be used to better investigate various geometries to help pinpoint and evaluate indications, as necessary.

5.2.3 Angle beam scanning will normally be performed with a 1 inch (25.4mm) x 1 inch (25.4mm) or 1 inch (25.4mm) x ½ inch (12.7mm) search unit. A 45 degree angle wedge will be used unless the OD/ID ratio or other geometric configuration causes a failure to calibrate. The preferred search unit frequency is 2-1/4 MHz. For austenitic materials or other course gained material, a lower frequency transducer may be used down to 1 MHz. Other angle wedges may be used as required to facilitate inspection.

5.2.4 Search units will be used at their rated frequencies.

5.2.5 Variables such as production material grain structure, geometry, thickness, and anticipated type / size of discontinuities to be detected, may require the use of other frequencies to assure adequate penetration, and better resolution.

5.2.6 Certification is required on all search units. Minimum certification will include the search unit waveform, frequency spectrum, and effective beam dimensions at -3 db from the center axis amplitude.
5.3 Couplant

5.3.1 Couplants with good wetting characteristics such as light weight oil, glycerin, cellulose or equivalent will be used. The couplant used will not be harmful to the part being examined.

5.3.2 The couplant used for calibration will be the same couplant used during examination.

5.4 Reference Blocks - Straight Beam

5.4.1 The material to be used for reference blocks shall be similar in its acoustic attenuation to the material which is to be examined. The grain size, heat treat condition, physical and chemical composition, surface finish, and manufacturing procedure (rolling, forging, and so forth) are variables to be considered in matching acoustic responses.

5.4.2 The block material will be ultrasonically examined and meet the requirements of ASTM E428.

5.4.3 Each reference block will be serialized. Records will be retained to provide traceability to material and inspection results.

5.4.4 Surface finish of the reference blocks shall be comparable to, but no better than the item to be examined.

5.4.5 Geometry of the reference blocks is not limited to the requirements of ASTM E428. An actual item or other shape can be used provided that the blocks demonstrate the required accuracy.

5.4.6 Each reference block will be permanently marked with the type and size of reflector(s). Reflectors in each block will meet the following requirements:

- Straight Beam Examination Reference Blocks
  
  - 1/16-inch (1.6mm) Flat Bottom Hole for thickness up to and including 1-1/2-inches (38mm)
  
  - 1/8-inch (3.2mm) Flat Bottom Hole for thickness greater than 1-1/2 (38mm) up to and including 6-inches (152mm)
  
  - ¼-inch (6.35mm) Flat Bottom Hole for thickness greater than 6-inches (152mm)

- Angle Beam Examination Reference Blocks

5.4.7 Flat Bottom Hole reference reflectors will meet the dimensional requirements specified in ASTM E428.

Alternate Flat-bottom Hole Sizes - If blocks with the specified flat-bottom hole sizes are not available, alternative sizes may be used provided the
instrument gain is changed by a factor given by the ratio of the areas of the two relevant holes. For cases where only a larger size is available, the gain must be increased by the ratio \((d_r/d_a)^2\), where \(d_r\) and \(d_a\) are respectively the diameters of the reference and specified acceptance flatbottom holes. With instruments having gain controls calibrated in dB, the required change is given by \(40 \log_{10} (d_r/d_a)^2 = \text{dB}\). Table 1 can be used for the extrapolation of gain between any standard hole sizes in the range of 1/64 inch (0.4 mm) through 8/64 inch (3.2 mm). Gain extrapolation shall be restricted to hole diameters having ratios no greater than 2:1, requiring gain changes no greater than 12 dB.

<table>
<thead>
<tr>
<th>Acceptable Flat Bottom Hole Diameter, (\frac{1}{64}) in. [(\text{mm})]</th>
<th>Reference Flat Bottom Hole Diameter, (\frac{1}{64}) in. [(\text{mm})]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 dB</td>
</tr>
<tr>
<td>0.038</td>
<td>-12 dB</td>
</tr>
<tr>
<td>0.121</td>
<td>-7 dB</td>
</tr>
<tr>
<td>0.250</td>
<td>0 dB</td>
</tr>
<tr>
<td>0.322</td>
<td>+5 dB</td>
</tr>
<tr>
<td>0.450</td>
<td>+12 dB</td>
</tr>
<tr>
<td>0.500</td>
<td>+4 dB</td>
</tr>
<tr>
<td>0.625</td>
<td>+5 dB</td>
</tr>
<tr>
<td>0.750</td>
<td>+10 dB</td>
</tr>
<tr>
<td>0.875</td>
<td>+12 dB</td>
</tr>
<tr>
<td>0.988</td>
<td>-16 dB</td>
</tr>
<tr>
<td>1.038</td>
<td>-8 dB</td>
</tr>
<tr>
<td>1.250</td>
<td>-5 dB</td>
</tr>
<tr>
<td>1.625</td>
<td>-2 dB</td>
</tr>
<tr>
<td>2.000</td>
<td>0 dB</td>
</tr>
</tbody>
</table>

Table 1: dB Gain Changes between FBH Sizes

The FMC approved raw material supplier or tier 1 supplier shall be fully responsible for communicating the finished product application of the raw material under inspection to the NDE suppliers.

5.5 Reference Blocks - Angle Beam

5.5.1 The angle beam reference block shall have the same nominal composition, heat treatment, and thickness as the forging it represents. Where a group of identical forgings is made, one of the forgings may be used as the separate calibration standard.
5.5.2 Rings or hollow forgings having an OD/ID ratio of less than 2:1 and an axial length greater than 2-inches (51mm) require ID and OD notches.

5.5.3 Hollow forgings having an axial length greater than 6 times the wall thickness require ID and OD transverse notches.

5.5.4 Rectangular or 60 degree vee notches with a depth equal to the lesser of ¼-inch (6.35mm) or 3% of the wall thickness (1/4-inch maximum), a length of approximately 1-inch (25.4mm) and a width not greater than twice the depth (1/8-inch (3.2mm) maximum). Notches must be oriented 90-degrees from the direction of examination.

5.5.5 Blocks used for angle beam calibration on curved surfaces shall be of similar curvature and thickness as the area under examination. The similarity shall be sufficient to meet the transfer correction criteria in 8.0.

5.5.6 A convex block will be used for convex test surfaces, and a concave block will be used for concave test surfaces, as applicable.

5.6 Reference Blocks - API 6A Stem Material

A 1/8-inch (3.2mm) Flat Bottom Hole for straight beam examination and a 1/16-inch (1.6mm) side drilled hole for angle beam examination. Holes should be drilled radially to a depth of ¾-inch (19mm) or 1/2t, whichever is less.

6.0 MATERIAL CONDITION

6.1 Material shall be examined after heat treatment for mechanical properties (exclusive of stress relief treatments) and prior to machining operations that limit effective interpretation of the examination results.

6.1.1 Forgings that require machining prior to quench and temper will be examined after quench and temper only if the geometrical shape does not limit effective interpretation. Machined forgings that geometrically limit effective interpretation shall be ultrasonically examined while in the simplest shape and examined again after quench and temper.

6.1.2 The surfaces of the forging to be examined shall be free of extraneous material such as loose scale, paint, dirt, and so forth.

6.1.3 The surface roughness of as forged or as cast material must allow proper coupling of the search units, typically a maximum of between 250-350 RMS. The UT technician shall ascertain the surface roughness suitability and direct the need for surface grinding in spots where required. The surface shall be comparable to the reference block used for calibration. Machined surfaces shall have a surface finish of 250 RMS or better.
7.0 CALIBRATION

7.1 Instrument calibration will be in accordance with the latest edition of ASTM E317.

7.2 Straight Beam Calibration

7.2.1 Reference Block Technique - establish a minimum three point DAC curve.

7.2.2 Calibrate Screen Range using the reference block. The screen range shall cover at least 2 material thicknesses.

7.2.3 The db gain control shall be adjusted on the UT instrument so that the indication responding with the highest amplitude is set at 80% of Full Screen Height (FSH). A point, either manually or electronically, shall be made marking the amplitude height on the instrument screen. Without adjusting the gain, a point shall be made for at least 2 other reflectors that are at different distances than the first. A line shall be drawn connecting each point establishing the Distance Amplitude Correction (DAC) curve. The DAC is the Primary Reference Level (PRL).

7.3 Angle Beam Calibration - Rings and Hollow Forgings

7.4 Adjustment of the sweep line will be such that the full scale horizontal distance is equal to or greater than the area of interest.

7.4.1 Adjust the gain to obtain an indication of 80% Full Screen Height (FSH) from the ID notch and mark the peak on the screen.

7.4.2 At the same gain setting, obtain a reflection from the OD notch and mark the peak on the screen.

7.4.3 Connect the screen for the ID and OD notches to provide the 100% DAC Curve. This is the primary reference level. The DAC curve may be manually or electronic displayed.

If the OD notch cannot be detected when examining from the OD surface, perform the examination, when practical, by examining from the OD utilizing the ID notch and examining from the ID utilizing the OD notch.

7.4.4 The calibration for circumferential scanning shall use axial (longitudinal) OD / ID notches. The calibration for axial (longitudinal) scanning shall use OD / ID transverse notches.

7.5 A signal-to-noise of 2:1 or greater is required during calibration.

7.6 Calibration verification is required prior to the evaluation of indications.
7.7 Stem material angle beam calibration is obtained by maximizing the indication amplitude at 80% of full screen height from the 1/16" (1.6 mm) side drill hole with the beam directed along the axis of the calibration standard.

8.0 TRANSFER CORRECTION

8.1 When required, transfer correction shall be used to correlate the amplitudes from the basic calibration block and the production material. Amplitude transfer corrections should be performed at initial examination of a group of similar materials and whenever significant changes in surface roughness, condition profile, or coating observed.

8.2 Straight Beam

8.2.1 The transfer correction shall be accomplished by using the calibration block to establish a DAC. The DAC is established by obtaining a number of backwall echoes and setting the gain to bring the first back-echo to a reference level to 80%, utilizing the peaks of the multiple back-wall echoes to establish a DAC curve. Using the test material, obtain a back-wall echo, and continue to set the gain to bring the back-echo to the established DAC curve, the transfer correction is the difference in gain. Reference Figure 1.

8.2.1 Each type of material and each size and wall thickness shall be considered separately in applying the transfer method. In addition, at least two (2) areas on the production material under examination shall be checked.

Figure 1: Transfer Correction – Straight Beam
8.3 Angle Beam

8.3.1 Transfers shall be accomplished by using the through transmission method and two identical angle probes. For any material thickness, at least full skip shall be used. The amplitudes of both, calibration block and production material shall be evaluated at the established DAC level, the difference in the gain levels between the calibration block and production material responses (A) shall be recorded and used for the correction of the reference sensitivity (Figure 2).

8.3.2 Each type of material and each size and wall thickness shall be considered separately in applying the transfer method. In addition, at least two (2) areas on the production material under examination shall be checked.

8.3.3 A separate transfer correction determination shall be made for each probe angle employed.

8.4 Transfer correction procedure:

8.4.1 The DAC curve shall be established per the requirements of 7.4 for the angle beam probe to be used for the examination.

8.4.2 The calibration block used to establish DAC along with two angle beam probes of the same type used to establish the DAC, one acting as a transmitter (TX) and the second as receiver (RX) (Condition A Calibration
Block above). The probes are directed at each other at one skip distance and the signal adjusted to the established DAC.

8.4.3 Without altering the instruments sensitivity, a maximum reflection is obtained at one skip distance on the production material. (Condition B, Calibration Block above).

8.4.4 The change in gain (dB) required to adjust the amplitude of the signal in condition B to the reference DAC is the "Transfer Correction".

8.5 Allowances shall be made for differences in attenuation or transfer loss between the parent material and the test block used to plot the DAC curves.

8.5.1 Differences of < 2 dB no correction required

8.5.2 Differences >2 dB < 8 dB shall be compensated for by adjusting the primary reference to reflect the transfer correction.

8.5.3 Differences >8 dB shall require further analysis to determine cause and corrective actions. Notify the FMC Level III for further directions.

8.6 The maximum velocity difference between the calibration block and the production material should be 2%.

9.0 RECALIBRATION

9.1 Recalibration is required for significant changes in section thickness or diameter. Any change in the search unit, couplant, operator, instrument settings (excluding the gain or attenuator controls), coaxial cable, temperature variation of + 25°F (14°C) or scanning speed from that used for calibration requires recalibration.

9.2 A complete recalibration is required at least once every 4 hours.

9.3 Calibration verification is required after evaluation of indications to avoid misinterpretation of signal responses.

9.3.1 When a loss of 15 percent or greater in the reference level is indicated, re-establish the required calibration and re-examine all of the material examined since the preceding calibration check.

9.3.2 When an increase of 15 percent or greater in the reference level is indicated, reevaluate all recorded indications since the preceding calibration check.

9.3.3 Re-evaluation of all indications is required if the reference points have moved more than 10% of the original sweep reading or if the calibration check fails to show the required reference reflector.
10.0 EXAMINATION PROCEDURE

Scanning technique shall include at least two perpendicular directions with a minimum probe overlap of 15%.

NOTE

10.1 Straight-Beam Technique

10.1.1 Increase the gain setting from the calibration setting 6 db and the manual scanning rate shall not exceed 6 inches (152 mm) per second.

10.1.2 Due to the effects of an existing "Dead Zone". If the thickness of the forging under examination is less than or equal to 1.75 inch (44.45 mm), or if the measured dead zone is greater than ¼ inch (6.35 mm), scanning shall be done with a dual element transducer.

NOTE: Take all necessary steps to achieve 100% coverage, although where 100% coverage is not possible and accessibility is decreased due to only having one surface to scan from, regardless of the thickness, scanning shall be done with a dual element search unit to minimize the dead zone depth and increase the near surface sensitivity.

10.2 Angle-Beam Technique

10.2.1 Scan hollow forgings that have an axial length greater than 2-inches (51mm) and an OD/ID ratio of less than 2:1 over the entire OD surface area circumferentially in both the clockwise and counter-clockwise directions with a 45° sound path. If the 45° does not successfully detect the OD and ID notches, you may use the formula in Note A to determine the optimal angle for calibration. The intent is to select the correct angle beam to achieve a successful calibration for OD / ID notch.

10.2.2 Hollow forgings which cannot be examined axially using the straight-beam technique will be scanned with the angle-beam technique in both axial directions.

10.2.3 Stem material having a length greater than six (6) times the diameter will be examined with a beam directed along the axis in both directions utilizing the angle beam technique.

10.2.4 Scanning will be performed +6 db over the reference level. The manual scanning rate shall not exceed 6 inches (152 mm) per second.
10.3 Scan Plans for Specific Shapes

10.3.1 Scan Plan for Bar Stock and Solid Rounds— Shall be performed as described in Figure 3.

10.3.2 Scan Plan for Tubing, ID/OD Rounds and Ring shapes (Hollow Forging)

10.3.2.1 Straight Beam scan in both radial and axial direction. (Figure 4).

10.3.3 Scan Plan for Squares and Rectangles—Scan from at least three mutually perpendicular surfaces with the straight Beam Technique. (Figure 5).

10.3.4 Scan Plan for Valve Bodies—Straight Beam scan from all accessible contact surfaces. (Figure 6).

10.3.5 Scan Plan for Heads and Spools—Straight Beam scan from all accessible contact surfaces. (Figure 7).

10.3.6 Scan Plan for complex geometries— Scanning must be done in two perpendicular directions, with a single, dual element or angle search unit. Submit Scan Plan with the Test Report.

Figure 3: Scan Plan for Barstock and Solid Rounds

SCANNING POSITIONS: (1 & 2 are Straight Beam, 3 is Angle Beam)

Technique 1: Position 1 and Position 2

Technique 2: Position 1, Position 2; and Position 3 (When the length is greater than six (6) times the diameter for stem material)
**Figure 4: Scan Plan for Tubing and ID/OD Rounds**

**SCANNING POSITIONS:** (1 & 2 are Straight Beam, 3 & 4 are Angle Beam)

Technique 1: Position 1 and Position 2

Technique 2: Position 2 and Position 3 (Both axial directions)
(When the length is greater than six (6) times the wall thickness)

Additional: Position 4 (Both circumferential directions)
(When OD/ID ratio is less than 2:1 and the length is greater than 2.0 inches)

**Figure 5: Scan Plan for Squares and Rectangles**

**SCANNING POSITIONS:** (All Straight Beam)

Technique 1: Position 1, Position 2 and Position 3

Technique 2: All accessible contact surfaces
(When the material has a bore)
Figure 6: Scan Plan for Valve Bodies

SCANNING POSITIONS: (All Straight Beam)

Technique 1: All Positions (accessible contact surfaces)

Figure 7: Scan Plan for Heads and Spools

SCANNING POSITIONS: (All Straight Beam)

Technique 1: Position 1, Position 2, Position 3 and Position 4

(Position 5 required when the Head/Spool has two (2) flanges)

Technique 2: Position 2, Position 4 and Position 6

Note A
To calculate the optimal angle for inspection of ID originating discontinuities, the following formula may be used:

\[
\frac{r}{R} = \sin(\text{of Angle})
\]

Invert \(\sin(\text{of Angle})\) = Optimal Inspection Angle

Where:
\(r\) = ID radius
\(R\) = OD radius

**11.0 GENERAL ACCEPTANCE CRITERIA for FORGINGS, BARSTOCK, MILL SHAPES**

11.1 Definitions

Recordable Indications - indications exceeding 50% of the reference amplitude line or the Distance Amplitude Correction (DAC) curve for forgings, bar stock, and mill shapes.

Single Indications - indications greater than 1/2" (12.7mm) apart, in any direction.

Multiple Indications - two or more recordable indications within 1/2" (12.7mm) of each other, in any direction.

11.2 Evaluation of indications will be carried out with the gain (attenuation) setting at the calibration reference level.

11.2.1 The length of indications shall be measured by the 6 db drop method.

11.2.2 Record amplitudes of indications in increments of 1%, location to the nearest 0.1" (2.54mm), and length if mapped by the 6 db drop method.

11.3 Items with rejectable indications that will be removed in machining operations will be acceptable only if subsequent examination proves that all the rejectable indications have been completely removed.

**12.0 SPECIFIC ACCEPTANCE CRITERIA for FORGINGS, BAR STOCK, AND MILL SHAPES**

- No single indications exceeding the reference amplitude.
- No multiple indications exceeding 50% of the reference amplitude.
Additionally, for API 6A PSL 4 material no continuous cluster of indications on the same plane regardless of amplitude shall be found over an area twice the diameter of the search unit.

13.0 REPORTING

13.1 An Ultrasonic examination report is required and will contain the following minimum information:

- Ultrasonic Test Report Number
- Company performing inspection
- Part Number and revision Level
- Part Description and material
- Traceability Code / Heat Number, Serialization (as applicable)
- Date of examination
- Scope of examination, including referenced scan plan from this procedure that was used (if applicable), or a sketch of the component showing the details of the technique(s) and the scan plan employed for different areas and geometries of the component.
- FMC UT specification number(s) with revision level
- Procedure number and revision level
- Examination parameters: transducer frequency, sensitivity setting, type of instrument, couplant, and any other information necessary to duplicate the examination.
- Type of Instrument used, manufacturer, model, serial number, and calibration date
- Reference or calibration blocks used for examination
- Quantity Examined
- Results of examination: rejectable, and recordable indications, location, depth, percent of DAC, and length
- Technician Name and Certification Type (ASNT, SNT-TC-1A, ISO 9712, etc.) and Level
- If examination is performed by third party, the report shall be presented to FMC on third party letter head
• For purposes of reporting the locations of rejectable and recordable indications, a sketch will be prepared showing the physical outline of the forging, including dimensions of all areas, if any, not inspected due to geometric limitations or geometric configuration with the axial, radial and circumferential distribution of the indications when applicable.

• The traceability code on the UT report shall match that provided by the material supplier.

• Customer witness name and date (if applicable).