API

Defined Procedure

for the

Ultrasonic Examination

of

Ferritic Welds

API-UT-2

This Procedure Defines the Recommended Techniques for the API Qualification of Ultrasonic Examiners Certification Program.

1.0 SCOPE

1.1 This procedure is applicable only to ultrasonic examinations conducted for American Petroleum Institute (API) Qualification of Ultrasonic Examiners Certification Program.

1.2 This procedure applies to the manual, contact ultrasonic examination of the material product forms and component designs identified in Figure 1. Examinations shall be performed using the pulse echo examination technique.

1.3 The objective of examinations performed in accordance with this procedure is to accurately detect, characterize, and length size discontinuities within the specified examination volume from the outside surface. Expected flaw mechanisms for each of these components are identified in Table 1 of Section 9.0.

1.4 Dual side access shall be available for all samples. Examinations shall always be performed from both sides of the weld.

1.5 The weld crown condition shall be "as-welded".

2.0 REFERENCE

2.1 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section V

3.0 PERSONNEL REQUIREMENTS

3.1 Personnel performing this qualification should be, as a minimum, certifiable to UT Level II or III in accordance with their employers written practice.

4.0 EQUIPMENT

4.1 Ultrasonic Instruments

4.1.1 Any ultrasonic instrument may be used provided that it satisfies the requirements of this procedure. Ultrasonic instruments should be equipped with a calibrated dB gain or attenuation control stepped in increments of 2db or less.

4.2 Search Units

4.2.1 Search units parameters are identified in Section 6.

4.3 Cabling

4.3.1 Any convenient type and length of cable may be used.

4.4 Couplant

4.4.1 Any couplant material may be used.

4.5 Calibration and Reference Blocks

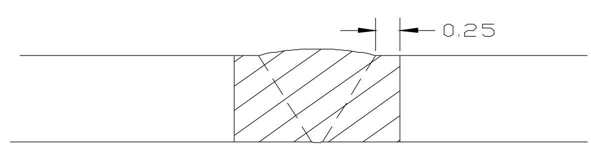
4.5.1 Calibration blocks shall be provided for each component identified in Figure 1. Calibration block design is in accordance with ASME B & PV Code Section V.

4.5.2 Reference blocks (i.e. IIW, DSC, Rompas, etc.) should be used for establishing linear screen ranges and determining refracted angle and exit point information. Reference blocks should be made of ferritic material.

5.0 EXAMINATION AREA REQUIREMENTS

5.1 Examination Volume

5.1.1 The examination volume shall consist of the entire weld volume and base material for a distance of 1/4 inch from each weld toe shown below. This volume applies to all configurations.



5.2 Surface Condition Requirements

5.2.1 The examination surface shall be free of irregularities, loose material, or coatings, which interfere with the ultrasonic wave transmission.

6.0 TECHNIQUE SELECTION

6.1 General Information

6.1.1 This section defines the requirements for search unit mode of propagation, frequency, element shape/size, and examination angle(s).

6.1.2 Weld contour and thickness information should be acquired and reviewed prior to the examination to ensure that the examination angles and screen ranges selected will provide adequate coverage of the examination volume.

6.2 Search Unit Mode of Propagation

6.2.1 Examinations shall be performed using shear wave search units.

6.3 Search Unit Frequency

6.3.1 Search unit nominal center frequency should be 5.0 MHz. Other frequencies may be used at the discretion of the examiner.

6.4 Search Unit Element Size

6.4.1 The search unit element size (and associated "footprint") should be small enough to allow for adequate contact and coupling to each examination surface.

6.4.2 Shear wave search unit element size (maximum) should be selected from the table below:

Component	Maximum Element Size Shear Wave
8 " Nominal Pipe	0.25"
12" Nominal Pipe	0.375"
½" Thick Plate	0.25"
1" thick Plate	0.375"

6.4.3 If the maximum search unit size is utilized, the search unit wedge may require conditioning to allow for increased access in areas limited by the weld crown width. Wedge conditioning is defined as reducing the wedge front to exit point dimension. Calibrations shall be performed after completion of all wedge conditioning.

6.5 Search Unit Angle(s)

6.5.1 Search unit wedges designed to produce nominal inspection angles of 45°, 60°, or 70° in ferritic material should be used.

6.5.2 The search unit angles selected for each component should be chosen based upon the configuration of the component and expected flaw mechanism. Variables such as weld design, weld crown width, and material thickness should be evaluated prior to selecting the inspection angle(s).

7.0 CALIBRATION

7.1 General Information

7.1.1 Weld profile and thickness data should be available for review prior to calibration.

7.1.2 Calibration should be performed and recorded prior to the start of any examination or series of examinations. Calibration should include the complete ultrasonic examination system.

7.2 Instrument Settings

7.2.1 The settings of the ultrasonic instrument (pulser and receiver settings) should be optimized during calibration in order to maximize the systems resolution capabilities.

7.3 Search Unit Exit Point and Beam Angle Measurements

7.3.1 Actual search unit exit points and beam angles should be determined prior to calibration using a ferritic reference standard. The following process is provided for reference.

a.) Exit Point Measurement - Position the search unit perpendicular to the radius of the reference block and maximize the signal response. The exit point is the location where the side of the wedge/search unit coincides with the reference line on the calibration standard

b.) Beam Angle Measurement - Position the search unit perpendicular to the applicable beam angle measurement reflector in the standard reference block and maximize the signal response. The actual refracted angle is the point where the measured exit point intersects with the angle gradients scribed on the reference block.

7.4 Time Base Calibration

7.4.1 A linear time base (screen range) representing either metal path or material depth should be established. The time base should be calibrated using a ferritic reference block with known reflector distances.

7.5 Time Base (Range) Size

7.5.1 The time base size selected should be sufficient to provide adequate coverage of the required examination volume (Figure 1) from each side of the weld with sufficient allowance for material thickness and/or sound path variation. The maximum time base size should not be excessive to the extent that resolution capabilities are compromised. Recommended time base sizes are identified as:

Examination Angle	Time Base Size	Calibration Reflector(s) (DAC)
45°	Full V-Path (+ ~25%)	ID/OD Notch
60°	Full V-Path (+ ~25%)	ID/OD Notch
70°	½ V-Path (+ ~25%)	ID Notch

7.5.2 Recommended calibration reflector positioning for ½ V-Path calibrations would properly position the ID notch response at approximately 7 screen divisions. Recommended calibration reflector positioning for Full V-Path examinations would properly position the ID and OD notch responses at approximately 4 and 8 screen divisions.

7.5.3 During examination, the time base size may be adjusted for indication discrimination and characterization. Final recording of indications and indication plotting should be done utilizing the time base settings established during calibration.

7.6 Primary Reference Sensitivity and DAC

7.6.1 The primary reference sensitivity level and associated distance amplitude correction curve (DAC) should be established using the inside and outside surface notches in the following manner:

a.) Maximize the signal response from the ID notch at ½ V-Path and set the response at ~ 80% FSH, establishing a flat line DAC at 80% for ½ V-Path examinations. For examinations beyond ½ V-Path continue the DAC curve as defined in step b.

b.) Without changing the gain control established in step a, determine and mark the maximum signal response obtainable from the OD notch at a full V-Path. Construct the DAC curve from these points.

8.0 EXAMINATION

8.1 Scan Direction

8.1.1 For the examination of reflectors oriented parallel with the weld, the sound beam should be directed essentially perpendicular to the weld axis from two directions.

8.2 Scan Pattern

8.2.1 The probe movement should consist of a raster type scanning sequence providing adequate beam overlap in the indexing direction. This scanning pattern may be supplemented as needed with localized lateral scanning and probe oscillation to provide information important to indication characterization.

8.2.2 For Full V-Path examinations the scan length should be sufficient to allow for full evaluation of the OD surface of the component.

8.3 Technique Application

8.3.1 The 70° search unit at ½ V-Path calibration is intended to provide 2 direction coverage of the lower ½ of the inspection volume. This probe may also be utilized to confirm indications in the upper ½ of the inspection volume if coverage is obtainable.

8.3.2 The 45° and/or 60° search units at full V-Path calibration are intended to provide 2 direction coverage of the upper ½ of the inspection volume. These probes may also be utilized to confirm indications in the lower ½ of the inspection volume if coverage is obtainable.

8.3.3 Characterization and positioning of suspect indications should be done with the search unit angle(s) that provides the greatest response from the indications.

8.4 Examination Sensitivity (Scan Gain)

8.4.1 The examination sensitivity (scan gain) should be a minimum of twice (+ 6 dB) the primary reference level. Scan sensitivity should be increased beyond the + 6dB level as geometric responses allow.

8.4.2 Scan sensitivity may require adjustment during the examination to compensate for changes in material type, thickness, surface condition, or to evaluate suspect indications.

8.5 Scan Speed

8.5.1 Scan speed should not exceed 3.0" per second.

9.0 INDICATION EVALUATION

9.1 General Information

9.1.1 All suspected flaw indications, regardless of amplitude, should be investigated to the extent necessary to provide accurate characterization, identity, and location.

9.1.2 All suspected flaw indications should be plotted on a cross sectional drawing of the weld in order to accurately identify the specific origin of the reflector.

9.2 Indication Classification

9.2.1 Non-relevant indications (Geometric/Metallurgical)

9.2.1.1 All indications produced by reflectors within the volume to be examined that can be attributed to the geometry of the weld configuration (Inside surface mismatch, root geometry, weld cap responses, metallurgical responses, etc.) shall be considered as non-relevant indications.

9.2.2 Flaw Indications

9.2.1.1 All indications which are produced by reflectors within the exam volume, that cannot be clearly attributed to the geometry of the weld configuration (Inside surface mismatch, root geometry, weld cap responses, metallurgical responses, etc.) should be considered as flaw indications. The minimum reporting threshold for flaw indications is identified in Section 10.

9.2.1.2 Table 1 identifies the flaw mechanisms that potentially exist in the qualification specimens. Specific test specimens and test sets are not required to contain all of the flaws identified within this table.

Table 1
Potential Flaw Mechanism's

	8.0" Pipe Weld	12" Pipe Weld	½" Plate	1" Plate
Inside surface connected crack (ID Crack)	X	X	X	X
Outside surface connected crack (OD Crack)	X	X	X	X
Embedded Center Line Cracking				X
Lack of root penetration (LOP)	X	X	X	
Lack of side wall fusion (LOF)	X	X	X	X
Porosity	X	X	X	X
Slag inclusion	X	X	X	X

9.3 Indication Discrimination

9.3.1 Flaw Indications

9.3.1.1 All suspected flaw indications should be evaluated taking into account the following typical indication characteristics. These characteristics should not be considered as mandatory criteria for reporting indications as flaws, but are listed as significant points of interest for the examiner to consider during the exam.

a. Inside Surface Connected Crack (ID Crack)
b. Outside Surface Connected Crack (OD Crack)

- Unique, significant, and sharp amplitude response with defined start and stop positions
- Unique and significant signal travel or “walk”
- Multiple points of reflection (flaw base, flaw tip, faceting, etc.)
- Similar response from opposite scan direction
- Plots correctly to expected ID or OD crack location from both directions (correct sound path, surface distance, and flaw positioning from both directions)

c. Embedded Center Line Cracking (CL Crack)

- Unique, significant, and sharp amplitude response with defined start and stop positions
- Unique and significant signal travel or “walk”
- Similar response from opposite direction (comparable amplitude, surface position, signal responses from each scan direction)
- Does not connect to either the inside or outside surfaces
- Plots correctly to centerline area of weld volume from both directions (similar and correct sound path, surface distance, and flaw positioning from both directions)

d. Lack of Root Penetration (LOP)

- Unique and significant amplitude response with defined start and stop positions
- Unique and significant signal travel or “walk”
- Similar response from opposite scan direction
- Plots correctly near the centerline of weld from both directions (comparable and correct sound path, surface distance, and signal response from both directions)
- Through wall dimension supported by component design

e. Lack of Side Wall Fusion (LOF)

- Unique and significant amplitude response with defined start and stop positions
- Unique and significant signal travel or “walk”
- Indication may provide unique upper and lower tip responses from favorable angles and scan directions
- Response from opposite scan direction may be significantly reduced in amplitude or observable from a much different sound path and surface distance position
- Plots correctly near the fusion line of weld

f. Porosity

- Multiple less significant signal responses or signal clusters varying randomly in amplitude and position
- Plots correctly to weld volume
- Start and stop positions “blend in” with background responses

g. Slag Inclusion

- Unique signal responses which plot correctly to weld volume
- Amplitude responses dependant upon the size, shape, and orientation of inclusion
- Typically detectable using several examination angles from both sides of the weld

9.4 Length Sizing

9.4.1 Length sizing should generally be performed using the search unit(s) that provide the most significant signal responses.

9.4.2 Length sizing should be performed in a manner similar to the technique identified below. Multiple search unit angles should be evaluated in order to properly discriminate flaw responses from surrounding metallurgical and geometrical responses.

a.) Optimize the signal response from the flaw indication.

b.) Scan the indication area with specific focus on the flaw signal responses, (e.g., signal shape, walk, orientation, effect of skew, etc). Adjust the system gain as needed to optimize the flaw response.

c.) Scan an adjacent unflawed area in close proximity to the flaw area with specific focus on the surrounding geometrical responses (weld noise, root, weld cap response, etc.).

d.) Scan along the length of the flaw in each direction until the signal response has diminished into the background noise.

10.0 <u>RECORDING AND REPORTING OF EXAM RESULTS</u>

10.1 General Information

10.1.1 Component reference information (datum 0 position, direction of flow) used for indication reporting shall be identified on the examination sample.

10.1.2 Exam results shall be reported on the API indication report sheet.

10.2 Non Relevant Indications

10.2.1 Reporting of non-relevant indications is not required.

10.3 Flaw Indications

10.3.1 Flaw indications 20% of DAC or greater shall be reported.

10.3.2 The following information shall be recorded on the applicable indication report sheets for each reported flaw:

a.) The flaw length dimension (L_1 and L_2)

b.) The flaw location in relationship to the weld centerline (e.g., upstream, downstream, centerline)

c.) The flaw location in relationship to the weld volume (e.g., inside surface connected, outside surface connected, embedded)

d.) The flaw type (See Table 1)

e.) Flaw amplitude response as either a % of DAC or as a dB level compared to reference sensitivity.

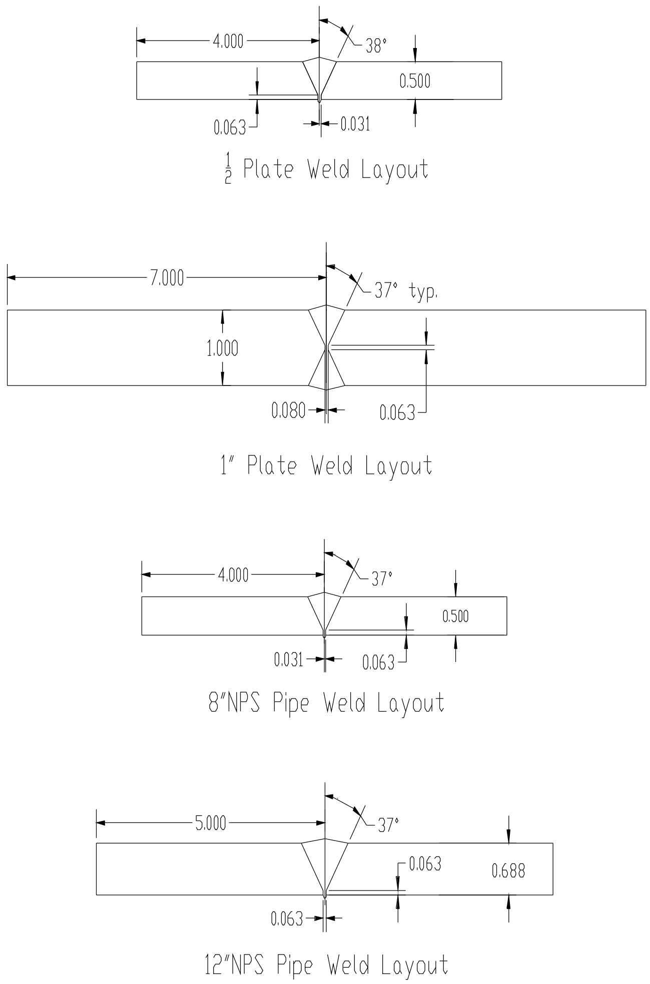


Figure 1
Demonstration Sample Design
(Typical)