Appendix A
API QUTE M & PA Examination Forms

Figure A1: QUTE (M) Equipment Inventory Form

QUTE(M)
Equipment Inventory and Calibration Data Sheet

Name: ______________________ Date: ______________ Session ID: ______________

Company Name: ______________________ Test Set: ______________

Email Address: ______________________

Phone Number: ______________________ Instrument Manufacturer: ______________ Model: ______________

Reference Block(s): ______________________________

	Search Unit 1	Search Unit 2	Search Unit 3	Search Unit 4
Manufacturer				
Model				
Size (in.)				
Shape				
No. Elements				
Frequency				
Wedge Angle				
Wedge Type				
Wave Mode				
Focus?				
Focus Depth (in.)				

	Setup 1	Setup 2	Setup 3	Setup 4
Search Unit				
Range (in.)				
Delay (in.)				
Velocity (in./µs)				
Veleocity Cal Min. (in.)				
Velocity Cal Max. (in.)				
DAC				
DAC Range Min (in.)				
DAC Range Max (in.)				
Reference Sensitivity (db)				
Scan Sensitivity	+	+	+	+
Calibration Type				

Figure A2: QUTE (PA) Equipment Inventory Form

QUTE-PA
Equipment Inventory

Name: ____________ Date: ____________ Session ID: ____________

Company Name: ____________ Test Set: ____________

Email Address: ____________

Phone Number: ____________ Instrument Manufacturer: ____________ Model: ____________

Reference Block(s): ____________

	Search Unit 1	Search Unit 2	Search Unit 3	Search Unit 4
Manufacturer				
Model				
Elements				
Pitch (mm)				
Configuration				
Frequency				
Wedge Model				
Mode				

	Setup 1	Setup 2	Setup 3	Setup 4
Search Unit				
Active Aperture				
Angles Used				
Angle Resolution (deg.)				
Range (in.)				
Delay (in.)				
Velocity (in./µs)				
TCG				
Reference Sensitivity (db)				
Exam Sensitivity (db)	+	+	+	+
Calibration Type				
Focus Type				
Focus Depth (in.)				

Figure A3: QUTE (M & PA) Data Report Form (pipe and plate specimens)

QUTE(M)- Pipes and Plates

Test Set: 0

Sample ID	Indication	Setup #	Flaw Type	% Amplitude (at reference)	Crack Height (base to tip)	Flaw Start (inches)	Flaw Stop (inches)	Total Axial Length	Transverse Crack Length	Flaw Location	
A	1							0			NO REPORTABLE IND.
(.250" Plate)	2							0			
	3							0			
	4							0			
	5							0			
	6							0			
	7							0			
	8							0			
B	1							0			NO REPORTABLE IND.
(1" Plate)	2							0			
	3							0			
	4							0			
	5							0			
	6							0			
	7							0			
	8							0			
C	1							0			NO REPORTABLE IND.
(8" Pipe)	2							0			
	3							0			
	4							0			
	5							0			
	6							0			
	7							0			
	8							0			
D	1							0			NO REPORTABLE IND.
(12" Pipe)	2							0			
	3							0			
	4							0			
	5							0			
	6							0			
	7							0			
	8							0			
E	1							0			NO REPORTABLE IND.
(2" Pipe)	2							0			
	3							0			
	4							0			
	5							0			
	6							0			
	7							0			
	8							0			

- ID Crack
- OD Crack
- Lack of Penetration
- Lack of Fusion
- Porosity
- Slag
- Transverse Crack
- Base Metal Lamination

Figure A4: QUTE (M & PA) Data Report Form (crack sizing bars)

QUTE(M) - Crack Bars

Test Set: 0

Sample ID	T. Nom.	Actual thickness 90˚ Side	Actual thickness 270˚ Side	First Leg Estimate 90˚	First Leg Estimate 270˚	Second Leg Estimate 90˚	Second Leg Estimate 270˚	FINAL REPORTED CRACK HEIGHT (BASE TO TIP)
1	0.375"							
2	0.375"							
3	0.375"							
4	0.375"							
5	1.000"							
6	1.000"							
7	1.000"							
8	1.000"							

Appendix B
API Ultrasonic Examination Procedures

B.1 Each candidate shall perform examinations to a written ultrasonic examination procedure. The candidate can use his own company's procedure, or he can use any of the ultrasonic procedures developed by the API which are shown below.

API-UT-1: Generic Procedure for the Ultrasonic Examination of Ferritic Welds

NOTE: This procedure defines the minimum mandatory requirements for the API Qualification of Ultrasonic Examiners.

1.0 SCOPE

1.1 This procedure is applicable only to ultrasonic examinations conducted for the 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.

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.

1.4 Examinations shall be performed using the pulse echo examination technique.

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

1.6 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 employer's 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.

4.2 Search Units

4.2.1 Any search unit may be used provided that it satisfies the requirements of this procedure.

4.2.2 Search unit frequency should be between 2.25 and 5.0 MHz.

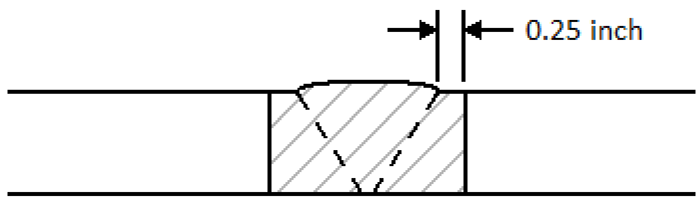
4.2.3 Search unit wedges designed to produce nominal inspection angles of 45°, 60°, or 70° (± 3°) in ferritic material should be used.

4.2.4 Any search unit size may be used provided that adequate contact can be maintained.

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 Blocks
4.5.1 ASME B & PV Code, Section V, Calibration blocks shall be provided.

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.



5.1.2 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 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.

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.

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 and the ID notch at one and one half (1 ½) V-Paths as applicable. Construct the DAC curve from these points.

7.7 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.

7.7.1 Wedge conditioning is defined as reducing the wedge front to exit point dimension.

7.7.2 Calibrations shall be performed after completion of all wedge conditioning.

7.8 Search Unit Angle(s)

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

7.8.2 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).

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 reflectors.

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 Mechanisms

	2" Pipe	8" Pipe	12" Pipe	1/4" Plate	1" Plate
Inside surface connected crack (ID crack)	X	X	X	X	X
Outside surface connected crack (OD crack)	X	X	X	X	X
Embedded Center Line Cracking					X
Transverse Crack		X	X	X	X
Lack of root penetration (LOP)	X	X	X	X	
Lack of side wall fusion (LOF)	X	X	X	X	X
Porosity	X	X	X	X	X
Slag inclusion	X	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 dependent 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 provides 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 RECORDING AND REPORTING OF EXAM RESULTS

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 are defined as being less than 0.25" in length, unfavorable geometry reflections, or indications with a depth of less than 1/32" (undercut).

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) Flaw type (See Table 1)
e) Flaw amplitude response as either a % of DAC or as a dB level compared to reduced sensitivity.

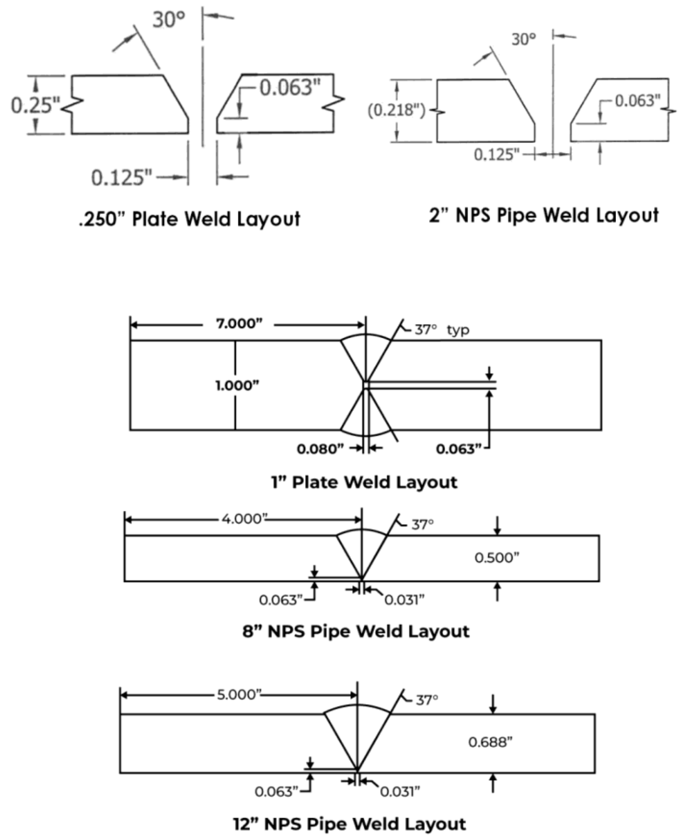


Figure 1: Specimen weld specimen details

B.2 API-UT-10: Defined Procedure for Advanced Ultrasonic Crack Sizing of Ferritic Welds

***NOTE:** This procedure defines the recommended methods and techniques for the API Qualification of Ultrasonic Examiners.*

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 The following procedure addresses equipment and sizing evaluation techniques for crack height sizing examinations.

1.3 This procedure provides guidelines and techniques for ultrasonic sizing of planar cracks which originate at the same or opposite side of the scanning surface.

1.4 This procedure is applicable to carbon steel material thicknesses from 0.250 inches to 1.0 inches.

1.5 The Ultrasonic Crack Sizing Procedure outlines the requirements for contact methods, using refracted longitudinal wave and shear wave techniques for carbon steel materials.

1.6 Other methods and techniques may be used when an appropriate sizing calibration block is utilized.

1.7 Special longitudinal and/or shear wave search units, and special ultrasonic sizing calibration blocks are used for the sizing examinations.

1.8 These sizing techniques are applicable to manual examinations only.

2.0 **REFERENCES**

2.1 American Society for Nondestructive Testing (ASNT), SNT-TC-1A

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

2.3 ASTM Crack Sizing Standard ASTM E-2192

3.0 **PERSONNEL REQUIREMENTS**

3.1 Personnel performing the sizing examination should be, as a minimum, certified to UT Level II or III in accordance with their employer's 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.

4.2 Search Units

4.2.1 Search units shall be in the frequency range of 1.0 to 10.0 MHz

4.2.2 Search units may be of the single or dual element type, which may produce shear and/or longitudinal waves as they apply to the appropriate crack sizing technique.

4.2.3 Search units to be used in crack sizing shall be of the type to produce the appropriate wave physics associated with the following crack sizing methods described in this procedure.

a) Tip Diffraction
b) Focused Refracted L-Waves or focused Shear Waves

4.2.4 Other search units and techniques may be used provided that the methods and techniques are outlined in a procedure.
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 Special Crack Sizing Calibration Blocks shall be used to establish specific calibrations for the sizing methods identified in this procedure.
4.5.2 Sizing calibration blocks shall contain notches and/or side drilled holes (SDH) reflectors at specific known depths for calibration of the applicable sizing method.
4.5.3 The sizing calibration blocks shall be fabricated from the carbon steel materials.
4.5.4 Normally, a flat plate with notches from 20% to 80% through-wall in 20 % steps is used to calibrate the screen range in depth. Other blocks thicknesses in the range of the material being examined may be used.
4.5.5 Special blocks may be used for calibration of other sizing methods.
4.5.6 Reference blocks (i.e. IIW, DSC, Rompas, etc.) may be used for establishing linear screen ranges and determining refracted angle and exit point information. Calibration blocks should be made of carbon steel material.

5.0 CALIBRATION

5.1 The temperature of the calibration block material shall be within 25°F of the component to be examined.
5.2 System Calibration
5.2.1 System calibration shall include the complete examination system. Any changes in search unit, shoes, couplant or instrument shall be cause for recalibration.
5.2.2 The crack sizing techniques utilized in accordance with this procedure are as follows:
5.2.3 The **Tip Diffraction Method** is used for height sizing ID, OD connected or embedded cracks. See **Technique 1**) for a description of the crack sizing method.
5.2.4 The **Focused Refracted Longitudinal Wave and Focused Shear Wave** Methods are used for cracks near the at the OD surface, or at other specific inspection zones. See **Technique 2** for a description of the dual-element focused crack sizing method.
5.3 Calibration for screen range may be accomplished by either direct sound path or actual depth. Specific calibrations may be performed as outlined in the technique descriptions below.
5.4 The sizing method and search unit shall be selected from the appropriate techniques, based upon the zone of investigation.
5.6 Whenever practical, the through wall crack height should be verified by more than one sizing technique.
5.7 In addition, whenever practical, sizing should be performed from both sides of the crack.

6.0 EXAMINATION

6.1 Scanning Requirements
6.1.1 The area designated by the API Test Administrator shall be investigated with the appropriate sizing technique. The sizing examination shall be performed along the length of the crack to determine the ***maximum crack height***, defined as the through wall distance from the crack base to the crack tip. The largest through wall height dimension shall be recorded on the API Crack Sizing Report Form.

6.1.2 Whenever possible, crack height sizing should be performed in both sides of the weld.

6.1.3 Weld crown configuration may restrict search unit movement for proper crack sizing using the specific technique. Select the appropriate crack sizing technique to accommodate this limitation.

7.0 SIZING EVALUATION AND RECORDING CRITERIA

7.1 Sizing Application

7.1.1 It is important to understand the use and application of each sizing technique and the associated wave physics so that accurate crack height sizing is achieved.

7.2 Recording

7.2.1 Clearly document the height of each crack on the designated API Crack Sizing Reporting Form, Figure 1. The maximum through wall depth along the length of the crack in decimal inches from the ID shall be recorded for each of the cracks to be sized.

Figure 1: QUTE (M & PA) Data Report Form (pipe and plate specimens)

QUTE(M)- Pipes and Plates

API

Test Set: 0

Sample ID	Indication	Setup #	Flaw Type	% Amplitude (at reference)	Crack Height (base to tip)	Flaw Start (inches)	Flaw Stop (inches)	Total Axial Length	Transverse Crack Length	Flaw Location	
A	1							0			NO REPORTABLE IND.
(.250" Plate)	2							0			
	3							0			
	4							0			
	5							0			
	6							0			
	7							0			
	8							0			
B	1							0			NO REPORTABLE IND.
(1" Plate)	2							0			
	3							0			
	4							0			
	5							0			
	6							0			
	7							0			
	8							0			
C	1							0			NO REPORTABLE IND.
(8" Pipe)	2							0			
	3							0			
	4							0			
	5							0			
	6							0			
	7							0			
	8							0			
D	1							0			NO REPORTABLE IND.
(12" Pipe)	2							0			
	3							0			
	4							0			
	5							0			
	6							0			
	7							0			
	8							0			
E	1							0			NO REPORTABLE IND.
(2" Pipe)	2							0			
	3							0			
	4							0			
	5							0			
	6							0			
	7							0			
	8							0			

ID Crack
OD Crack
Lack of Penetration
Lack of Fusion
Porosity
Slag
Transverse Crack
Base Metal Lamination

Figure 2: QUTE (M & PA) Data Report Form (crack sizing bars)

QUTE(M) - Crack Bars

Test Set: 0

Sample ID	T. Nom.	Actual thickness 90° Side	Actual thickness 270° Side	First Leg Estimate 90°	First Leg Estimate 270°	Second Leg Estimate 90°	Second Leg Estimate 270°	FINAL REPORTED CRACK HEIGHT (BASE TO TIP)
1	0.375"							
2	0.375"							
3	0.375"							
4	0.375"							
5	1.000"							
6	1.000"							
7	1.000"							
8	1.000"							

8.0 **TECHNIQUE 1: TIP DIFFRACTION METHOD**

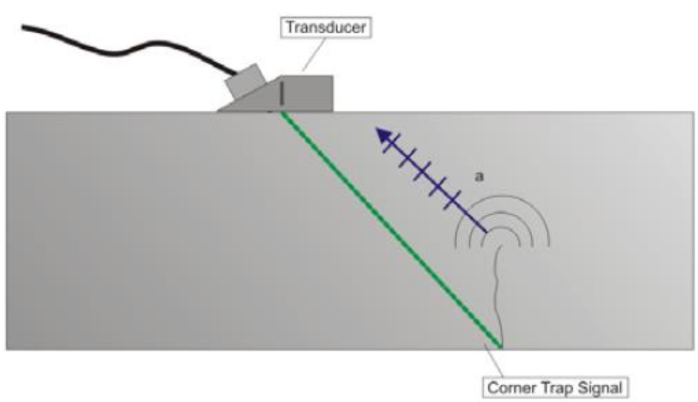
8.1 Description

The Tip Diffraction Method is based upon the diffracted sound energy from the tip of a crack. A single or dual element, 1 MHz through 10 MHz, 45 degree to 60 degree shear or longitudinal wave search unit is used to ultrasonically measure the time-of-flight, (TOF) or sound path distance, (SP) from the crack tip, or the time or sound path separation of the tip signal and relatively larger response at the crack opening at the ID. Generally, 3 to 5 MHz search units, which produce shear waves, are used for sensitivity and resolution.

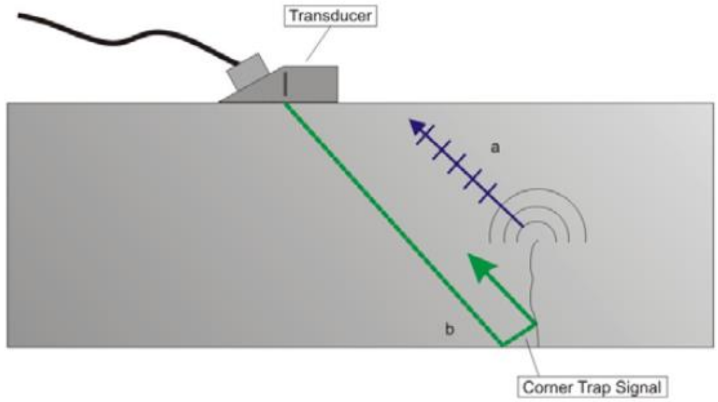
8.2 The ½ V-Path technique is generally used for the Tip Diffraction method; however, the full V-Path is applicable for qualitative sizing of OD connected cracks or deep ID cracks.

8.3 The two basic Tip Diffraction Techniques are:

a) Time of Flight (TOF), or, RATT (Relative Arrival Time Technique), or AATT (Absolute Arrival Time Technique)



b) Delta Time of Flight (Δ TOF), or SPOT (Satellite Pulse Observation Sizing Technique, or RATT (Relative Arrival Time Technique).



8.4 Calibration

Obtain a calibration block of known thickness and similar material specification as the component to be examined (0.375 or 1 inch thick) with the required ID notches, e.g., 20%, 40%, 60%, and 80%.

8.5 Limitations

8.5.1 The ultrasonic instrument should have a RF displays to aid the sizing examiner to resolve the crack tip signal. The crack tip signal may have a low signal-to- noise ratio. The RF display may help the sizing examiner to detect the crack tip signal.

9.0 TECHNIQUE 2: FOCUSED REFRACTED LONGITUDINAL (HALT) WAVE AND FOCUSED SHEAR WAVE (HAST) METHODS

9.1 Description

9.1.1 This technique employs a dual element, focused, refracted longitudinal wave or shear wave search unit to detect, locate and measure the Time of Flight or sound path of the crack tip signal.

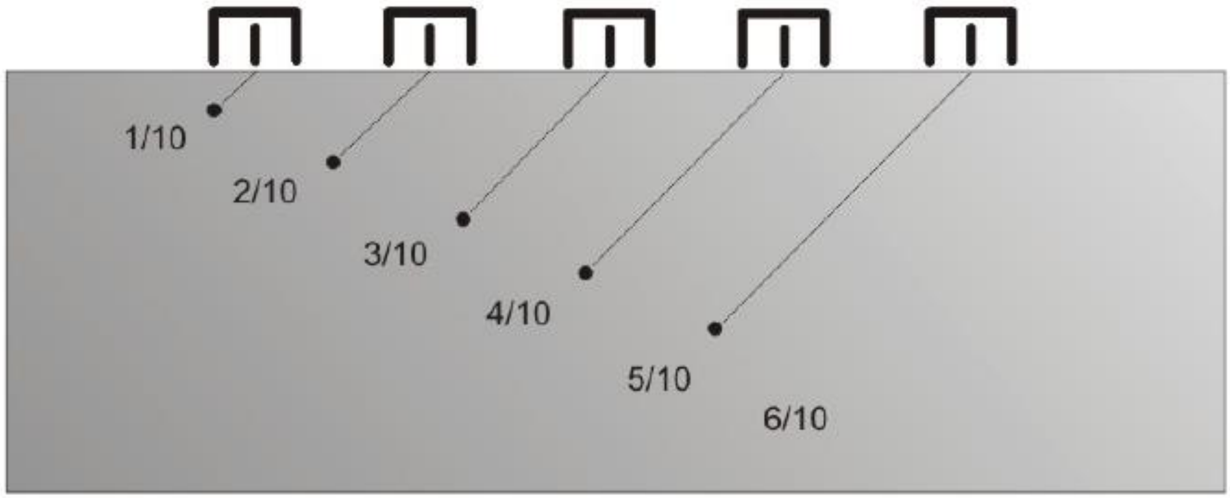
9.1.2 The HALT or HAST techniques are effective for sizing cracks in the outer 1/3 thickness of material, and is an effective method for determining if a crack has propagated near the OD surface of the component.

9.2 Calibration

9.2.1 The UT screen presentation shall be adjusted to represent actual depth or remaining ligament from the OD surface of material.

9.2.3 The depth calibration is performed by utilizing a calibration block with holes or notches that provide a calibrated CRT for the desired depth range. See Figure 3.
For example, a .100" reflector from the OD surface of the calibration block will appear at sweep division 1 and a .500" reflector from the OD will appear at a sweep division 5.

Figure 3: HALT Calibration Block (example)



1/10 Inch Depth Increments
Side Drilled Holes (SDH)

9.4 The desired search unit should be selected based upon refracted angle, frequency, and focal depth.

9.5 Other calibration methods utilizing sound path or depth calibrations may be used.

9.6 Scanning/Evaluation

9.6.1 Move the search unit over the area to be examined perpendicular to the suspected crack axis and observe the CRT for signals.

9.6.2 If a response is obtained, record the first signal (closest in time) at its peaked amplitude.

9.7 Calculations for Crack Sizing (ID cracks)

9.7.1 The depth of the crack tip from the OD surface of the pipe, (Remaining Ligament, RL) shall be subtracted from the wall thickness of the material at the crack location to determine the height of the crack.

$$\text{Crack Height} = T - RL$$

Where: T = the thickness of the pipe/component
RL = the remaining ligament from the OD surface to crack tip

9.8 Limitations

9.8.1 With the refracted longitudinal wave search unit, an associated shear wave is present which may produce confusing signals or other mode-converted signals.

9.8.2 Focal depth is a very important consideration for accurate crack sizing. This is controlled by the roof angle of the search unit.

9.8.3 Sizing in the less intense area of the beam spread may produce inaccuracies in crack depth estimates.

9.8.4 Generally, the useful focal range is from .5 to 1.5 times the actual focal depth of a refracted L-Wave or Shear Wave transducer.