



TITLE: ISQ-O&G Manual Ultrasonic Thickness & Corrosion Examination	Number:	UT-PTP7
	Revision:	2
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ISQ-O&G

Manual Ultrasonic Thickness & Corrosion Examination

ASNT Document UT-PTP7 Revision 2

Approved:



The American Society for Nondestructive Testing, Inc.

The American Society for Nondestructive Testing,
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Revision	Date	Summary of Changes
Original	5-16-2019	Original Document
1	8-14-2019	Added Appendix A
2	12-19-2019	Additional wording added to Appendix A & Figure 2



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1.0 Scope

- 1.1 This NDT procedure describes the method for performing manual (non-encoded) pulse-echo contact straight beam Ultrasonic examinations on carbon steel test specimens that are utilized in the ASNT ISQ-O&G Ultrasonic Thickness & Corrosion Scanning exam. This procedure is not applicable for use outside of the ASNT ISQ-O&G examination.
- 1.2 The purpose of this procedure is to provide instructions for performing these examinations to identify the presence of wall loss or mid-wall laminations and to measure the minimum remaining material wall thickness.
- 1.3 This procedure is only applicable to carbon steel specimens in the base thickness range of 0.250" (6.35mm) to 2.500" (63.5mm), for curved specimens of 4" (101.6mm) diameter or greater up to flat plate, and for bare or coated specimens.


2.0 References

Unless otherwise specified, the latest edition of the below referenced documents are applicable.

- QP-ISQ-2 Industry Sector Qualification Oil & Gas Program
- ASTM E797 Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method
- SNT-TC-1A Recommend Practice for Personnel Qualification and Certification in Nondestructive Testing Personnel
- O&G UTT-5 Exam Instructions
- O&G UTT-6 Exam Report Form

3.0 Acronyms

- ANSI American National Standards Institute
- ASNT American Society of Non-destructive Testing
- ASTM American Society for Testing & Materials
- ISQ Industry Sector Qualification
- NDT Nondestructive Testing
- O&G Oil & Gas
- UTT Ultrasonic Thickness

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4.0 Definitions

- 4.1 **Certification Management Council:** The ASNT council that has the overall responsibility for developing and maintaining the technical content of all ASNT certification programs and shall have the sole responsibility for the determination of certification outcomes in those programs.
- 4.2 **Industry Sector Qualification (ISQ):** A qualification program where practical demonstration examinations are given to an NDT examiner, for a specific NDT technique applicable to a given industry sector, to assess competency in performing examinations. The ISQ shall be awarded upon successful passing of the examination.
- 4.3 **International Services Center Certification Group:** The ASNT department responsible for the administration and facilitation of ASNT certification programs in accordance with procedures developed by the ASNT Certification Management Council (CMC).
- 4.4 **Steering Committee:** The group of OG owner / operator subject-matter experts responsible for the development and maintenance of the ISQ program that fairly and equitably represents the interests of all parties significantly concerned with the ISQ-O&G scheme without any particular interest predominating. The parent committee is the ASNT Certification Management Council (CMC) over the Oil & Gas owner/user steering committee for the ISQ-O&G program.
- 4.5 **Test specimen:** A sample of a product form containing known discontinuities used in practical examinations.

5.0 Qualifications

- 5.1 The ISQ UTT candidates shall understand that the expected prerequisite level of competency to sit for this exam is at least equal to a Level II ultrasonics limited certification in A-scan thickness measurement per the guidelines in SNT-TC-1A.

6.0 Responsibilities

- 6.1 The examination instructions O&G UTT-5 and this examination procedure UT-PTP7, shall be read and understood by the candidate before applying for the ISQ-O&G UTT exam. The candidate shall be expected to follow the UTT examination instructions and the UTT examination procedure during the examination. Failure to do so may cause a failure on the exam.
- 6.2 O&G UTT candidates are responsible for bringing and utilizing their own equipment including; ultrasonic thickness gauge or flaw detector, transducers, cables, reference standards, couplant, & rags. The candidate is responsible for referring to this procedure and selecting the proper equipment for use during their ISQ UTT exam.



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- 6.3 The candidate shall perform manual (non-encoded) contact straight beam UT examinations on the ISQ UTT test specimens assigned to them during their exam which may, or may not, contain service induced or manufactured discontinuities.
- 6.4 The candidate shall complete their ISQ UTT examination and the associated reporting in compliance with O&G UTT-5 exam instructions.
- 6.5 The steering committee and CMC are responsible for this ISQ UTT NDT technique procedure and any revisions required for this procedure.

7.0 Equipment

7.1 Ultrasonic Instruments

7.1.1 A candidate shall only use an Ultrasonic Thickness Meter with an A-scan presentation and/or an Ultrasonic Flaw Detector. Digital or Analog Instruments may be used. A candidate should take the ISQ UTT exam with the instrument they normally use on a regular basis during their work duties. Ultrasonic instruments with no A-scan presentation will not be allowed for use on the ISQ UTT exam, i.e. digital gauges with only a numeric readout.

7.1.1.1 For Instruments with additional B-scan and/or C-scan functions, the B-scan and/or C-scan functions will have to be switched off and only the A-scan function shall be utilized during the exam.

7.1.2 Thickness gauging instrumentation should be capable of generating frequencies within the range of 1 MHz to 10 MHz, with 2.25 MHz to 5 MHz being the typical range of frequency for use with this procedure.

7.1.3 Ultrasonic instruments used for thickness gauging to this procedure should be calibrated within the last year.

7.2 Transducers

7.2.1 Straight beam contact or delay line, single and/or dual element, transducers that are applicable to wall thickness measurements and flaw detection are acceptable to be used in accordance with this procedure. For Instruments that have automatic transducer recognition, consult the owner/user manual for compatibility of the transducer.

7.2.2 Straight beam, pulse echo, single or dual element transducers having element sizes from 0.125" (3.175mm) to 0.750" (19.05mm), round or square in shape should be used with this procedure.

7.2.3 The selection of search unit frequency, type, & diameter will depend on the test specimen thickness and the presence or lack of coating.

7.2.3.1 In general, the search unit frequency should be from 2 MHz to 5 MHz. For this exam, thin test specimens or test specimens with



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deep corrosion (minimal remaining wall thickness), a higher frequency is more likely to give more accurate readings. However very rough corrosion might cause too much scattering of the Ultrasonic energy at high frequencies, testing at multiple frequencies may be required. The table below provides frequency *recommendations* based on thickness however adequate results might be achieved outside of these ranges.

Recommended Frequency Ranges	
Material Thickness	Frequency (MHz)
$\leq \frac{1}{4}$ " (6.35mm)	5.0 to 10.0 MHz
$\frac{1}{4}$ " (6.35mm) $\leq \frac{3}{4}$ " (19.05mm)	4.0 to 7.5 MHz
$\frac{3}{4}$ " (19.05mm) to $\leq 1 \frac{1}{2}$ " (38.1mm)	2.0 to 5.0 MHz
$1 \frac{1}{2}$ " (38.1mm) to $\leq 2 \frac{1}{2}$ " (63.5mm)	2.0 to 5.0 MHz

7.2.3.2 For test specimens under 1" (25.4mm) thickness, a dual element transducer should be used however consideration should be given to thin material, under 0.250" (6.35mm) thickness, to ensure no doubling effect is occurring.

7.2.3.3 For test specimens 1" (25.4) and greater in thickness, a single element transducer should be used however a dual element transducer with sufficient focal depth might be adequate to achieve accurate results.

7.2.3.4 Consideration for test specimen curvature should be given when selecting transducers for examination. Transducers should be selected that will sit flat on curved surfaces to minimize errors due to transducer rocking. Curved exam specimens shall not be less than ANSI 4" outside diameter pipe sections.

7.3 Couplant

7.3.1 A suitable couplant designed for use in ultrasonic testing should be used for the exam. The couplant shall be of a type that can be easily cleaned off specimens with wiping a rag across the surface.

7.3.2 The same couplant that is used for equipment standardization should be used for examination.

7.3.3 All couplant shall be cleaned off specimens before being returned to the specimen holding area.

7.4 Reference Standards

7.4.1 Reference standards with flat, parallel surfaces, should be used. They should have thin and thick sections that fully cover the range of specimen thickness to be inspected. Multiple reference standards might be required to cover the full range of specimen thickness included in this exam.



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- 7.4.2 Reference standards should be certified with known thickness values.
- 7.4.3 Reference standards should have similar acoustic properties as the low alloy carbon steel test specimens

8.0 Specimens

- 8.1 Test Specimens in the ISQ UTT exam shall have the following characteristics;
 - 8.1.1 They shall be low alloy carbon steel.
 - 8.1.2 The thickness range of UTT test specimens shall be from 0.250" (6.35mm) to 2.5" (63.5mm).
 - 8.1.3 Test specimens shall be of either flat plate or curved section product form. Curved section specimens shall not have a radius smaller than that of an ANSI 4" outside diameter pipe.
 - 8.1.4 Test specimens may be coated with 10 to 50 mils of coating; fusion bonded epoxy, two-part polyurethane, or similar.

9.0 Standardization

- 9.1 The ultrasonic instrument should be standardized (often referred to as calibrated or technique calibration) for horizontal linearity (thickness) on reference standards having similar acoustic properties as the low alloy carbon steel test specimens.
- 9.2 Reference standards should have a minimum of 2 (two) sections of different thickness which cover the minimum and maximum thickness range expected for the specimen(s) to be examined. The more steps that are machined into a reference standard and used for standardization, the better the accuracy of the instrument standardization will be.
- 9.3 The ultrasonic instrument shall be standardized prior to examination and should be standardized upon completion.
- 9.4 The technician should also check their instrument standardization anytime during their examination when one of the following conditions occur;
 - 9.4.1 Any equipment component is changed; transducer, cable, delay line standoff, battery, etc.
 - 9.4.2 The technician doubts the accuracy of their standardization.

10.0 Examination

- 10.1 Specimen surface condition;



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- 10.1.1 Prior to examination the test specimens should be visually examined, in the area to be contacted by the transducer, to ensure the scanning surface is free of couplant residue, loose paint, dirt, mill scale, machining or grinding particles, or other loose foreign matter that would impair the free movement of the transducer or affect the accuracy of the thickness measurement results.
- 10.2 Place transducer on test specimen and move it across the surface to see the average backwall signal amplitude. Adjust instrument gain to achieve an 80-100% full screen height signal amplitude of the first back wall reflection for the specific test specimen under examination. This should be used as the base gain setting for examination of this test specimen.
 - 10.2.1 Scanning may be performed with an additional +6dB for greater sensitivity to detect small discontinuities.
 - 10.2.2 Additional gain above base and scanning dB may be needed to evaluate small indications. Care should be taken in distinguishing between real indications and background noise in the A-scan when adding gain.
- 10.3 Each test specimen shall be examined from the scanning surface only to determine the presence and type of any discontinuities (flaws) in the specimen by scanning the entire specimen. Possible flaw types are detailed in 11.1.1. **No specimens shall include flaw types from more than one of the three categories detailed in 11.1.1.**
 - 10.3.1 Scanning speed should not exceed 6" (152.4mm) per second.
 - 10.3.2 Scanning overlap should be a minimum of 10% of the width or diameter of the active area of the transducer.
- 10.4 For test specimens with coating the following methods should be utilized to accurately measure the minimum and maximum wall thickness.
 - 10.4.1 Measurement calculated by subtracting the first back wall signal from the second back wall signal. This can be accomplished either by an instrument's Echo to Echo function or by manually subtracting the value observed from the first back wall signal from the value observed from the second back wall signal.

Note: When using echo to echo, many instrument manufacturers warn users about potential signal mode conversion that can occur when measuring thicknesses above 0.7". When this occurs, a mode converted shearwave signal can appear before the second backwall reflection, which can trigger the instrument to focus on it, rather than the true second backwall reflection, yielding a thinner reading than is actually present.
 - 10.4.2 In some cases, such as on test specimens with rough back wall surfaces, the echo to echo function might not work due to the inability to produce



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multiple back wall reflections. As an alternative option for acquiring accurate wall thickness readings through coating without multiple backwall signals the following method may be utilized for each individual specimen;

- 10.4.2.1 Examine the test specimen in the standard first back wall method to identify areas without wall loss adjacent to the area(s) with wall loss.
 - 10.4.2.2 Record the measurement of the test specimen with coating in the standard first back wall technique in an area with no wall loss.
 - 10.4.2.3 Then record a measurement in the same area with no wall loss utilizing the method in 10.4.1 above to measure the wall thickness without coating.
 - 10.4.2.4 Subtract the wall thickness reading without coating (echo to echo method) from the wall thickness measurement with coating (standard first back wall method) and record the difference. This recorded value is the equivalent coating thickness as measured by the UT instrument calibrated for carbon steel.
 - 10.4.2.5 Scan the entire test specimen in the standard first back wall method to locate the minimum remaining wall thickness.
 - 10.4.2.6 Subtract the previously recorded value for the coating thickness from the minimum wall thickness observed in the standard first back wall technique.
 - 10.4.2.7 This method should only be utilized when it is impossible to acquire a second multiple back wall signal.
- 10.5 Utilize the examination dry erase specimen sketch note sheet provided by the AEP to record notations during the exam. Transfer recorded notes / answers from the specimen sketch note sheet to the dry erase report form O&G UTT-6, also provided by the AEP, for data recording during the exam.
- 10.6 Clean off all residual couplant from test specimens before returning them to the holding area and retrieving any subsequent specimens.

11.0 Reporting


- 11.1 During the exam, the dry erase report form provided by the AEP shall be used for recording examination results. The following details shall be recorded for each test specimen;
 - 11.1.1 The flaw type determined shall be recorded in the 'flaw type' data entry location for the corresponding specimen by the candidate. The flaw type options for data entry for each specimen are as follows; N for a specimen



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with no damage observed, 'W' for a specimen observed as containing any form of wall loss, or 'M' for a specimen with one or multiple mid-wall laminations observed. See Appendix A for more information on signal evaluation.

- 11.1.2 For test specimens identified as containing wall loss, the minimum remaining wall thickness for the entire test specimen shall be determined and recorded in the 'minimum thickness' data entry location for the corresponding specimen by the candidate.
- 11.1.3 For test specimens identified as containing (a) mid-wall lamination(s), the minimum remaining **full wall thickness** for the entire test specimen shall be determined and recorded in the 'minimum thickness' data entry location for the corresponding specimen by the candidate. *The depths or horizontal dimensions of the mid-wall lamination(s) shall **not** be recorded.*
- 11.1.4 For test specimens identified as containing no damage, the minimum remaining wall thickness for the entire test specimen shall be determined and recorded in the 'minimum thickness' data entry location for the corresponding specimen by the candidate.
- 11.1.5 The maximum thickness shall be determined for each test specimen, from all flaw type categories, and recorded in the 'maximum thickness' data entry location for the corresponding specimen by the candidate.
- 11.2 After examination completion the candidate shall follow the instructions provided in O&G UTT-5 Exam Instructions to complete their computerized report entry and submission to the ASNT computerized grading system. Or in the case of an issue with the computerized report submission system, follow the AEP's instructions for hard copy report completion and submission.
- 11.3 Once report submission is completed the candidate shall clean off the dry erase forms provided and turn them into the AEP.

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Appendix A – Signal Evaluation

Careful evaluation of A-scan signals is required to differentiate signal responses generated by wall loss from signal responses generated by mid-wall laminations or inclusions. Below is some guidance that can be used to assist with signal evaluation to identify if signal responses are from wall loss or from mid-wall reflectors. The information provided is guidance only and should not be considered as absolute for all situations. All items below should be considered when evaluating ultrasonic 0-degree signal responses from unknown reflectors.

1. **Laminations** generate signals that are typically higher in amplitude, narrow on the time base, and have a flat vertical leading edge, similar to a flat back wall response;
 - a. Sharp, flat leading edge to the signal.
 - b. Signal has little to no movement horizontally across A-scan display from variation in sound path. Laminations are at a constant, or near constant, depth and therefore rise and fall at the same location on the time base.
 - c. Large laminations close to the surface can have a signal amplitude larger than the backwall signal from the full material thickness.
 - d. Laminations almost always create multiple, or repeat, signals in equidistant steps from the scanning surface. Coated samples are an exception to this guidance as ultrasonic signals through coating may have considerable ring down, additional cycles in the sine wave, in the first back wall response that greatly reduce the level of continued energy required to create multiple back wall signals.
 - e. Signal responses from laminations are consistent in shape, size, & time base location regardless of the scanning direction the transducer moves on and off of the lamination from.
 - f. Multiple laminations of various sizes and at various depths in one material can be mistaken as corrosion covering a range of depth. Care must be taken to evaluate these signals individually to verify they are laminations. These situations are often seen in older equipment with many small mid-wall laminations.
 - g. Laminations are most likely contained within the middle half of the material and are very unlikely to be close to the front or back-wall surface.

2. Areas of **wall loss** generate signals that are typically lower in amplitude than back-wall echoes and are broad with multiple peaks;
 - a. Rough, wide signals, with multiple peaks.
 - b. Corrosion signals move left of the back-wall signal along the time base.
 - c. Corrosion signals with substantial change in depth likely have responses that move across a significant amount of the time base.
 - d. Very unlikely to have amplitude larger than the back-wall. If wall loss is very deep (close to scanning surface) and has a large plateau (flat area) then it is possible to have a larger amplitude than a back-wall response, but this is very rare.
 - e. Corrosion is very unlikely to create multiple, or repeat, signals. If wall loss is very deep (close to scanning surface) and has a large plateau (flat area) then it is possible, but this is also very rare. Samples with erosion that have a smooth area that is parallel to



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the scanning surface are an exception to this guidance. These types of areas can generate multiple reflection signals like a lamination. However, areas of erosion will generate changes in signal behavior when moving the transducer on and off of the eroded area in various scanning directions unlike laminations which will generate the same signal behavior in every direction as the transducer is moved on and off of the area containing the lamination.

- f. Shallow internal pitting can be seen in small changes to the back-wall signal. Monitor drops in signal amplitude in conjunction with slight movement to the left on the time base line.
- g. Shallow pitting and corrosion will generate signals close to the full sample back-wall thickness at undamaged areas.
- h. Isolated areas of corrosion with steep sides to the wall loss (i.e. large single pits) can generate A-scan signals similar to large laminations where the back-wall signal disappears completely, and a signal appears with shorter sound path. In a situation where this occurs, care must be taken to verify if there is any movement on the time base to the left (shorter sound path) along with reduced amplitude of the back-wall signal and/or a slight movement to the left (shorter sound path) along with increasing amplitude of the mid-wall signal. If either of these conditions occur the reflector is likely an isolated pit with significant wall loss rather than a mid-wall lamination.

3. **Coated** parts can cause additional difficulties in signal evaluation;

- a. Coating can cause an increase in signal ring-down, additional cycles in the sine wave, which makes all signals seem broader with an increased number of signal cycles seen on the A-scan. This makes all signals, including clean back-wall signals and laminations, to appear broader. Coating on samples that creates additional signal ring-down can also cause laminations to not generate multiple signals.
- b. Extra care must be taken on coating parts when evaluating signals from laminations to verify they do not move back and forth on the time base.



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Figure 1 – Signal Patterns (© ASNT 2019)

The following figure provides some examples of signal patterns indicative of the various scenarios detailed. The figure assumes a back-wall signal from an undamaged area on a part was set to 80% full screen height at a position on the time base 40% across the screen from the left side (0 distance).

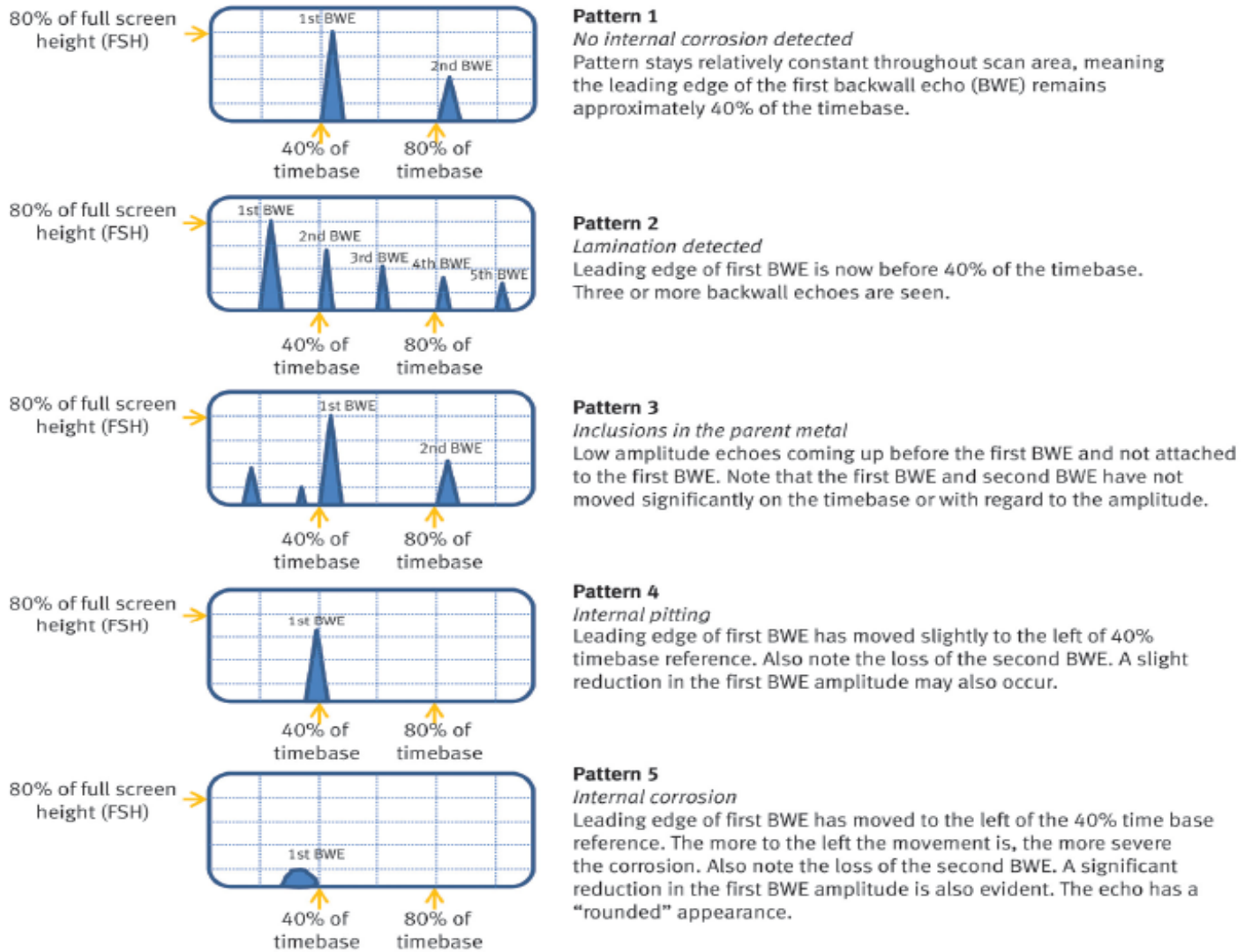




Figure 2 – Evaluation Flowchart (© ASNT 2019)

The following figure provides some guidance on signal evaluation in the form of a flowchart that can be followed for differentiating corrosion from mid-wall laminations or inclusions. This flowchart is not absolute as every flaw in a material can exhibit different ultrasonic signal behaviors. Information provided above in sections 1. Laminations and 2. Wall loss should be considered when determining the nature of ultrasonic signals.

