

Recommended Practice for Ultrasonic Evaluation of Pipe Imperfections

API RECOMMENDED PRACTICE 5UE
SECOND EDITION, JUNE 2005

ADDENDUM 1, APRIL 2009

REAFFIRMED, JULY 2020



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Upstream Segment

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Recommended Practice for Ultrasonic Evaluation of Pipe Imperfections

1 Scope

1.1 This recommended practice describes procedures which may be used to "prove-up" the depth or size of imperfections. Included in this practice are the recommended procedures for ultrasonic prove-up inspection of new pipe using the Amplitude Comparison Technique and the Amplitude-Distance Differential Technique for evaluation of 1) surface breaking imperfections in the body of pipe and 2) surface breaking and subsurface imperfections in the weld area of electric resistance, electric induction or laser welded pipe and 3) surface breaking and subsurface imperfections in the weld area of arc welded pipe. For the purpose of this document, pipe is defined as including casing, plain-end casing liners, tubing, plain-end drill pipe, line pipe, coiled line pipe, pup joints, coupling stock, and connector material.

1.2 Prove-up inspection is a method to evaluate the radial depth of imperfections detected by automated inspection equipment or other nondestructive testing (NDT) technique(s) to determine acceptance criteria compliance with the appropriate API specification.

1.3 The recommended prove-up practices established within this document are intended as a guide, and nothing in this guide should be interpreted to prohibit the agency or owner from supplementing the guide with other techniques or extending existing techniques.

1.4 This RP covers evaluation, a description of inspection methods, calibration and standardization procedures, and inspection personnel requirements for prove-up.

1.5 Appendix A of this document is provided as an overview to inform the user of the basis for the techniques outlined in this RP.

1.6 Appendix B of this document provides a procedure for determining if imperfections are surface breaking and a formula for calculating the sound path distance for a circumferential or axial scan of a curved surface and a sample look-up table.

1.7 Appendix C of this document is provided as an overview to inform the user of the specifics for the evaluation of welds with filler metal.

1.8 Appendix D of this document provides a procedure for sizing planar non-surface breaking imperfections from the pipe's outside surface.

2 References

2.1 This recommended practice includes by reference, either in total or in part, the latest editions of the following API and industry standards, unless a specific edition is listed:

API

RP 5A5	<i>Field Inspection of New Casing, Tubing, and Plain-end Drill Pipe</i>
Spec 5CT	<i>Casing and Tubing</i>
Spec 5D	<i>Drill Pipe</i>
Spec 5L	<i>Line Pipe</i>
RP 5L8	<i>Field Inspection of New Line Pipe</i>
Std 5T1	<i>Imperfection Terminology</i>

ASNT¹

SNT-TC-1A	<i>Personnel Qualification and Certification in Nondestructive Testing</i>
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ASTM²

E 317	<i>Standard Practice for Evaluating Performance Characteristics of Ultrasonic Pulse-echo Testing Systems Without the Use of Electronic Measurement Instruments</i>
E 1065	<i>Standard Guide for Evaluating Characteristics of Ultrasonic Search Units</i>

3 Definitions

The following terms are used frequently in the nondestructive testing of pipe:

3.1 A-scan: A method of data presentation utilizing a horizontal time-base that indicates distance or time and a vertical deflection from the base line that indicates amplitude.

3.2 active peak memory: The capability of an instrument to retain an A-scan presentation while allowing instrument controls to be functionally active.

3.3 agency: An entity contracted to inspect new pipe using the methods and criteria specified.

3.4 Amplitude Comparison Technique (ACT): An ultrasonic prove-up method comparing the reflected signals from a reference indicator of known radial depth and an imperfection.

3.5 Amplitude Distance Differential Technique (ADDT): An ultrasonic prove-up method comparing both the

¹American Society for Nondestructive Testing, Inc., 1711 Arlington Lane, P.O. Box 28518, Columbus, Ohio 43228-0518.

²American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19380-2959.

distance and amplitude at 50% peak amplitude levels from a reference indicator of known radial depth and an imperfection.

3.6 angle beam: An inspection method in which the angle of incidence or refraction is other than perpendicular to the surface of the test object being inspected. This includes the use of shear waves and longitudinal (compression) waves.

3.7 angle beam block: A specified type of reference standard used for the angle beam method.

3.8 angle of incidence: The included angle between the beam axis of the incident wave and a line perpendicular to the surface at the point of incidence.

3.9 angle of refraction: The included angle between the beam axis of a refracted wave and a line perpendicular to the refraction interface.

3.10 API: Abbreviation for American Petroleum Institute, headquartered in Washington, D.C.

3.11 artificial discontinuity: See reference indicator.

3.12 ASNT: Abbreviation for American Society for Non-destructive Testing, headquartered in Columbus, Ohio.

3.13 ASTM: Abbreviation for American Society for Testing and Materials, headquartered in West Conshohocken, Pennsylvania.

3.14 axial scanning: Scanning for imperfections with a transverse orientation. The transducer is aligned with the longitudinal axis of the pipe.

3.15 calibration: The comparison of an instrument with, or the adjustment to, known reference(s) often traceable to the National Institute of Standards and Technology (NIST).

3.16 certification: A written declaration stating compliance with stated criteria.

3.17 circumferential scanning: Scanning for imperfections with a longitudinal orientation. The transducer is aligned perpendicular with the longitudinal axis of the pipe.

3.18 couplant: A material (usually a liquid) used between an ultrasonic transducer and the test specimen to conduct ultrasonic energy between them.

3.19 Differential Time of Flight: ($T_2 - T_1$), time difference from the leading edge of signal envelope to the trailing edge of the signal envelope.

3.20 digital readout: Numeric display of ultrasonic data.

3.21 disposition: The action taken in conformance with the applicable API Specification with regard to an imperfection in a length of new pipe.

3.22 distance standardization: The adjustment of the A-scan display to accurately reflect known distances to specific positions on the time-base.

3.23 evaluation: The process of determining the severity of an imperfection, which leads to determining whether the pipe is acceptable or rejectable under the appropriate specification.

3.24 frequency: Number of complete cycles of a wave motion per second of time. Unit of measure is called a hertz (Hz).

3.25 FSH: Abbreviation for full screen height.

3.26 gain: The controlled adjustment of the amplified, displayed signal response in dB units.

3.27 gate: An electronic device for monitoring signals in a selected segment of the trace on an A-scan display.

3.28 gate start: The position along the A-scan display where the gate begins. The displayed value may be expressed in inches or microseconds.

3.29 gate width: The length of the gate along the A-scan display as measured from the gate start. The displayed value may be expressed in inches or microseconds.

3.30 IIW block (International Institute of Welding): See angle beam block.

3.31 imperfection: A discontinuity or irregularity in the product. For exact definitions and illustrations of specific imperfections, see API Std 5T1.

3.32 indication: A response from nondestructive inspection that requires interpretation in order to determine its significance.

3.33 instrument delay control: An electronic circuit used to adjust the start of the time-base. May also be referred to as the zero control.

3.34 instrument material velocity control: An electronic circuit used to adjust the length of the time-base relative to the velocity of the material being inspected. May also be referred to as the range or calibrate control.

3.35 inspection: The process of examining pipe for possible defects or for deviation from established standards.

3.36 inspector: A person who is qualified and responsible for one or more of the inspections or tests specified in this document.

3.37 k factor: A derived factor for calculating depth when using the Amplitude Distance Differential Technique (ADDT).

3.38 longitudinal imperfection: An imperfection that has its principal direction or dimension approximately parallel to the longitudinal pipe axis.

3.39 marking: Assorted marks on tubular products, which includes inspection markings made with paint sticks and stencils, and ball-point paint tubes.

3.40 nondestructive testing (NDT): Inspection to detect defects or imperfections in materials, using techniques that do not damage or destroy the items being tested.

3.41 notch: See reference indicator.

3.42 oblique imperfection: An imperfection at an angle other than longitudinal or transverse to the axis of the pipe.

3.43 operator: The person present throughout the inspection or testing process who is responsible for the ultrasonic inspection unit, operates the controls, and observes the readout to detect imperfections.

3.44 owner: The entity who has ownership of the pipe at the time inspection is contracted, specifies and authorizes the type of inspection or testing to be conducted. The owner may be the purchaser.

3.45 parallax: Apparent displacement, or difference in the apparent position, of an object, caused by the actual change of the point of observation.

3.46 peak memory mode: An instrument capability that captures and stores the A-scan display.

3.47 pipe: Includes oil field casing, plain-end casing liners, tubing, plain-end drill pipe, line pipe, coiled line pipe, pup joints, coupling stock, and connector material.

3.48 plain-end: Pipe end without threads or tool joint.

3.49 planar: This term refers to an imperfection lying in one geometric plane that is normally parallel to, and within, the outer and inner surfaces.

3.50 prime pipe: Pipe meeting all of the specified inspection and testing requirements.

3.51 prove-up: The ultrasonic processes described within this RP for measuring and evaluating imperfections.

3.52 pulse: A short wave train of mechanical vibrations.

3.53 pulse-echo method: An ultrasonic test method that both generates ultrasonic pulses and receives the return echo.

3.54 quality program: A documented system to ensure quality.

3.55 recommended practice (RP): A standard to facilitate the broad availability of proven sound engineering and operating practices.

3.56 reference indicator: Real or artificial discontinuities in a reference standard that provide reproducible sensitivity levels for inspection equipment. Artificial indicators may be holes, notches, grooves, or slots.

3.57 reference standard: A pipe, or pipe section, containing one or more reference indicators used as a base for comparison or for inspection equipment standardization.

3.58 reflection: The return of sound waves from surfaces.

3.59 sensitivity: The size of the smallest imperfection detectable by a nondestructive test method with an acceptable signal-to-noise level.

3.60 shall: Used to indicate that a provision is mandatory.

3.61 should: Used to indicate that a provision is not mandatory but recommended as good practice.

3.62 signal: An electronic response of NDT equipment to an imperfection or defect.

3.63 signal envelope: The curve that encompasses successive return signals along the time-base on an A-scan display as an imperfection is scanned.

3.64 signal-to-noise ratio: The ratio of the signal from a significant imperfection or defect to signals generated from surface noise.

3.65 6 dB drop technique: An ultrasonic technique traditionally used as a means for the dimensional sizing of laminar imperfections in plate and for measuring the length of radial imperfections.

3.66 skip distance: In angle beam examination, the distance along the test surface, from sound entry point to the point at which the sound returns to the same surface. It can be considered the top surface distance of a complete vee path of sound in the test material.

3.67 skip position: The location on the A-scan display, along the time-base, relative to the skip distance for a given reflector.

3.68 sound path distance: The distance ultrasound travels from the entry point in the material to a given reflector.

3.69 standardization: The adjustment of instruments, to a known reference value.

3.70 standardization check: A check of the standardization adjustments to ensure that they remain correct.

3.71 time-base: The horizontal line on the A-scan display that represents time or distance.

3.72 transducer: Electroacoustical device for converting electrical energy into acoustical energy and vice versa.