



AEROSPACE MATERIAL SPECIFICATION

AMS-STD-2154™**REV. E**

Issued 1998-03
Reaffirmed 2005-09
Revised 2021-07

Superseding AMS-STD-2154D

Inspection, Ultrasonic, Wrought Metals, Process for

RATIONALE

AMS-STD-2154D revises standard test block inspection (5.1.2.1), reference standards (5.3), distance-amplitude correction (5.4.10), evaluation of discontinuities (5.4.16), and Table 2, Note 4.

AMS-STD-2154E includes revision to transducer size (5.2.4), adds (5.4.15.1) exceptions to the transfer technique, allows a type 1 option (5.1.1.2), deletes noise note in Table 6, and adds notes of explanation for Figure 12. Because this revision clarifies changes from revision D, changes for both revisions are maintained.

NOTICE

The initial SAE publication of this document was taken directly from U.S. Military Standard MIL-STD-2154. This SAE Standard may retain the same part numbers established by the original military document.

Any requirements associated with Qualified Products Lists (QPLs) may continue to be mandatory for DoD contracts. Requirements relating to QPLs have not been adopted by the SAE for this standard and are not part of this SAE document.

FOREWORD

This document supersedes MIL-I-8950B and MIL-STD-2154, Inspection, Ultrasonic, Wrought Metals, Process. The purpose of AMS-STD-2154 is to standardize the process for applying ultrasonic inspection in the evaluation of wrought metals and wrought metal products.

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<https://www.sae.org/standards/content/AMS-STD-2154E/>

Documents

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1. SCOPE

1.1 Purpose

The purpose of this standard is to provide uniform methods for the ultrasonic inspection of wrought metals and wrought metal products.

1.2 Application

The methods for ultrasonic inspection in this standard are applicable in the detection of flaws in wrought metals and wrought metal products having a cross section thickness equal to 0.250 inch or greater. Round bar and billet may use AMS2628 techniques and equipment for billet over 4.5 inches using the acceptance criteria of Table 6 of AMS-STD-2154. Wrought metals include forging stock, forgings, rolled billet or plate, extruded or rolled bars, extruded or rolled shapes, and parts made from them. Application of the methods in this standard is not intended for non-metals, welds, castings, or sandwich structures.

1.2.1 Wrought Aluminum Alloy Products

Requirements for ultrasonic inspection of aluminum alloy wrought products, except as noted below, shall be in accordance with ASTM B594:

- a. Ultrasonic inspection of machined aluminum alloy parts shall be in accordance with this standard.

1.3 Classification

The ultrasonic inspection methods in this standard shall be classified as follows:

1.3.1 Type

- a. I - Immersion method
- b. II - Contact method

1.3.2 Class

Five ultrasonic acceptance classes shall be as defined in Table 6.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2628	Enhanced Ultrasonic Immersion Inspection for Titanium Alloy and Other Metal Alloy Billets
AMS2632	Inspection, Ultrasonic, of Thin Materials 0.50 Inch (12.7 mm) and Under in Cross-Sectional Thickness
AMS4928	Titanium Alloy Bars, Wire, Forgings, Rings, and Drawn Shapes, 6Al - 4V Annealed
AMS-QQ-A-200/3	Aluminum Alloy 2024, Bar, Rod, Shapes, Tube, and Wire, Extruded

AMS-QQ-A-200/11	Aluminum Alloy 7075, Bar, Rod, Shapes, Tube, and Wire, Extruded
AMS-QQ-A-225	Aluminum and Aluminum Alloy, Bar, Rod, Wire, or Special Shapes; Rolled, Drawn, or Cold Finished; General Specification For
AMS-S-5000	Steel, Chrome-Nickel-Molybdenum (E4340) Bars and Reforging Stock

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM A36	Carbon Structural Steel
ASTM B107	Magnesium-Alloy Extruded Bars, Rods, Profiles, Tubes, and Wire
ASTM B221	Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B241/B241M	Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube
ASTM B594	Ultrasonic Inspection of Aluminum-Alloy Wrought Products
ASTM E127	Fabrication and Control of Flat Bottomed Hole Ultrasonic Standard Reference Blocks
ASTM E317	Performance Characteristics of Ultrasonic Pulse-Echo Testing Instruments and Systems Without the Use of Electronic Measurement Instruments
ASTM E1316	Standard Terminology for Nondestructive Examinations

2.3 AIA Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NAS410	NAS Certification and Qualification of Nondestructive Test Personnel
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3. DEFINITIONS

The following definitions and the definitions in ASTM E1316 shall apply to terms which are uncommon or have special meaning as used in this specification. Definitions of terms included herein are in addition to terms defined in referencing specifications and are associated primarily with ultrasonic inspection.

3.1 A-Scan Presentation

A method of data presentation on a display screen utilizing a horizontal base line that indicates distance, or time and vertical deflections from the base line which indicate pulse amplitudes.

3.2 Angle Beam Examination

Examination conducted using an ultrasonic beam traveling at an angle measured from the normal to the test surface.

3.3 Attenuation

Loss of energy per unit distance, commonly expressed in decibels per unit length.

3.4 Back Surface Resolution

The minimum distance between the back surface and a discontinuity of known size that will give an indication whose trailing edge will clearly be separated from the far surface indication down to at least 20% of full scale when the ultrasonic beam is perpendicular to the back surface.

3.5 C-Scan Presentation

A means of data presentation which provides a plan view of the part or material being tested. The location and sizes of areas containing discontinuities which give ultrasonic reflection above a pre-set amplitude are indicated on the C-scan presentation.

3.6 Decibel (dB)

Logarithmic expression of a ratio of two amplitudes.

$$db = 20 \log_{10} A_1/A_2 \quad (\text{Eq. 1})$$

where:

A_1 and A_2 = amplitudes or the area of reflectors

3.7 Distance-Amplitude Correction (DAC) (Swept Gain, Time Corrected Gain, and Time Variable Gain, etc.)

Electronic change of amplification to provide equal amplitude from equal reflectors at different depths.

3.8 Entry Surface Resolution

The minimum distance between the entry surface and a discontinuity of known size that will produce a first-echo indication whose leading edge will clearly be separated from the entry surface indication down to at least 20% of full scale when the ultrasonic beam is perpendicular to the entry surface.

3.9 Far Field

The region of sound beam travel beyond near field, in which intervals of high and low acoustic transmission intensity cease to occur. A reflector gives monotonically decreasing amplitude with increasing distance in this zone.

3.10 Horizontal Linearity Range

The range of horizontal deflection in which a constant relationship exists between the incremental horizontal displacement of vertical indications on the A-scan presentation and the incremental time required for reflected waves to pass through a known length in a uniform transmission medium.

3.11 Horizontal Limit

The maximum readable length of horizontal deflection that is determined either by an electrical or a physical limit in the A-scan presentation of an ultrasonic testing instrument. Horizontal limit is expressed as the maximum observed deflection in inches from the left side, or the start, of the horizontal line representing the time base.

3.12 Linear Array Probes

Probes made using a set of elements juxtaposed and aligned along a linear axis. They enable a beam to be rastered and focused along a single azimuthal plane (active axis) only.

3.13 Lower Linearity Limit

The level of vertical deflection defining the lower limit of an observed constant relationship between the amplitude of the indications on an A-scan screen and the corresponding magnitude of the reflected ultrasonic wave from reflectors of known size.

3.14 Near Field

The region immediately in front of a transducer in which the ultrasonic beam is subject to variation of intensity due to interference effects. The length of a region is governed primarily by frequency and probe diameter. The sound beam travel distance from the face of the transducer given by the equation:

$$N = D^2 f / 4C \quad (\text{Eq. 2})$$

where:

N = near field length, inches

D = major dimension of the transducer element, inches

for circles, D = diameter

for rectangles or squares, D = diagonal

F = ultrasonic frequency, Hertz

C = ultrasonic velocity, inches per second

3.15 Noise

A large number of unresolved signals at the baseline of the display which can be caused by nonhomogeneous structure, surface roughness, electrical interference, etc.

3.16 Primary Reference Response

The amplitude established from reference standards at metal travel distance where the least response is obtained.

3.17 Signal to Noise Ratio

The ratio of the amplitude of a given ultrasonic signal to the amplitude of the average background noise signal.

3.18 Straight Beam Examination

Examination conducted using an ultrasonic beam traveling normal to the test surface.

3.19 Transducer Element

The portion of a transducer which is made out of a piezoelectric material and used to transform electrical energy to ultrasonic energy and vice-versa.

3.20 Ultrasonic Sensitivity

The capacity of an ultrasonic testing system to detect a very small discontinuity. Ultrasonic sensitivity is expressed as the amplitude of the indication obtained from a small discontinuity of known size when the instrument gain setting is maximum.

3.21 Ultrasonic Penetration

A relative term denoting the ability of an ultrasonic testing system to inspect material exhibiting high absorption or scattering.

3.22 Upper Linearity Limit

The level of vertical deflection defining the upper limit of an observed constant relationship between the amplitude of the indications on an A-scan screen and the corresponding magnitude of the reflected ultrasonic wave from reflectors of known size.

3.23 Vee-Path

The angle-beam path in materials starting at the transducer examination surface, through the material to the reflecting surface, continuing to the examined surface in front of the search unit, and the reflection back along the same path to the transducer. The path is usually shaped like the letter V.

3.24 Vertical Limit

The maximum readable level of vertical indications that is determined either by an electrical or a physical limit in the A-scan presentation of an ultrasonic testing instrument. For purposes of definition, vertical limit is expressed as the maximum observed deflection in inches from the horizontal line representing the time base.

3.25 Virtual Probe

A group of individual array elements pulsed simultaneously or at phasing intervals to generate a larger acoustic aperture.

4. GENERAL REQUIREMENTS

4.1 Specifying

When ultrasonic inspection is specified in accordance with this standard, orders, contracts, or referencing specifications shall specify the ultrasonic type and class or classes (see Table 6). Engineering drawings shall be zoned to indicate different quality level acceptance classes based on the criticality of each zone. Directions of maximum stressing shall be indicated on engineering drawings to indicate the requirements for performing ultrasonic inspection to locate discontinuities oriented perpendicular to the directions of maximum stressing.

4.2 Personnel Qualification

Personnel making accept-reject decisions described in this standard shall be qualified in accordance with NAS410.

4.3 Written Procedure

A detailed NDT procedure shall be prepared for each part and type of inspection to be performed. The procedure shall meet the requirements of this standard and shall provide consistency for producing the desired results and quality level. The procedure shall cover all of the specific information required to set-up and perform the test, such as the following:

- a. Name and address of testing facility.
- b. Number of the procedure including latest revision letter, if applicable, and date.
- c. Personnel requirements.
- d. Number of this standard including latest revision letter, if applicable, and date.
- e. Inspection method type and acceptance class or classes to be applied.
- f. Inspection mode (shear longitudinal, etc.).
- g. Inspection zones, if applicable.
- h. Specific part number and configuration to be tested.
- i. Specific material and form for which the procedure is being prepared.

- j. Manufacturer and model numbers of any instrumentation to be used in the test. Include any recording equipment, alarm equipment, and electronic distance-amplitude correction equipment.
- k. Type and size of transducer. Include frequency, sound beam angle and description of any wedges, shoes, saddles, stand-off attachments, bubblers, or squirters.
- l. Description of manipulating and scanning equipment.
- m. Surface condition requirements.
- n. Special material handling and processing of parts defined when needed.
- o. Couplant.
- p. Scanning plan. Describe the surfaces from which the tests will be performed and the ultrasonic beam paths to be used.
- q. Method of applying transfer, if utilized.
- r. Test blocks, water path, and methods of standardization and index determination.
- s. Scanning speed and index.
- t. Method of establishing scan sensitivity for concave and convex surfaces, if applicable.
- u. Limits on reject, noise level, gate levels.
- v. Discontinuity evaluation procedure.
- w. Complete post inspection cleaning instructions, or reference to procedures containing such instructions.
- x. Marking instructions that ensure compliance to 5.6.1.
- y. Any other pertinent data.

4.4 General Procedures

General procedures are acceptable for common product forms such as plate, bar stock extrusions and forgings. The general procedure shall cover applicable items of 4.3.

5. DETAIL REQUIREMENTS

5.1 Materials

5.1.1 Couplants

5.1.1.1 Immersion Method (Type I)

For the immersion method (Type I), water shall be used, either in an immersion tank or as a water column. The water shall be free of visible air bubbles and other foreign material which could interfere with ultrasonic tests. A suitable corrosion inhibiting agent and a wetting agent shall be added to the water, if necessary, to inhibit corrosion and to reduce the formation of air bubbles on the material and the transducer. The specific inhibiting and wetting agents shall have been previously determined to be suitable for the materials to be inspected.