



AEROSPACE MATERIAL

Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N. Y. 10001

SPECIFICATION

AMS 2631

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Revised

ULTRASONIC INSPECTION OF TITANIUM ALLOYS

1. SCOPE:

- 1.1 Purpose: This specification covers the procedure for ultrasonic inspection of titanium-base alloy products 0.5 in. (13 mm) and over in cross sectional thickness.
- 1.2 Application: Primarily for locating internal defects such as cracks, voids, spongy areas, and other structural discontinuities which may or may not be exposed to the surface.
2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

- 2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., Two Pennsylvania Plaza, New York, New York 10001.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 2380 - Approval and Control of Premium Quality Titanium Alloys
AMS 4928 - Titanium Alloy Bars and Forgings, 6Al-4V, Annealed, 120,000 psi Yield

2.1.2 SAE Standards and Recommended Practices:

SAE J300 - Crankcase Oil Viscosity Classification

- 2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

ASTM E428 - Fabrication and Control of Steel Reference Blocks Used in
Ultrasonic Inspection

- 2.3 ANSI Publications: Available from American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018.

ANSI B46.1 - Surface Texture

- 2.4 ASNT Publications: Available from American Society for Nondestructive Testing, Inc., 914 Chicago Avenue, Evanston, Illinois 60202.

SNT-TC-1A - Ultrasonic Testing Method

3. TECHNICAL REQUIREMENTS:

3.1 Qualification:

- 3.1.1 Personnel: Operators shall be certified to SNT-TC-1A, Level I; personnel who read and interpret indications and evaluate them with reference to applicable codes and specifications shall be certified to SNT-TC-1A Level II or higher.

SAE Technical Board rules provide that: "All technical reports, including standards, and practices recommended, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to adhere to any SAE standard, or recommended practice, and no commitment to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its Committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against infringement of patents."

3.1.2 Facilities: Shall be subject to survey and approval by the purchaser.

3.2 Equipment:

3.2.1 Electronic Apparatus: Shall be capable of producing, receiving, and displaying high frequency electrical pulses at the required frequencies and energy levels. The ultrasonic instrument shall be of the pulse-echo type capable of operating at 2.25 through 10 MHz except as permitted in 3.2.2.1. Gates, distance-amplitude correction systems, and other electronic aids to ultrasonic testing and interpretation shall be used as required. An alarm system and/or a recorder and/or an auto-stop device shall be used unless otherwise permitted by purchaser.

3.2.2 Transducers: Shall be capable of transmitting and receiving ultrasonic vibrations at the frequency and energy levels specified below. The frequency used shall be the highest practical ultrasonic frequency which will provide the penetration and resolution required.

3.2.2.1 Transducers 0.75 - 1.25 in. (19.0 - 31.8 mm) in diameter and operating at 5 MHz frequency are recommended for product 0.5 to 9 in. (13 to 229 mm), incl, in cross section inspected by the immersion method and for product 3 to 9 in. (76 to 229 mm), incl, in cross section inspected by the contact method. Use of frequencies lower than 2.25 MHz or special type transducers is permissible when agreed upon by purchaser and vendor.

3.2.3 Other Equipment: Tanks, bridges, rotators, manipulators, and other equipment shall be adequate to perform the required tests.

3.2.3.1 Voltage Regulator: If fluctuations in line voltage cause variations exceeding $\pm 5\%$ in a signal with an amplitude equal to the upper linearity limit of the instrument, a voltage regulator shall be used on the power source; this requirement does not apply to battery-powered units.

3.2.4 Couplant:

3.2.4.1 Immersion Method: For inspection by the immersion method, clean tap water shall be used as the couplant material; rust inhibitors and/or wetting agents may be added. The water shall be free of visible air bubbles which could interfere with the ultrasonic test.

3.2.4.2 Contact Method: For inspection by the contact method, SAE 30 motor oil in accordance with SAE J300 or cellulose gum shall be used as the couplant material. Other types of couplant materials that have been proven acceptable for a particular type of test may be used if agreed upon by purchaser and vendor. Chloroprene rubber sheet or similar materials may be used between the transducer and the product being tested to prevent excessive transducer wear provided adequate compensation for its use is made.

3.2.5 Reference Standards: Shall be fabricated from AMS 4928 titanium-base alloy, or from the alloy to be tested, to meet the requirements of ASTM E428 and the following:

3.2.5.1 The test block material shall have ultrasonic sound transmission characteristics equal to those of the material to be tested within $\pm 25\%$. If the sound transmission characteristics vary more than $\pm 25\%$, compensation correction techniques shall be approved by the purchaser.

3.2.5.2 For testing flat surfaces, flat test blocks shall be used. For testing curved surfaces, the reference standards shall have similar contour within approximately $\pm 25\%$ of the radius of curvature of the dimensions being tested. Surface finish of the calibration standard shall be similar to that of the material being tested.

3.2.5.3 For longitudinal wave calibration, the calibration reflectors shall be flat-bottom holes. The distance from the entry face of the ultrasonic beam to the bottoms of the calibration holes shall be as follows, based on the material contour and section thickness "T":

- 3.2.5.3.1 Rounds 0.5 to 2 In. (13 to 51 mm), Incl, in Diameter: 0.5T and 0.250 in. (6.35 mm).
- 3.2.5.3.2 Rounds Over 2 to 5 In. (51 to 127 mm), Incl, in Diameter: T-0.50 in. (-12.7 mm), 1/2T, 1/4T, and 0.250 in. (6.35 mm).
- 3.2.5.3.3 Rounds Over 5 In. (127 mm) in Diameter: 1/2T, 1/4T, 1/8T, and 0.375 in. (9.52 mm). If frequencies below 5 MHz are used, the minimum metal travel of 0.50 in. (12.7 mm) may be used.
- 3.2.5.3.4 Flat Faced Material 0.5 to 2 In. (13 to 51 mm), Incl, in Cross Section: T-0.125 in. (-3.18 mm), 1/2T, and 0.125 in. (3.18 mm).
- 3.2.5.3.5 Flat Faced Material Over 2 to 5 In. (51 to 127 mm), Incl, in Cross Section: T-0.50 in. (-12.7 mm), 1/2T, 1/4T, and 0.250 in. (6.35 mm).
- 3.2.5.3.6 Flat Faced Material Over 5 to 8 In. (127 to 203 mm), Incl, in Cross Section: T-0.50 in. (-12.7 mm), 1/2T, 1/4T, 1/8T, and 0.250 in. (6.35 mm).
- 3.2.5.3.7 Flat Faced Material Over 8 In. (203 mm) in Cross Section: 1/2T, 1/4T, 1/8T, and 0.375 in. (9.52 mm). If frequencies below 5 MHz are used, the minimum metal travel of 0.50 in. (12.7 mm) may be used.
- 3.2.5.3.8 Special test blocks to calibrate testing modes other than longitudinal and any other blocks necessary to aid in testing or evaluation may be used as agreed upon by purchaser and vendor.
- 3.3 Surface Preparation:
 - 3.3.1 The surfaces to be inspected shall be common geometrical sections such as round, square, and octagonal. Flat-face product shall be prepared to assure flatness of the various faces.
 - 3.3.2 Texture of surfaces to be inspected shall be not rougher than 250 microinches (6.35 μ m). For longitudinal mode tests to Class AA or A1 requirements and for shear mode tests, surface texture of approximately 125 microinches (3.18 μ m) is desirable. Surface texture shall be determined in accordance with ANSI B46.1.
 - 3.3.3 Surface discontinuities remaining after surface preparation shall not be removed before ultrasonic inspection because local grinding depressions will cause sonic wave attenuation, loss of back reflection, and inability to locally meet standards. Surfaces shall be free from loose scale, machining or grinding particles, oil, grease, cutting compounds, and other foreign materials.
- 3.4 Calibration of Apparatus: Before inspecting the product, the apparatus shall be adjusted, using appropriate reference blocks, to produce from the simulated imperfections, clearly defined indications of sufficient height to assure that the product under test can be inspected as required to locate any imperfections of detrimental size, nature, and location. The minimum pip height shall be not less than 1.0 in. (25 mm); the maximum pip height shall be not greater than 90% of the screen height.
 - 3.4.1 Instruments of the vacuum tube type shall be warmed up for not less than 30 min. before being used; instruments using solid state electronic components shall be warmed up for not less than 10 min. before being used. Sufficient time shall also be allowed for temperature of water, reference blocks, and product to stabilize before calibration and testing.
 - 3.4.2 A calibration check shall be made prior to test or at the start of each shift for operation on successive shifts. Any change in the operation of equipment during test shall be cause for recalibration and for re-test of all material inspected since the previous calibration.

3.5 Procedure: The product shall be inspected by the longitudinal wave method. The sound beam entry angle for longitudinal wave (straight beam testing) shall be normalized by adjusting for maximum signal amplitude from the front (entry) surface. During testing, the angle established shall not vary more than ± 2 deg (0.035 rad). Additional modes other than longitudinal or normal longitudinal and the contact method shall be used when agreed upon by purchaser and vendor. Inspection by the longitudinal wave immersion method shall be in accordance with 3.5.1 and 3.5.2; inspection by the longitudinal wave contact method, when permitted, shall be in accordance with 3.5.1 and 3.5.3.

3.5.1 General:

3.5.1.1 Calibration for determination of loss in the back reflection pattern shall be performed on parallel surfaces of the product being tested. The back reflection pattern from the full material thickness section of the test block at the scanning sensitivity shall be recorded. If the back reflection pattern from the product being tested averages a variation of more than $\pm 50\%$ from that recorded from the test block, no testing shall be performed until necessary corrective action is taken.

3.5.1.2 The permissible background noise shall not exceed 56% of saturation or 70% of the response height from the reference standard of the same alloy as the product being tested. If the background noise exceeds this level, the section involved shall be re-examined to assure that the product meets the specified requirements.

3.5.1.3 The pulse rate shall be not lower than 600 per second.

3.5.1.4 The scanning speed in scanning reference standards shall be not greater than that at which the calibration holes in the reference standards are resolved. The scanning speed in testing the product shall be not greater than that established for resolution of calibration holes in the reference standards.

3.5.1.4.1 For manual scanning without alarm systems, a scanning speed not greater than 5.0 in. (127 mm) per sec is recommended.

3.5.1.4.2 For alarm systems with or without automatic scanning, a scanning speed not greater than 20 in. (508 mm) per sec is recommended.

3.5.1.5 When the alarm system is used during testing, it shall be set at "Hold" or "Manual Reset".

3.5.1.6 The instrument control settings and test parameters established during calibration shall not be changed during testing of the product. The pulse length shall be set at the minimum that will afford the proper resolution. The reject control shall be off.

3.5.1.7 The surface area of the product to be scanned shall be as follows:

3.5.1.7.1 Bars and Forging Stock:

3.5.1.7.1.1 Rounds 2.0 In. (51 mm) and Over in Diameter: The entire circumference.

3.5.1.7.1.2 Flat-Faced Product 2.0 to 8.0 In. (51 to 204 mm), Incl. in Cross Section: All adjacent faces representing 50% of the periphery.

3.5.1.7.1.3 Flat-Faced Product Over 8.0 In. (204 mm) in Cross Section: All faces.

3.5.1.7.1.4 If all faces of flat-faced product of 3.5.1.7.1.2 are scanned, $1/2T$, $1/4T$, $1/8T$, and minimum metal travel test blocks (See 3.2.5.3.5 and 3.2.5.3.6) may be used.

3.5.1.7.1.5 Single face or opposite face tests of all flat-faced product may be made if shear or refracted longitudinal wave testing is substituted for the adjacent face test. These tests and the calibration and testing parameters shall be negotiated between purchaser and vendor.