



AEROSPACE MATERIAL SPECIFICATION

AMS2175™**REV. B**

Issued 2003-07
Reaffirm 2018-08
Revised 2024-04

Superseding AMS2175A

Castings, Classification and Inspection of

RATIONALE

AMS2175B results from a Five-Year Review and update of this specification with replacement of ARP1917 with AS7766 (see 2.5), new definitions (see 2.5.5 and 2.5.15), changes to Surface Characteristics (see 3.4.1.1), changes to Gate Riser and Parting Line Projections (see 3.4.1.3), and changes to Surface Pits and Raised Metal (see 3.4.1.4.1 and 3.4.1.4.2).

1. SCOPE

1.1 Purpose

This specification establishes nondestructive testing methods, sampling frequency, and acceptance criteria for the inspection of metal castings.

1.2 Application

This specification has been used typically for structural castings, but usage is not limited to such applications.

1.2.1 Casting Methods

This specification is intended to apply to all casting methods except high pressure die castings (see 8.2).

1.2.2 Casting Alloys

This specification is intended to apply to all casting alloys covered in Tables 7 through 15. Other alloys may be inspected to this standard as described in 3.4.3.2 using criteria specified by the cognizant engineering organization.

1.3 Classification

Castings that are inspected in accordance with this specification are designated by classes and applicable grades. The "Casting Class" governs the frequency of inspection (see 3.1 and 4.3), while the "Casting Grade" controls the acceptance criteria (see 3.1 and 3.4).

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1.3.1 Classes

Class 1 - A casting, the single failure of which would endanger the lives of operating personnel, or cause the loss of a missile, aircraft, or other vehicle.

Class 2 - A casting, the single failure of which would result in a significant operational penalty. In the case of missiles, aircraft, and other vehicles, this includes loss of major components, unintentional release, or inability to release armament stores, or failure of weapon installation components.

Class 3 - Castings not included in Class 1 or Class 2 and having a margin of safety of 200% or less.

Class 4 - Castings not included in Class 1 or Class 2 and having a margin of safety greater than 200%.

1.3.2 Grades

Castings, or sections of a casting, shall be of the following grades:

Grade A - The highest quality grade of casting, or area of a casting, with minimum allowable discontinuities and very difficult to produce except in local areas.

Grade B - The second highest quality grade of casting, or area of a casting, which allows slightly more discontinuities than Grade A, and difficult to produce, except in local areas.

Grade C - A high quality grade of casting, or area of a casting, that can be consistently produced.

Grade D - The lowest quality grade of a casting, or area of a casting, that is easily produced and is used primarily for low stress or noncritical areas adjacent to the higher graded areas.

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.

AS7766 Terms Used in Aerospace Metals Specifications

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 A802 Steel Acceptance Standards, Visual Examination

ASTM E155 Reference Radiographs for Inspection of Aluminum and Magnesium Castings

ASTM E186 Reference Radiographs for Heavy-Walled (2 to 4 1/2-in. (50.8 to 114-mm)) Steel Castings

ASTM E192 Reference Radiographs of Investment Steel Castings for Aerospace Applications

ASTM E272 Reference Radiographs of High-Strength Copper-Base and Nickel-Copper Alloy Castings

ASTM E280 Reference Radiographs for Heavy-Walled (4 1/2 to 12 -in. (114 to 305-mm)) Steel Castings

ASTM E310	Reference Radiographs for Tin Bronze Castings
ASTM E446	Reference Radiographs for Steel Castings up to 2 in. (50.8 mm) in Thickness
ASTM E1255	Radioscopy
ASTM E1320	Reference Radiographs for Titanium Castings
ASTM E1417	Liquid Penetrant Testing
ASTM E1444	Magnetic Particle Testing
ASTM E1742	Radiographic Examination
ASTM E2033	Radiographic Examination Using Computed Radiology (Photostimulable Luminescence Method)
ASTM E2104	Radiographic Examination of Advanced Aero and Turbine Materials and Components
ASTM E2422	Digital Reference Images for Inspection of Aluminum Castings

2.3 NAS Publications

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

NAS 410 Certification & Qualification of Nondestructive Test Personnel

2.4 ANSI Accredited Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ANSI/MSS SP-55 Quality Standard for Steel Castings for Valves, Flanges, Fittings, and Other Piping Components – Visual Method for Evaluation of Surface Irregularities

2.5 DEFINITIONS

Terms used in AMS are defined in AS7766 and as follows:

2.5.1 CHAPLET

Metal core support that is used in the mold cavity and fuses into the casting.

2.5.2 COLD SHUT

An imperfect junction between two flows of metal in a mold caused by the surface of the streams of molten metal chilling too rapidly such that complete fusion does not occur. This discontinuity may have the appearance of a crack or lap with smooth or rounded edges.

2.5.3 CORE SHIFT

Movement of a casting core such that a change in position can be discerned. Cores are portions of the mold that may create internal passageways or other casting features.

2.5.4 CRACK

A separation (rupture or fracture) of metal that was once joined in the solid state and produces a linear indication observed during nondestructive testing. See “cold shut” and “hot tear” for examples of other discontinuities that also produce linear indications.

2.5.5 CRACK-LIKE

A discontinuity from any cause that exhibits the linear shape characteristics of a crack without meeting the metallurgical definition of a crack. Examples include, but are not limited to, linear defects resulting from cold shuts, shrinkage and tears.

2.5.6 DEFECT

A discontinuity or condition that exceeds allowable limits. Defects are, by definition, unacceptable.

2.5.7 DISCONTINUITY

An interruption in the normal physical structure or configuration of a part such as a crack, inclusion, or porosity, which may or may not affect the usability of the part.

2.5.8 FOREIGN MATERIAL

Material other than the specified metal alloy, typically sand, slag, oxide, dross, or metal of different density. Indications of foreign material appear as isolated, irregular, or elongated variations of radiographic film density. In radiographic inspection where acceptance criteria exists for both foreign material and inclusions, the distinguishing factor is that the foreign material indications usually occur over a larger area while the inclusion indications are usually singular indications of a few discrete inclusions.

2.5.9 GAS HOLES

Round or elongated, smooth-edged voids occurring individually, in clusters, or distributed throughout the casting. They are generally caused by trapped air or gases evolved from the metal during solidification.

2.5.10 GAS POROSITY

Tiny voids distributed throughout the entire casting or a portion of the casting. They are generally caused by trapped air or gases rejected from the metal or mold material during solidification.

2.5.11 HOT TEAR

A fracture that forms upon solidification of the molten metal, often resulting from abrupt changes in section thickness that cause nonuniform cooling contraction. Radiographic images of hot tears appear as ragged dark lines of variable width and with no definite line of continuity. Hot tears may exist in groups and generally start at the surface.

2.5.12 INCLUSIONS

Particles of a material different than the intended casting composition, such as mold material, core material, slag, dross, etc., that are embedded in the casting. These particles may be internal, or surface connected.

2.5.13 INSERT

A piece of metal preplaced within the mold cavity and used to locally increase the rate of heat removal during solidification. It fuses to the final casting and is also called an internal chill.

2.5.14 IMAGE QUALITY INDICATOR (IQI)

A device or combination of devices whose demonstrated image or images provide visual or quantitative data, or both, to determine radiologic quality and sensitivity. Also known as a penetrameter.

2.5.15 LINEAR DISCONTINUITY

A discontinuity, e.g., cold shut, crack, shrinkage, tear, etc., with a length to width ratio of 3 to 1 or greater.

2.5.16 MISRUN

The failure of the molten metal to completely fill the mold. A misrun appears on the radiograph as prominent darkened areas of variable dimensions with a definite and smooth outline.

2.5.17 RADIOGRAPHIC QUALITY LEVEL

The ability of the radiographic procedure to demonstrate a certain IQI sensitivity based on the detection of the IQI holes or wires.

2.5.18 SEGREGATION

Variation in composition among regions of a casting that occurs during solidification. Segregation tends to form in thicker cross sections of susceptible alloys and will appear as areas with varying radiographic density.

2.5.19 SHRINKAGE

The term shrinkage, as used in this standard, refers to a network of small voids that formed during solidification. A larger and singular void caused by solidification shrinkage on a large scale, as defined in 2.5.20 is called a shrinkage cavity. Shrinkage is typically categorized as dendritic, filamentary, feathery, or sponge. Shrinkage is usually concentrated below the surface but may extend to the surface. In radiographic inspection, depending on the category, shrinkage may appear as dark irregular patches, as dark feathery streaks, or as a lacy or a honeycombed darkened area with a diffuse outline. Radiographic reference standards provide visual examples of each subcategory of shrinkage. In penetrant inspection, dendritic shrinkage (sometimes called "microshrinkage") and sponge shrinkage are often indistinguishable from each other and appear as a sponge-like cluster of tiny pinholes or spotty irregular areas with feathery outlines. In magnetic particle inspection shrinkage, may appear as a jagged area or irregular patch of magnetic particles.

2.5.20 SHRINKAGE CAVITY

A discrete void within a section of the casting caused by insufficient feeding of molten metal during solidification and volume reduction of the metal as it solidifies. Shrinkage cavities appear on the radiograph as dark areas that are indistinctly outlined and have irregular dimensions.

2.5.21 SURFACE IRREGULARITIES

Any anomaly, either positive (raised) or negative (depressed) from the normal cast surface.

2.5.22 VISUAL INSPECTION

Inspection of casting surfaces to determine conformance to the requirements for surface roughness, surface irregularities, dimensions, or visible surface discontinuities.

3. TECHNICAL REQUIREMENTS

3.1 Classification of Castings

3.1.1 Determination of Classes and Grades

The cognizant engineering organization shall establish the class and grade(s) for each casting design in accordance with 1.3. If the grade of casting is not specified on the drawing or other contractual document, Grade C shall apply, except for Class 4 castings, where Grade D shall apply. Sections of a casting may be of varying grades depending on the applied stresses to that portion of the casting. Particular attention should be given to areas that contain, or will eventually contain, stress risers after machining (such as sharp internal corners, holes, or notches).

3.1.1.1 Class 1 Casting Requirements

All areas of Class 1 castings shall be of a quality equivalent to, or higher quality grade than, Grade C, except that all highly stressed areas of a Class 1 casting shall be of a quality equivalent to, or higher quality grade than, Grade B.

3.2 Inspection Sequence

It is the responsibility of the supplier to perform and comply with inspections as necessary and in the proper sequence during processing to assure freedom from harmful discontinuities in the final product. The intent of inspections during processing is to detect discontinuities that would be detrimental to the final product at the earliest stage in processing so as to minimize the cost of rejected or scrapped castings. The sequence for penetrant, magnetic particle, and radiographic inspections shall be as specified in ASTM E1417, ASTM E1444, and ASTM E1742, respectively, or as otherwise specified by the cognizant engineering organization.

3.3 Personnel Qualification

Personnel performing penetrant, magnetic particle or radiographic inspections shall be qualified and certified in accordance with NAS 410 for the applicable method and technique.

3.4 Inspection Methods and Acceptance Criteria

3.4.1 Visual Inspection

Visual inspection shall be performed in areas with ambient lighting that is not less than 75 foot-candles.

3.4.1.1 Surface Characteristics

Castings shall not contain cracks, hot tears, cold shuts, and negative core seams (also called parting line below flush). In addition, castings shall conform to the criteria specified on the engineering drawing, specification, or agreed upon observational standards (see 8.3).

3.4.1.2 Surface Roughness

Surface roughness shall conform to the engineering drawing requirements. Surface roughness requirements specified on the engineering drawing (e.g., 63 Ra, 125 RMS, etc.) do not preclude the presence of acceptable liquid penetrant or magnetic particle indications. Visual and tactile comparison with commercially available observational standards may be used to determine conformance to surface roughness requirements.

3.4.1.3 Gate, Riser, and Parting Line Projections

If allowance limits for gate, riser, or parting line projections are not specified on the engineering drawing or casting (material) specification, or otherwise specified by the cognizant engineering organization, then the maximum limit for gates, risers and parting lines shall be in accordance with Table 4.

3.4.1.4 Surface Pits and Raised Metal

Allowable surface pits and raised metal (also called positive metal), other than gates, risers, and parting lines, that are not specifically controlled by the engineering drawing or agreed-upon observational standards shall be allowed as specified in 3.4.1.4.1 and 3.4.1.4.2.

3.4.1.4.1 Sand Castings

3.4.1.4.1.1 Surface pits are acceptable if they have smooth, rounded contours and do not cause the casting to fall outside the dimensional requirements of the engineering drawing.

3.4.1.4.1.2 Raised metal that has a jagged or irregular surface, or which causes the casting to fall outside of the dimensional requirements of the engineering drawing, shall be removed or blended to conform to the dimensional and surface roughness requirements of the engineering drawing.

3.4.1.4.2 Investment and Permanent Mold Castings

3.4.1.4.2.1 Surface Pits

Surface pits shall meet the following requirements. In addition, surface pits of any diameter are not acceptable if they cause the casting to fall outside the dimensional requirements of the engineering drawing.

3.4.1.4.2.1.1 Surface pits with a diameter <0.030 inch (0.76 mm) of any depth are not considered detectable under visual inspection.

3.4.1.4.2.1.2 Surface pits with a diameter of 0.030 – 0.060 inch (0.76 – 1.5 mm) and a depth of <0.030 inch (<0.76 mm) are allowed up to 1 per square inch (650 mm²) of surface area.

3.4.1.4.2.1.3 Surface pits with a diameter of 0.030 – 0.060 inch (0.76 – 1.5 mm) and a depth of ≥ 0.030 inch (≥ 0.76 mm) are not allowed.

3.4.1.4.2.1.4 Surface pits with a diameter of >0.060 inch (>1.5 mm) and a depth of <0.030 inch (<0.76 mm) are allowed.

3.4.1.4.2.1.5 Surface pits with a diameter of >0.060 inch (>1.5 mm) and a depth of ≥ 0.030 inch (≥ 0.76 mm) are not allowed.

3.4.1.4.2.2 Raised Metal

3.4.1.4.2.2.1 Random raised metal 0.015 to 0.030 inch (0.38 to 0.76 mm) in height with an area not greater than 0.125×0.125 inch (3.2×3.2 mm) is acceptable and is limited to no more than 1 per square inch (650 mm²). All raised metal less than 0.015 inch (0.38 mm) in height is allowed.

3.4.2 Magnetic Particle and Penetrant Inspection

3.4.2.1 Inspection Method for Ferromagnetic Materials

The method for inspection of ferromagnetic materials shall be in accordance with ASTM E1444. When approved by cognizant engineering organization, penetrant inspection may be performed in lieu of magnetic particle inspection (e.g., casting size or complex shape prevent adequate magnetic particle inspection). All precipitation hardening stainless steels shall be penetrant inspected in accordance with 3.4.2.2, unless otherwise specified by the cognizant engineering organization.

3.4.2.2 Inspection Method for Nonferromagnetic Materials

The method for inspection of nonferromagnetic materials shall be in accordance with ASTM E1417. The cognizant engineering organization may specify the sensitivity level of the penetrant materials to be used. If no sensitivity level is specified, the inspection facility shall use Sensitivity Level 1 or higher level.

3.4.2.3 Magnetic Particle and Penetrant Acceptance Criteria

If the magnetic particle or penetrant acceptance criteria are not specified, the surface quality shall conform to Table 5.

3.4.3 Radiographic Inspection

3.4.3.1 Radiographic Inspection Method

The method for inspection shall be in accordance with ASTM E1742, or when specified, in accordance with ASTM E2104. The use of nonfilm radiographic techniques (i.e., radioscopy, digital radiography, etc.) is permitted provided the method used is sufficiently sensitive to resolve the required radiographic quality level. Non-film inspection shall be conducted in accordance with ASTM E1255 or ASTM E2033; however, prior approval shall be obtained from the cognizant engineering organization on the detailed inspection, evaluation, documentation, and quality control procedures.