SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2175

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Superseding AMS-STD-2175

Castings, Classification and Inspection of

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 8.3).

1.2.2 Casting Alloys: This specification is intended to apply to all casting alloys covered in Tables 6 through 14. 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).

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.

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1.3.1 (Continued):

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 percent or less.

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

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 canceled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 or www.astm.org.

ASTM E 155	Reference Radiographs for Inspection of Aluminum and Magnesium Castings
ASTM E 186	Reference Radiographs for Heavy-Walled (2 to 4.5-in. (51 to 114-mm)) Steel Castings
ASTM E 192	Reference Radiographs of Investment Steel Castings for Aerospace Applications

2.1 (Continued):

ASTM E 272	Reference Radiographs of High-Strength Copper-Base and Nickel-Copper Alloy Castings
ASTM E 280	Reference Radiographs for Heavy-Walled (4.5 to 12-in. (114 to 305-mm)) Steel Castings
ASTM E 310	Reference Radiographs for Tin Bronze Castings
ASTM E 446	Reference Radiographs for Steel Castings up to 2 in. (51 mm) in Thickness
ASTM E 1255	Radioscopy
ASTM E 1320	Reference Radiographs for Titanium Castings
ASTM E 1417	Liquid Penetrant Examination
ASTM E 1444	Magnetic Particle Examination
ASTM E 1742	Radiographic Examination

2.2 NAS Publications

Available from AIA, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3901 or www.aia-aerospace.org.

NAS 410	Certification and Qualification of Nondestructive Test Personnel

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 (see 1.3). 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 If the grade of casting is not indicated on the drawing or other contractual document, Grade C shall apply, except for Class 4 castings, where Grade D shall apply.

3.1.1.2 Class 1 Casting Requirements: All areas of Class 1 castings shall be of a quality equivalent to, or better than, Grade C, except that all highly stressed areas of a Class 1 casting shall be of a quality equivalent to, or better than, Grade B.

3.2 Inspection Sequence:

It is the responsibility of the vendor to perform appropriate 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 flaws 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 E 1417, ASTM E 1444, and ASTM E 1742, 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.

3.4 Inspection Methods and Acceptance Criteria:

3.4.1 Visual Inspection: Visual inspection shall be performed in areas with adequate lighting. Ambient lighting should not be less than 75 foot-candles. Castings shall be free of foreign materials, and 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 8.4). The following criteria shall also apply:

3.4.1.1 Surface Roughness: Surface roughness shall conform to the engineering drawing requirements. Surface roughness requirements specified on the engineering drawing (i.e., 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.

3.4.1.2 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, then the maximum limit for gates, risers and parting lines shall be in accordance with Table 3.

3.4.1.3 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 3.4.1.3.1 and 3.4.1.3.2.

3.4.1.3.1 For sand castings, 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. 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.

3.4.1.3.2 For investment and permanent mold castings, random raised metal shall be limited to a height of 0.015 to 0.030 inch (0.38 to 0.76 mm) in an area 0.125 x 0.125 inch (3.2 x 3.2 mm) and no more than one per square inch (650 mm^2). Random surface pits shall be limited to 0.030 to 0.060 inch (0.76 to 1.5 mm) in diameter and 0.030 inch (0.76 mm) in depth and no more than one per square inch (650 mm^2). Surface pits less than 0.030 inch (0.76 mm) deep or raised metal less than 0.015 inch (0.38 mm) in height may be present.

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 E 1444. When approved by purchaser, 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 purchaser.

3.4.2.2 Inspection Method for Nonferromagnetic Materials: The method for inspection of nonferromagentic materials shall be in accordance with ASTM E 1417. 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 better.

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 4.

3.4.3 Radiographic Inspection:

3.4.3.1 Radiographic Inspection Method: The method for inspection shall be in accordance with ASTM E 1742. 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. Radioscopic inspection shall be conducted in accordance with ASTM E 1255; however, prior approval shall be obtained from the cognizant engineering organization on the detailed inspection, evaluation, documentation, and quality control procedures.

3.4.3.2 Radiographic Reference Standards: Radiographic standards shall be as required in ASTM E 155, ASTM E 186, ASTM E 192, ASTM E 272, ASTM E 280, ASTM E 310, ASTM E 446, and ASTM E 1320. For alloy types where reference radiographs are specifically covered, the reference radiographic shall be of the same alloy family as the casting. For alloys not specifically included in the alloy family covered by the ASTM reference radiographic standards, the cognizant engineering organization shall either specify an ASTM standard representative of the quality required, or develop its own radiographic standards containing details comparable to an ASTM standard.

3.4.3.3 Radiographic Acceptance Criteria: The cognizant engineering organization shall specify the radiographic grade(s) for Class 1, 2 and 3 casting designs. Radiographic grade(s) may be specified for Class 4 castings. Castings shall meet the requirements for the applicable grade(s) as shown in Tables 6 through 14. The maximum permissible radiographic severity levels for graded titanium castings shall be specified by the cognizant engineering organization.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection:

The vendor of castings shall supply all samples for vendor's tests and shall be responsible for the performance of all required tests. All testing shall be performed at facilities acceptable to purchaser. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the castings conform to specified requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Inspection for visual (3.4.1), magnetic particle or penetrant (3.4.2), and, when specified (see 4.3.3), radiographic (3.4.3) soundness are acceptance tests and shall be performed on each lot.

4.2.1.1 Inspection Lot: An inspection lot, for the purposes of visual, penetrant, magnetic particle, and radiographic inspection shall be as defined in the casting (material) specification, engineering drawing, or purchase order. If not specified in any of the above documents, an inspection lot shall be defined as all castings of the same part number and the same alloy, produced using the same processing parameters of the casting procedure, and submitted for inspection as a single group.

4.3 Sampling and Testing:

Shall be in accordance with the following:

4.3.1 Visual inspection: Each casting shall be 100% visually examined.

4.3.2 Magnetic particle and penetrant inspection: Each casting shall be subjected to either magnetic particle or penetrant inspection, as appropriate (see 3.4.2), except that Class 4 castings shall be sample inspected in accordance with Table 1 or greater, unless a frequency of 100 percent is specified.

4.3.3 Radiographic inspection: Sampling inspection and inspection coverage shall be as indicated below:

Class 1 castings - Each casting shall be completely examined.

Class 2 castings - Castings shall be selected in accordance with Table 1 and completely examined.

Class 3 castings - Castings shall be selected in accordance with Table 2 and completely examined.

Class 4 castings - Radiographic examination is not required unless otherwise specified.

4.3.3.1 If radiographic examination is specified and no sampling is specified, Table 2 shall apply.

4.3.3.2 When approved by purchaser, a statistically based continuous sampling plan may be used instead of lot sampling.

4.4 Reports:

The vendor of castings shall furnish with each shipment a report showing the results of inspections for visual, magnetic particle or penetrant, and, when specified, radiographic soundness of each lot of castings. This report shall include the purchase order number, melt and heat treat lot numbers, AMS 2175, casting part number, quantity, and, when applicable, casting serial number(s).

4.5 Resampling and Retesting:

4.5.1 Reinspection of Rejected Lots: When an inspection lot is rejected on the basis of a sampling plan, regardless of the inspection method, it may be resubmitted for 100 percent inspection and unacceptable castings removed from the lot per 4.5.2. For lots rejected by a radiographic inspection sampling plan, the radiographic views where the unacceptable discontinuities were found shall be inspected on the balance of the castings in the lot.

4.5.2 Individual Casting Rejection: Individual casting rejection shall apply in those instances where all castings in the lot are inspected and any individual casting is found unacceptable to visual, penetrant, magnetic particle, or radiographic inspection requirements. Only unacceptable castings need to be rejected, and individual castings meeting the requirements of this standard may be accepted.

4.5.3 Discontinuity Removal: If it is determined that rejectable discontinuities shall subsequently be removed by machining on machining stock surfaces, or by blending on as-cast surfaces, then those discontinuities shall not be cause for rejection provided reinspection is performed after the material removal to verify that the discontinuity was removed and the dimensional tolerance requirements of the casting are satisfied.

5. PREPARATION FOR DELIVERY:

Not applicable

6. ACKNOWLEDGEMENT:

A vendor shall mention this specification number and its revision letter in all quotations and when acknowledging purchaser orders.

7. REJECTIONS:

Castings not conforming to this specification, or to modifications authorized by purchaser, will be subject to rejection.

8. NOTES:

8.1 A change bar (|) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of a specification. An (R) symbol to the left of the document title indicates a complete revision of the specification, including technical revision. Change bars and (R) are not used in original publications, nor in specifications that contain editorial changes only.

8.2 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as approximate equivalents of the primary units and are presented only for information.

8.3 Intended Use:

This standard prescribes acceptance criteria for surface inspections and radiographic inspections applied to metal castings. This standard is not intended to apply to high pressure die castings. Acceptance criteria for die castings may be based on standards and guidelines developed by the American Society for Testing and Materials (ASTM), and the North American Die Casting Association (formerly the American Die Casting Institute (ADCI)). Examples are ASTM B 505 and ADCI “Q”, “E”, and “M” series standards.

8.4 Observational Standards:

Observational standards for visual inspection may include sample castings with known discontinuities. Assistance with the visual inspection criteria for steel castings may be obtained by reference to MSS SP-55 and ASTM A 802. MSS SP-55 (“Quality Standard for Steel Castings for Valves, Flanges, and Fittings and other Piping Components - Visual Method” available from the Manufacturer’s Standardization Society of the Valve and Fittings Industry, 127 Park Street, N.E., Vienna, VA 22180) contains reference photographs that illustrate various types and degrees of surface discontinuities, while ASTM A 802 (“Steel Castings, Surface Acceptance Standards, Visual Examination”) contains plates that model actual discontinuities and surface roughness.

8.5 Producibility Considerations:

The class and grade assigned to the castings should represent a realistic value for the functional requirements (e.g., Class 1 castings should not be specified for a Class 2 application). Casting design coupled with foundry practice can make overly severe soundness requirements impractical for a manufacturer to satisfy. Consultation with the producing foundry or experienced casting design personnel is recommended before specifying the casting grade. (See 1.3.)

8.6 Radiographic quality grades for machined areas:

Castings that have been found acceptable per the ASTM radiographic standards may have internal discontinuities (such as shrinkage, porosity, and inclusions) that become exposed by machining. One method of alleviating this problem is quantifying (in terms of size) the ASTM reference radiographic discontinuities so that their size on the surface may be approximated. Once this has been performed, the cognizant engineering organization should be able to determine if the discontinuities allowed in the radiographic grade will be permissible on the surface. If they are not permissible, the area that is machined should be zoned to a more stringent radiographic grade.

8.7 Ultrasonic Inspection of Thick Castings:

Class 1 and Class 2 castings that have a section thickness of 4.50 inches and greater should also be inspected by ultrasonic methods due to the loss of radiographic sensitivity in the thicker sections. It should be noted that ultrasonic examination may not be practical for all casting configurations. Because ultrasonic inspection and radiographic inspection require different test method standards and different acceptance standards, the cognizant engineering organization will need to specify the appropriate document for performing ultrasonic inspection along with the appropriate quality level of acceptance criteria contained within that document.

8.8 Terms used in AMS are clarified in ARP1917 and defined as follows:

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

8.8.2 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.

8.8.3 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.

8.8.4 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.

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

8.8.6 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.

8.8.7 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.

8.8.8 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.

8.8.9 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.

8.8.10 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.

8.8.11 Inclusions: Particles of foreign material such as mold sand or shell and slag or dross that are embedded in the casting.

8.8.12 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.

8.8.13 Misruns: 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.

8.8.14 Penetrameter or Image Quality Indicator (IQI): A strip of metal that is radiographically similar to the metal being tested, representing a percentage of object thickness and provided with a combination of steps, holes, or wires. When placed between the radiation source and film, its image provides a check on the radiographic technique employed.

8.8.15 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.

8.8.16 Segregation: A concentration of alloying elements in specific regions of the casting, usually the result of the primary crystallization of one phase with the subsequent concentration of other elements in the remaining liquid.

8.8.17 Shrinkage: The term shrinkage, as used in this standard, refers to a network of small voids forming due to grain boundary solidification phenomena. A larger and singular void caused by solidification shrinkage on a large scale, as defined in 8.8.18 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.

8.8.18 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.

8.8.19 Surface Irregularities: Any anomoly, either positive (raised) or negative (depressed) from the normal cast surface. These are best observed by visual inspection, but may produce indications in magnetic particle, penetrant, or radiographic inspection.

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

8.9 Cross Reference:

The class of castings defined in 1.3 corresponds to previous designations of this specification as follows:

AMS 2175 AMS-STD-2175	MIL-STD-2175 MIL-C-6021H	MIL-C-6021G
Class 1	Class 1	Class 1, Class 1A
Class 2	Class 2	Class 1, Class 1B
Class 3	Class 3	Class 2, Class 2A
Class 4	Class 4	Class 2, Class 2B

PREPARED UNDER THE JURISDICTION OF AMS COMMITTEE “B”

TABLE 1 – Sampling, Radiographic Inspection of Class 2 Castings, and Magnetic Particle and Penetrant Inspection of Class 4 Castings

Lot Size [1]	Sample Size [2]		Lot Size [1]	Sample Size [2]
2 – 5	All		27 – 36	10
6 – 8	5		37 – 51	11
9 – 11	6		52 – 82	12
12 – 15	7		83 – 162	13
16 – 20	8		163 – 971	14
21 – 26	9		972 and over	15

Notes:

[1] See 4.2.1.1 for lot definition. When approved by purchaser, a statistically based continuous sampling plan may be used instead of lot sampling.

[2] Acceptance number is 0.

TABLE 2 – Sampling, Radiographic Inspection of Class 3 Castings

Lot Size [1]	Sample Size [2]		Lot Size [1]	Sample Size [2]
2 – 4	All		18 – 27	7
5 – 6	4		28 – 48	8
7 – 11	5		49 and over	9
12 – 17	6			

Notes:

[1] See 4.2.1.1 for lot definition. When approved by purchaser, a statistically based continuous sampling plan may be used instead of lot sampling.

[2] Acceptance number is 0.

TABLE 3 – Maximum Allowable Gate, Riser, and Parting Line Projections

Casting Weight, Pounds (Kg)	Nonmachined Surface, Inches (mm)	Machined Surface, Inches (mm)
Up to 10 (Up to 4.5)	0.031 (0.79)	0.062 (1.57)
Over 10 thru 25 (Over 4.5 thru 11.3)	0.047 (1.19)	0.062 (1.57)
Over 25 thru 50 (Over 11.3 thru 22.7)	0.062 (1.57)	0.094 (2.39)
Over 50 (Over 22.7)	0.125 (3.18)	0.188 (4.78)

TABLE 4 – Maximum Allowable Discontinuity Size and Distribution in Inches for Magnetic Particle and Penetrant Inspection [1] [2] [3] [4] [9]

Discontinuity Type		Grade A	Grade B	Grade C	Grade D
Random Individual Discontinuities (Gas Holes, Inclusions, Discrete Shrinkage Cavities), Nonlinear [5] [6] Surface ..... Subsurface (Magnetic Particle only) ...		1/4 T or the sizes shown below, whichever is less: 0.03 dia 0.05 dia	1/3 T or the sizes shown below, whichever is less: 0.05 dia 0.09 dia	1/3 T or the sizes shown below, whichever is less: 0.09 dia 0.12 dia	1/2 T or the sizes shown below, whichever is less: 0.12 dia 0.15 dia
Cracks, Hot Tears, Cold Shuts, or Through-Wall Discontinuities		None	None	None	None
Microshrinkage or Shrinkage Sponge, Nonlinear [7]		0	0.12 dia	0.38 dia	0.75 dia
Microshrinkage or Shrinkage Sponge, Linear [1] [4]		0	0	0.12	0.25
Number of Discontinuities Allowed Within a 2 x 2 Inch Area	Random Individual Discontinuities [8]	2	3	4	4
	Microshrinkage or Shrinkage Sponge	0	1	1	1

Notes:

[1] Linear discontinuities (length to width ratio of 3 to 1 or greater) are not allowed except under the following circumstances:

a) Linear dendritic shrinkage or linear shrinkage sponge indications shall be evaluated in accordance with this table and shall not be allowed to break over an edge, extend through a wall, or be located in internal corners of fillet radii.

b) In magnetic particle inspection, discontinuities 0.030 inches or less in length need not be evaluated for linearity. In penetrant inspection, discontinuities 0.015 inches or less in length need not be evaluated for linearity.

[2] Discontinuities that are visible under white light without the use of penetrant or magnetic particles may be evaluated to the criteria of this table.

[3] Size limits shown are for actual discontinuity size as opposed to bleed out from penetrant inspection. Indications may be inspected by measuring their size after wiping with a solvent dampened cloth, cotton swab, or brush. Immediately evaluate the discontinuity for size as soon as the solvent has evaporated.

[4] For rounded indications exhibiting excessive bleedout, or doubtful indications of microshrinkage or sponge shrinkage, disposition may be based on the radiographic acceptance criteria after radiographing the part. Linear microshrinkage or linear sponge shrinkage shall only be acceptable after verification by radiography.

[5] For random individual discontinuities, the minimum resolvable size shall be 0.030 inches for magnetic particle inspection and 0.015 inches for penetrant inspection. Discontinuities smaller than these sizes shall be considered non-interpretable.

[6] For Grade A, any two random individual discontinuities shall be separated by a distance of at least three times the maximum dimension of the larger discontinuity. For Grades B, C, and D, random individual discontinuities shall be separated by a distance equal to twice the maximum dimension of the larger discontinuity. However, if the total length of the discontinuities that violate this spacing requirement does not exceed the maximum length permitted for a single discontinuity, then these discontinuities shall be considered as one and shall not be cause for rejection.

[7] Microshrinkage is also called dendritic shrinkage.

[8] The limits for random individual discontinuities do not apply if the discontinuities are smaller than one-half their maximum allowable size and they meet the minimum spacing requirement of Note [6].

[9] "T" is the casting section thickness.

TABLE 5 – Notes for Tables 6 through 14

[1] An area of like size to the reference radiograph shall be the unit area by which the production radiograph is evaluated. If the production radiograph shows a discontinuity that is equal to or better than the severity level of the reference radiograph, the casting shall be acceptable. If the production radiograph shows a discontinuity of greater severity than the reference radiograph, the casting shall be rejected.

[2] When two or more types of discontinuities are present (in an area equal to the reference radiographic plate area) to an extent equal to the maximum permissible severity level for each type, the casting shall be rejected.

[3] Numbers in the table are ASTM radiographic plate numbers for a particular type and severity of discontinuity. A low number indicates fewer, smaller discontinuities while a higher number indicates more numerous, larger discontinuities.

[4] The minimum resolvable radiographic indication size shall be 0.015 inches. Indications smaller than this size shall be considered non-interpretable.

[5] Gas holes, sand spots, and inclusions allowed by these tables (even those smaller than the maximum allowable size) shall be cause for rejection when closer than twice their maximum dimension to an edge. Exceptions to this note based on the Class and Grade of the casting are shown below:

Class 1 - No exceptions from Note [5].

Class 2 - No exceptions from Note [5] for Grade A and Grade B areas, or other areas that are specified critical or highly stressed. Otherwise, the Note [5] discontinuities are acceptable if they are separated from the edge by a distance equal to or greater than the discontinuity's maximum dimension.

Class 3 - Gas holes, sand spots, and inclusions of the maximum size allowed by these tables shall be cause for rejection if they are closer than one diameter of their maximum dimension to an edge. This does not apply to gas holes, sand spots, and inclusions smaller than the maximum allowable size.

Class 4 - Edge of part discontinuities are acceptable if they are not crack-like, linear, or round with protruding linear indications.

The term "edge" refers to the outer boundary of the radiographic image of the casting. This interpretation need only be made in the standard exposures (views) defined by the approved radiographic technique. Additional radiographic exposures to determine the distance from the surface of each gas hole, sand spot, or inclusion in other orientations are not required.

[6] "None", as used in these tables, means that the discontinuity is not allowed.

TABLE 6 – Maximum Permissible Radiographic Severity Levels for Discontinuities in Aluminum Castings per ASTM E 155 [3] [4] [5]

Discontinuity	Grade A Inch		Grade B Inch		Grade C Inch		Grade D Inch	
	1/4	3/4	1/4	3/4	1/4	3/4	1/4	3/4
Gas Holes	None	None	1	1	2	2	5	5
Gas Porosity, Round	None	None	1	1	3	3	7	7
Gas Porosity, Elongated	None	None	1	2	3	4	5	5
Shrinkage Cavity	None	None	1	NA [2]	2	NA [2]	3	NA [2]
Shrinkage Sponge	None	None	1	1	2	2	4	3
Foreign Material, Less Dense	None	None	1	1	2	2	4	4
Foreign Material, More Dense	None	None	1	1	2	1	4	3
Cracks [1]	---------- None ----------							
Cold Shuts [1]	---------- None ----------							
Surface Irregularity [1]	---------- Not to exceed drawing tolerance ----------							
Core Shift [1]	---------- Not to exceed drawing tolerance ----------							

Notes:

[1] Reference radiographic plates are not available for this type of discontinuity.

[2] A 3/4 inch shrinkage cavity plate is not available in ASTM E 155. For section thicknesses greater than 1/2 inch, use the 1/4 inch shrinkage cavity plate and the following limits: Grade A = none, Grade B = 3, Grade C = 4, Grade D = 5.

[3] Use ASTM E 155 Volume I reference radiographic plates.

[4] For feature thicknesses greater than two inches, the 3/4 inch reference radiographic plates may be used.

[5] See Table 5 for additional notes that apply to this table.