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MILITARY STANDARD

CASTINGS, CLASSIFICATION AND INSPECTION OF

NO DELIVERABLE DATA
REQUIRED BY THIS DOCUMENT

AREA NDTI

DEPARTMENT OF DEFENSE
Washington, DC 20301

Castings, Classification and Inspection of

MIL-STD-2175

1. This Military Standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, and deletions) any pertinent data which may be of use in improving this document should be addressed to: Commanding Officer, Naval Air Engineering Center, Systems Engineering and Standardization Department (SESD), Code 93, Lakehurst, NJ 08733, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

This document supersedes MIL-C-6021H, Castings, Classification and Inspection of. The purpose of MIL-STD-2175 is to standardize the process for Classification and Inspection of ferrous and non-ferrous raw metal castings.

CONTENTS

CONTENTS - Continued

CONTENTS - Continued

TABLES

1. SCOPE

1.1 Purpose. The purpose of this military standard is to prescribe the requirements for the classification and inspection of ferrous and non-ferrous raw metal castings.

1.2 Application. The criteria for the classification and inspection of metal castings in this standard are applicable to ferrous and non-ferrous raw metal castings.

1.3 Classification. Castings shall be classified by classes and applicable grades.

1.3.1 Classes. Castings shall be classified as follows:

1.3.1.1 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.

1.3.1.2 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.

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

1.3.1.4 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 shall be of grades A, B, C or D as shown in Tables III, IIIa, IV, V, VI, VII, VIII, VIIIa and IX.

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-I-6866	-	Inspection, Penetrant Method of
MIL-I-6868	-	Inspection Process, Magnetic Particle
MIL-I-25135	-	Inspection Materials, Penetrants

STANDARDS

MILITARY

MIL-STD-139	-	Radiographic Inspection: Soundness Requirements for Aluminum and Magnesium Castings (For Small Arms Parts)
MIL-STD-271	-	Nondestructive Testing Requirements for Metals
MIL-STD-410	-	Nondestructive Testing Personnel Qualification and Certification (Eddy Current, Liquid Penetrant, Magnetic Particle, Radiographic and Ultrasonic)
MIL-STD-453	-	Inspection, Radiographic

(Copies of specifications, standards, drawings and publications required by suppliers in connection with specified procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

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

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) (Continued)

ASTM E 272 - Reference Radiographs for 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

(Application for copies should be addressed to American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

(Technical Society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3. DEFINITIONS

3.1 Alloy. A metallic substance composed of two or more elements which possesses properties different from those of its constituents.

3.2 Buckles. Buckles are indentations in the surface of sand castings that result from expansion of the sand.

3.3 Cassette. A lightproof container which may or may not contain intensifying and/or filter screens, used for holding the radiographic film in position during the radiographic exposure.

3.4 Casting. An object at or near finished shape obtained by filling a mold with molten metal and allowing it to solidify.

3.5 Chaplet. Metal core support which is used in the mold cavity and which fuses into the casting.

3.6 Chill. A formed piece of metal applied to the exterior or interior surface of a casting to hasten the solidification of heavy sections and cause the casting to cool at a uniform overall rate.

3.7 Cold cracks. Cracks which appear on radiograph as a straight line, usually continuous throughout its length, and generally exist singly. These cracks start at the surface.

3.8 Cold shut. An imperfect junction between two flows of metal in a mold; this is caused by the surface of the streams of metal chilling too rapidly, or in effect, being chilled to the extent that fusion is impossible. This discontinuity may have the appearance of a crack or seam with smooth or rounded edges.

3.9 Contrast (radiographic). Contrast is the measure of difference in the film blackening resulting from various X-ray and gamma ray intensities transmitted through the object and recorded as density differences in the image. Thus, difference in film blackening from one area to another is contrast.

3.10 Corrosion. The deterioration of a metal by a chemical or electrochemical reaction with its environment.

3.11 Cope. The upper or topmost section of a flask, mold or pattern.

3.12 Dendritic structure. Dendritic structure is the "as cast" crystallization pattern of cast metal. The crystals form a tree-like pattern.

3.13 Density. The quantative measure of blackening of a photographic emulsion is called density and is defined by the equation:

$$D = \log (I_o/I_t)$$

Where: D = density
I_o = the intensity of light incident on the film
I_t = the intensity of light transmitted through the film.

3.14 Detail. Detail is the degree of sharpness of outline of the image. If the radiograph does not show a clear definition of the object or a discontinuity in the object, it is of little value although it may have sufficient contrast and density.

3.15 Discontinuity. An interruption in the normal physical structure or configuration of a part such as cracks, inclusions and porosity. A discontinuity may or may not affect the usefulness of a part.

3.16 Drag. The lower or bottom section of a flask, mold, etc.

3.17 Flask. A metal or wooden frame which holds the sand, chaplets, etc., and forms the mold. It consists of two or more parts.

3.18 Foreign materials. Appear as isolated, irregular, or elongated variations of radiographic film density, corresponding to variations in thickness of material, or to cavities. They may be due to the presence of sand, slag, oxide, dross, or metal of different density.

3.19 Gamma rays. Gamma rays are high-energy electro-magnetic waves of relatively short wave length that are emitted during radio active decay of both naturally occurring and artificially unstable isotopes.

3.20 Gate. The end of the runner where the molten metal enters the mold. Sometimes this term is applied to the entire assembly of connected channels, feeders, etc., of the metal that fills them.

3.21 Gas holes. Appears as round or elongated, smooth-edged dark spots on radiograph occurring individually, in clusters, or distributed throughout the casting. They are generally caused by trapped air or mold gases.

3.22 Gas porosity. Minute voids usually distributed through the entire casting. Represented by round or elongated dark spots on radiograph. They are generally caused by trapped air or mold gases rejected during solidification.

3.23 Grinding cracks. Thermal cracks due to local overheating of the surface being ground, generally caused by lack of, or poor coolant, a dull wheel or one of improper grain, too rapid a feed, or too heavy a cut. Also called grinding checks because they often appear as a checkered network.

3.24 Heat. All castings produced from one batch of alloy melted, then poured within a substantially brief and continuous production run.

3.25 Heat treat. Heating and cooling of a metal or alloy in the solid state for the purpose of obtaining certain desirable conditions or properties.

3.26 Hot cracks. Appears on radiograph as ragged dark lines of variable width and numerous branches. They have no definite line of continuity and may exist in groups. They may originate internally or at the surface.

3.27 Hot tear. Hot tears appear as ragged dark lines of variable width and with no definite line of continuity. Hot tears may exist in groups starting at a surface, or they may be internal. They usually result from contraction of the casting during or immediately after solidification.

3.28 Inclusions. Inclusions are particles of foreign material such as sand or slag that are embedded in the cast metal.

3.29 Micro-shrinkage. Appears on radiograph as dark feathery streaks, or dark irregular patches, indicative of cavities occurring in the grain boundaries.

3.30 Misruns. Misrun is caused by failure of molten metal to completely fill the mold. It appears on radiograph as prominent darkened areas of variable dimensions with definite smooth outline.

3.31 Penetrameter or Image Quality Indicator (IQI). A strip of metal the same composition as that of the metal being tested, representing a percentage of object thickness and provided with a combination of steps, holes or slots. When placed in the path of X-rays or gamma rays, its image provides a check on the radiographic technique employed.

3.32 Pipe. Cavity formed by contraction in metal during solidification of the last portion of liquid metal.

3.33 Radiography. The use of radiant energy in the form of X-rays or gamma rays for nondestructive examination of opaque objects, in order to produce graphic records which indicate the comparative soundness of the object being tested.

3.34 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.

3.35 Sensitivity. Sensitivity is the ratio (percent) of size of the smallest detectable defect on radiograph to the thickness of the section being radiographed. Major dimension of defect is used to calculate this ratio. Sensitivity, contrast, detail, and density are most closely allied, as sensitivity is the measure of the success of detecting small discontinuities.

3.36 Shrink. Internal rupture occurring in castings due to contraction during solidification. Also applied to surface shrinkage cracks.

3.37 Shrinkage cavity. Shrinkage cavities occur when insufficient feeding of a section results in a continuous cavity within the section. Shrinkage cavities appear on the radiograph as dark areas that are indistinctly outlined and have irregular dimensions.

3.38 Shrinkage porosity or sponge (Non-ferrous alloys). Shrinkage porosity or sponge appears on the radiograph as a lacy or honey-combed darkened area.

3.39 Surface irregularities. Any image corresponding to an irregularity visible on the surface.

3.40 X-rays. A form of radiant energy resulting from electrons changing energy levels within an atom. X-rays have wave lengths between 10^{-11} cm and 10^{-11} cm.

4. GENERAL REQUIREMENTS

4.1 Inspection.

4.1.1 Responsibility for inspection. The contractor is responsible for furnishing all supplies in conformance to contract or purchase order requirements and, unless otherwise specified in the contract or purchase order, the performance of all inspection requirements contained herein. The inspection provisions contained herein shall become a part of the contractor's overall inspection system or quality program. The absence of inspection requirements does not relieve the contractor of his responsibility for assuring that all supplies submitted to the Government for acceptance conform to all requirements of the contract. The Government reserves the right to perform any of the inspections set forth herein, or otherwise specified in the contract or purchase order, when such inspections are deemed necessary to assure that supplies conform to prescribed requirements.

4.1.2 Personnel qualification. Personnel making accept-reject decisions described in this standard shall be qualified to Level II or Level III in accordance with MIL-STD-410. Personnel qualified to Level I per MIL-STD-410 shall be restricted to performance of the nondestructive testing methods described in this standard.

4.1.3 Radiographic inspection. The radiographic inspection of production castings shall be in accordance with MIL-STD-453.

4.1.4 Final Inspection. Castings shall be inspected as specified herein unless the design activity has information substantiating the suitability of other inspection plans.

4.1.4.1 Documentation for final inspections. For all castings for which radiographic inspection is specified, the contractor shall prepare either photographs, X-ray film, sketches, documents or drawings containing:

a. Classification of casting.

b. Alloy and heat-treat condition or temper designation.

c. Grade(s) or discontinuity limits as applicable.

d. Deviations from this specification not covered by the purchase order, procurement specification, or standard.

5. DETAIL REQUIREMENTS

5.1 Classification of castings.

5.1.1 Determination of classes and grades. The design activity shall establish the class, grade, and surface quality by critical areas and stress levels for each casting design. The classification(s) and critical area(s) shall be indicated on the applicable drawing. If grade of casting is not indicated on drawing or other contractual document, grade C shall apply, except for class 4 castings which shall be inspected to requirements of grade D for foundry control samples.

5.1.1.1 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 critical areas of a class 1 casting shall be of a quality equivalent to or better than grade B (see tables III, IIIa, IV, V, VI, VII, VIII, VIIIa and IX).

5.1.1.2 Radiographic grades. The design activity shall specify on the drawing or other document the radiographic grade(s) for classes 1, 2 and 3 castings designs. The design activity may specify radiographic grade(s) for class 4 casting designs. Either the castings, or sections of the castings of grades A, B, C or D, as shown in tables III, IIIa, IV, V, VI, VII, VIII, VIIIa and IX shall be in accordance with the reference radiographs specified in the tables, unless the design activity has information substantiating the suitability of castings with more extensive discontinuities, in which case acceptable discontinuities will be defined on the drawing or in the contract.

5.1.1.3 Surface quality. Castings shall not contain cracks, cold shuts, hot tears or other foreign material in excess of that allowed by the applicable radiographic quality grade specified. Surface projections, such as those remaining after removal of gates and risers, shall not be higher than limits specified in drawings or other acquisition documents.

5.2 Reference standards

5.2.1 Visual standards. Specific standards, using sample parts wherever necessary, should be prepared. Where approved specified standards are not available, evaluations of discontinuities shall be based on a review of the radiographic film, past experience, and sound engineering criteria. Dissection as an aid in establishing acceptance criteria is recommended.

5.2.2 Radiographic 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 and ASTM E 446.

5.3 Inspection of castings.

5.3.1 Lot definition.

5.3.1.1 Heat treat lot. Heat treat lot shall consist of material of the same mill form, alloy, temper, section or size traceable to one heat treat furnace load, or, if heat treated in a continuous furnace, charged consecutively during 8 hour period.

5.3.1.2 Inspection lot. For heat treated castings, the inspection lot shall be identifiable quantity of material of the same mill form, alloy, temper, section or size traceable to a heat treat lot or lots and submitted for inspection at one time. For non-heat treated castings, the inspection lot shall be an identifiable quantity of material of the same mill form, alloy, temper, section or size submitted for inspection at one time.

5.3.1.3 Casting for small arms parts (except sand castings). When individual production heats are used, the first 10 inspection lots shall be defined as an individual production run. Lot size shall then be increased to all castings from 20 consecutive individual production heats, provided that the preceding 10 inspection lots (10 production heats) are acceptable.

5.3.1.3.1 Investment and shell molded castings. Inspection sampling frequency shall revert to the number of consecutive castings specified in 5.3.2.3.1 and lot size shall revert back to the first 10 lot individual production heat basis, in the event that any of the following conditions occur:

a. Failure of samples from a lot to meet the sampling inspection acceptance criteria.

b. Any pattern change or new pattern.

c. Any major change of foundry technique, such as risering, chilling, sand mix or pouring temperatures.

d. Start of a new foundry or furnace. (Includes lapse of production of 12 months or more.)

5.3.2 Sampling.

5.3.2.1 Visual inspection. Each casting shall be examined visually.

5.3.2.2 Magnetic particle and penetrant inspection. Each casting shall be subjected either to magnetic particle or penetrant inspection, as may be appropriate, except that class 4 castings shall be sample inspected in accordance with table I.

5.3.2.3 Radiographic inspection.

5.3.2.3.1 Castings, for small arms parts. Unless otherwise specified, sampling inspection for castings for small arms parts shall be in accordance with MIL-STD-139.

5.3.2.3.2 Castings, general. Unless otherwise specified as in 5.3.2.3.1, 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 I and completely examined.

Class 3 castings - Castings shall be selected in accordance with table II and completely examined.

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

5.3.2.4 Processing operations. When processing operations such as machining, cold grinding, welding or heat treating are involved, inspection(s) shall be performed both before and after completion of such operation(s). For processing operations such as grit blasting, inspection(s) shall be performed before such operation.

5.3.3 Test methods.

5.3.3.1 Visual inspection. Unless otherwise specified, each casting shall be 100 percent visually inspected for surface defects and irregularities, particularly in critical areas. Attention shall be given to the presence of discontinuities such as cracks, evidence of shrinkage, etc., not specifically permitted on the drawing. When necessary, a magnifying glass (10X) may be used to aid visual inspection. In case of dispute, castings shall be inspected either by penetrant or magnetic particle method and acceptance criteria shall conform to 5.1.1.3.

5.3.3.2 Magnetic particle and penetrant inspection.

5.3.3.2.1 Ferromagnetic materials. Class 1, 2 and 3 castings and sample castings of class 4 ferromagnetic materials shall be magnetic particle inspected. Magnetic particle inspection shall be in accordance with MIL-I-6868 or MIL-STD-271, as applicable. The surface quality of the castings shall conform to 5.1.1.3. Unless otherwise specified, all precipitation hardening steels shall be penetrant inspected in accordance with 5.3.3.2.2.

5.3.3.2.2 Nonferromagnetic materials. Class 1, 2 and 3 castings and sample casting of class 4 nonferromagnetic material shall be penetrant inspected in accordance with MIL-I-6866, or MIL-STD-271, as applicable, using Group V postemulsified penetrant or Group IV water-washable penetrant or water-washable penetrant of equivalent sensitivity conforming to MIL-I-25135. The surface quality of the castings shall conform to 5.1.1.3.

5.3.3.3 Radiographic inspection.

5.3.3.3.1 Castings, for small arms parts. Radiographic inspection shall be in accordance with standards negotiated between the supplier and the procuring activity.

5.3.3.3.2 Castings, general. Except as specified in 5.3.3.3.1 radiographic inspection shall be in accordance with MIL-STD-453 or MIL-STD-271, as applicable, except that nonfilm method may be used as follows:

a. Castings of any class may be screened, using 100 percent radiographic inspection by nonfilm methods. All castings found acceptable by nonfilm methods shall then be inspected by a film method in accordance with the sampling requirements applicable to the specific class.

b. When authorized by the procuring activity, Class 3 casting may be radiographically inspected, using 100 percent nonfilm methods in lieu of the sampling methods permitted for such castings by a film method. However, the disclosure of a single rejectable or borderline discontinuity shall be cause for reinspection of the lot in accordance with the sampling requirements of 5.3.2.3.2 using a film method.

5.3.3.3.3 Nonfilm radiographic procedures. The procedure used shall be sufficiently sensitive to discriminate between parts in a borderline category which are considered to be rejectable using film methods, and parts representing the worst condition acceptable as specified in tables III, IIIa, IV, V, VI, VII, VIII, VIIIa and IX, as applicable. To assure compliance therewith, at least two castings representing each of the two conditions shall be introduced periodically into the test lot to serve as a control in the inspection process.

5.3.4 Examination of resubmitted inspection lots.

5.3.4.1 Rejection. When an inspection lot is rejected on the basis of a sampling plan, it may be resubmitted for 100 percent inspection and the castings classified according to standard procedures. If more than 25 percent of any lot given 100 percent inspection are rejected because of the discontinuities in highly stressed areas, the entire lot shall be rejected.

5.4 Data records. Data records of all tests shall be kept on file in accordance with the contract or order. For any rejectable item, the location and general shape of the rejectable discontinuities within the material tested shall be recorded.

6. NOTES

6.1 Producibility considerations. The class assigned to the casting should represent a realistic value for the functional requirements; i.e., do not assign a class 1 casting for a class 2 function. Casting design coupled with foundry practice can make overly severe soundness requirements impractical for a manufacturer to satisfy. Caution should be exercised in specifying the grade of maximum permissible radiographic discontinuity level and surface quality requirements to be met in a casting.

6.2 For information:

Radiographic grade A - A highly stressed casting or area of a casting for critical application.

Radiographic grade B - A premium grade of casting for critical applications or specified area of a casting with low margin of safety.

Radiographic grade C - A high quality grade of casting or area of casting with average margin of safety.

Radiographic grade D - A casting or area of a casting subject only to low stresses.

6.3 Cross reference. The classification (Classes 1, 2, 3, 4) of castings defined in paragraph 1.3 correspond to those defined in MIL-C-6021.

Custodians:
Army - MR
Navy - AS
Air Force - 20

Review activities:
Army - AR, EA, MI
Navy - SH, OS
Air Force - 70, 71, 80, 82, 84, 99
DLA - IS

User activity:
Army - ME

Preparing activity:
Navy - AS

(Project No. NDTI-0058)

TABLE I. Sampling, Class 2 Castings.

Lot size	Sample size	Lot size	Sample size
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

Acceptance number is 0

TABLE II. Sampling, Class 3 Castings.

Lot size	Sample size	Lot size	Sample size
2-4	All	18-27	7
5-6	4	28-48	8
7-11	5	49 and over	9
12-17	6		

Acceptance number is 0

TABLE III. Discontinuity - severity level requirements for aluminum casting per ASTM E 155.

Discontinuity	Radiograph 2/	Grade A		Grade B		Grade C		Grade D	
		Inch		Inch		Inch		Inch	
		1/4	3/4	1/4	3/4	1/4	3/4	1/4	3/4
Gas holes	1.1	None		1	1	2	2	5	5
Gas porosity (round)	1.21	None		1	1	3	3	7	7
Gas porosity (elongated)	1.22	None		1	2	3	4	5	5
Shrinkage cavity	2.1	None		1	NA 1/	2	NA 1/	3	NA 1/
Shrinkage porosity or sponge	2.2	None		1	1	2	2	4	3
Foreign material (less dense material)	3.11	None		1	1	2	2	4	4
Foreign material (more dense material)	3.12	None		1	1	2	1	4	3
Segregation	3.2	None		None		None		None	
Cracks	NA 1/	None		None		None		None	
Cold shuts	NA 1/	None		None		None		None	
Surface irregularity	NA 1/	Not to exceed drawing tolerance							
Core shift	NA 1/	Not to exceed drawing tolerance							

1/ Not available.
2/ ASTM E 155 Volume I reference radiograph numbers.

NOTES: See table IX.

TABLE IIIa. Discontinuity - severity level requirements for magnesium castings per ASTM E 155.

Discontinuity	Radiograph 2/	Grade A		Grade B		Grade C		Grade D	
		Inch		Inch		Inch		Inch	
		1/4	3/4	1/4	3/4	1/4	3/4	1/4	3/4
Gas holes	1.1	None		1	1	3	2	4	4
Segregation	3.2	None		1	1	2	2	4	4
Shrinkage cavity	2.1	- - - - -		- - NA 1/		- - - - - -		- - - - -	
Microshrinkage (feathery)	2.31	None		1	1	4	4	7	7
Microshrinkage (sponge)	2.32	None		1	1	3	4	7	8
Foreign material (less dense material)	3.11	None		2	2	3	3	4	4
Foreign material (more dense material)	3.12	None		1	1	2	2	3	3
Cracks	NA 1/	None		None		None		None	
Cold shuts	NA 1/	None		None		None		None	
Surface irregularity	NA 1/	Not to exceed drawing tolerance							
Core shift	NA 1/	Not to exceed drawing tolerance							

1/ Not available.
2/ ASTM E 155 Volume I reference radiograph numbers.

NOTES: See Table IX.

TABLE IV. Maximum permissible radiographic severity levels for discontinuities in thin wall steel castings 1 in. (25.4 mm) wall or less per ASTM E 192.

Discontinuity	Grade A Inch 1/8	Grade A Inch 3/8	Grade A Inch 3/4	Grade B Inch 1/8	Grade B Inch 3/8	Grade B Inch 3/4	Grade C Inch 1/8	Grade C Inch 3/8	Grade C Inch 3/4	Grade D Inch 1/8	Grade D Inch 3/8	Grade D Inch 1/4
Gas holes	1	1	1	3	3	3	5	5	5	7 1/	7 2/	7
Foreign material (more dense)	Not to exceed sample radiograph in any grade											
Shrinkage cavity	None	None	None	None	None	1	NA 4/	NA 4/	3	3	4	5
Shrinkage sponge	1	1	1	2 3/	1	1	4	4	5	6	6	7
Shrinkage, dendritic	1	1	1	2	2	2	4	4	4	6	6	6
Shrinkage, filamentary	None	None	None	NA 4/	NA 4/	1	NA 4/	NA 4/	2	NA 4/	NA 4/	3
Foreign material (less dense)	1	1	1	3	3	3	5	6	6	6	7	7
Cold shut	None allowed											
Hot tear	None allowed											
Cold crack	None allowed											
Misrun	None allowed											
Core shift	Not to exceed drawing tolerance											
Mold buckle, positive	Not to exceed drawing tolerance											
Mold buckle, negative	Not to exceed drawing tolerance											
Mold ridge	Not to exceed drawing tolerance											
Excess metal in cracked core	Not to exceed drawing tolerance											
Surface irregularities	Not to exceed drawing tolerance											

1/ Excluding the single largest gas hole. 2/ Excluding the crack-like discontinuitues emitting from the gas holes. 3/ Excluding bottom half of the standard reference film. 4/ NA - Not available.

NOTES: See Table IX.

TABLE V. Maximum permissible radiographic severity levels for discontinuities in thick wall steel castings 2 - 4.5 in. (51 - 114 mm) per ASTM E 186.

Code or Category	Discontinuities 1/	Grade A	Grade B	Grade C	Grade D
A	Gas porosity	None	1	2	3
B	Sand/slag inclusions	None	1	2	4
C	Shrinkage type 1	None	2	3	5
C	Shrinkage type 2	None	2	3	4
C	Shrinkage type 3	None	2	3	4
F	Inserts A	None	None	None	None
F	Inserts B	None	None	None	None

1/ Cracks and hot tears are not allowed.

NOTES: See Table IX.

TABLE VI. Maximum permissible radiographic severity levels for discontinuities in steel casting up to 2 in. (51 mm) in thickness per ASTM E 446.

Code or Category	Discontinuities	Grade A	Grade B	Grade C	Grade D
A	Gas porosity	None	1	2	3
B	Sand spots and inclusions	None	1	2	3
CA	Shrinkage	None	1	2	3
CB	Shrinkage	None	1	2	3
CC	Shrinkage	None	1	2	3
CD	Shrinkage	None	1	2	3
D	Crack	None	None	None	None
E	Hot tear	None	None	None	None
F	Insert	None	None	1	2
G	Mottling	Not to exceed contract or drawing requirements			

NOTES: See Table IX.

TABLE VII. Maximum permissible radiographic severity levels for discontinuities in heavy walled 4.5 - 12 in. (114 - 305mm) steel castings per ASTM E 280.

Code or Category	Discontinuities	Grade A	Grade B	Grade C	Grade D
A	Gas porosity	1	2	3	4
B	Sand and slag inclusions	1	2	3	4
C	Shrinkage type 1	1	2	3	4
C	Shrinkage type 2	1	2	3	4
C	Shrinkage type 3	1	2	3	4
D	Crack	None	None	None	None
E	Hot tear	None	None	None	None
F	Insert	None	None	None	None

NOTES: See Table IX.

TABLE VIII. Maximum permissible radiographic severity levels for discontinuities in high-strength copper-base and nickel-copper alloy castings up to 2 in. (51 mm) in thickness per ASTM E 272.

Code or Category	Discontinuities 2/	Grade A	Grade B	Grade C	Grade D
A	Gas porosity	None	1	2	3
Ba	Sand inclusions	None	1	2	3
Bb	Dross inclusions	None	1	2	3
Ca	Shrinkage, linear	NA 1/	NA 1/	NA 1/	NA 1/
Cd	Shrinkage, feathery	None	1	2	3
Cd	Shrinkage, spongy	NA 1/	NA 1/	NA 1/	NA 1/

1/ Not available.
2/ Cracks, Hot tears and Inserts are not allowed.

NOTES: See Table IX.

TABLE VIIIa. Maximum permissible radiographic severity levels for discontinuities in high-strength copper-base and nickel-copper alloy castings 2 - 6 in. (51 - 153 mm) thickness per ASTM E 272.

Code or Category	Discontinuities 2/	Grade A	Grade B	Grade C	Grade D
A	Gas porosity	None	1	2	3
Ba	Sand inclusions	None	1	2	3
Bb	Dross inclusions	None	1	2	3
Ca	Shrinkage, linear	None	1	2	3
Cd	Shrinkage, feathery	NA 1/	NA 1/	NA 1/	NA 1/
Cd	Shrinkage, spongy	None	1	2	3

1/ Not available.

2/ Cracks, Hot tears and Inserts are not allowed.

NOTES: See Table IX.

TABLE IX. Maximum permissible radiographic severity levels for discontinuities in tin bronze castings up to 2 in. (51 mm) in thickness per ASTM E 310.

Code or Category	Discontinuities 1/	Grade A	Grade B	Grade C	Grade D
A	Gas porosity	None	1	2	3
B	Sand inclusions	None	1	2	3
Ca	Shrinkage, linear	None	1	2	3
Cd	Shrinkage, feathery or spongy	None	1	2	3
Da	Hot tear	None	None	None	None
Eb	Inserts, chaplets	None	None	None	None

1/ Cracks are not allowed.

NOTES: For Tables III, IIIa, IV, V, VI, VII, VIII, VIIIa, and IX.

1/ When two or more types of discontinuities are present to an extent equal to or not significantly better than the acceptance standards for respective defects, the parts shall be rejected.

2/ When two or more types of discontinuities are present and the predominating discontinuity is not significantly better than the acceptance standard, the part shall be considered borderline.

3/ Borderline castings may be considered acceptable, upon review by cognizant engineering personnel.

4/ Gas holes or sand spots and inclusions allowed by these tables shall be cause for rejection when closer than twice their maximum dimension to an edge or extremity of a casting.

5/ Drawing tolerance (dwg. tol.) is defined as minimum thickness of material after defect is removed by machining.

6/ Numbers in the tables are ASTM radiographic numbers for particular type and severity of discontinuity. A low number indicates few, small discontinuities while a higher number indicates numerous, large discontinuities.

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-STD-2175	CASTINGS, CLASSIFICATION AND INSPECTION OF

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR
b. ADDRESS *(Street, City, State, ZIP Code)*	☐ USER
	☐ MANUFACTURER
	☐ OTHER *(Specify)*: _____

5. PROBLEM AREAS

a. *Paragraph Number and Wording:*

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

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