MIL-S-22141B
13 April 1976
SUPERSEDING
MIL-S-22141A
2 August 1965
(See section 6)

STEEL, INVESTMENT CASTINGS ALLOY AND CARBON

This specification is approved for use by all the departments and agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers alloy and carbon steel castings made by the investment precision casting process. (See 6.1)

1.2 Classification. Alloy and carbon steel investment castings shall be of the composition and conditions shown in table I. (See 6.2.)

TABLE I. Compositions and conditions.

Composition number[1]	Conditions
IC-4130	As cast, annealed, or heattreated
IC-4140	As cast, annealed, or heattreated
IC-4335M	As cast, annealed, or heattreated
IC-4340	As cast, annealed, or heattreated
IC-4620	As cast, annealed, or heattreated
IC-6150	As cast, annealed, or heattreated
IC-8620	As cast, annealed, or heattreated
IC-8630	As cast, annealed, or heattreated
IC-8735	As cast, annealed, or heattreated
IC-8640	As cast, annealed, or heattreated
IC-52100	As cast, annealed, or heattreated
IC-Nitralloy 135	Heattreated
IC-1020	As cast or annealed
IC-1030	As cast, annealed, or heattreated
IC-1040	As cast, annealed, or heattreated
IC-1050	As cast, annealed, or heattreated

[1] Not identical to similar wrought metal designations.

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2. APPLICABLE DOCUMENTS

*2.1 Issues of documents. The following documents of the issues in effect on date of invitation for bids or request for proposals form a part of this specification to the extent specified herein:

SPECIFICATIONS

Federal

*MMM-A-260	Adhesive, Water-resistant, (For Sealing Waterproofed Paper)
PPP-B-566	Box, Folding, Paperboard
PPP-B-585	Box, Wood, Wirebound
PPP-B-601	Box, Wood, Cleated-Plywood
PPP-B-621	Box, Wood, Nailed and Lock-Corner
PPP-B-636	Box, Shipping, Fiberboard
PPP-B-676	Box, Setup
*PPP-C-1120	Cushioning Material; Uncompressed Bound Fiber for packaging
PPP-T-76	Tape, Pressure-Sensitive, Adhesive Paper, (For Carton Sealing)

Military

MIL-P-116	Preservation-packaging, Methods of
MIL-B-121	Barrier Material, Greaseproofed, Waterproofed, Flexible
MIL-C-6021	Casting, Classification and Inspection of

STANDARDS

Federal

FED-STD-151	Metal, Test Methods

FED-STD-356	Commercial Packaging of Supplies and Equipment

Military

MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-271	Nondestructive Testing Requirements for Metals

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific 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 specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposals shall apply.

*UNIFORM CLASSIFICATION COMMITTEE AGENCY

Uniform Freight Classification Rules

(Application for copies for these ratings, rules, and regulations should be addressed to the Uniform Classification Committee, Room 1106, 222 South Riverside Plaza, Chicago, Ill. 60606.)

American Society for Testing and Materials (ASTM)

*ASTM E 8	Tension, Testing of Metallic Materials, Methods of
*ASTM E 18	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials, Test for
*ASTM E 192	Investment Steel Castings for Aerospace Applications, Reference Radiographs of

(Copies of the above publication may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.)

*American National Standards Institute (ANSI)

ANSI B 46.1	Surface Texture; Surface Roughness, Waviness and Lay

(Application for copies should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, N. Y. 10018.)

*National Standards Association (NAS)

NAS 823	Surface Comparison Standard

(Copies of the above publication may be obtained from the National Standards Association, 1321 14th Street, N.W., Washington, D. C. 20005.)

3. REQUIREMENTS

3.1 Process. Castings shall be made by an investment process producing castings complying with this specification (see 4.1.1).

3.1.1 Initial production castings. When specified, castings from initial production shall be forwarded to a testing activity designated in the contract or order (see 4.1.2 and 6.2).

*3.2 Chemical composition. The chemical analysis of castings shall comply with table II for the composition specified (see 6.2).

*3.2.1 The contractor shall furnish an analysis of each master heat (not to exceed 10,000 pounds) used to provide molten metal or remelting stock. A production heat results from the remelting of a portion of a master heat. When alloying elements other than required for carburizing or deoxidizing are added to production heats, these heats shall be considered master heats.

TABLE II. Chemical requirements.[1]

Composition number[2]	Carbon %	Manganese %	Silicon %	Chromium %	Nickel %	Molybdenum %	Vanadium %	Aluminum %
IC-4130	0.25-0.35	0.40-0.70	0.20-0.80	0.80-1.10	-	0.15-0.25	-	-
IC-4140	0.35-0.45	0.70-1.05	0.20-0.80	0.80-1.10	-	0.15-0.25	-	-
IC-4335M[3]	0.30-0.38	0.60-1.00	0.50-1.00	-	-	0.65-1.00	0.14 (max)	-
IC-4340[3]	0.36-0.44	0.60-0.90	0.20-0.80	0.70-0.90	1.65-2.00	0.20-0.30	-	-
IC-4620	0.15-0.25	0.40-0.70	0.20-0.80	-	1.65-2.00	0.20-0.30	-	-
IC-6150	0.45-0.55	0.65-0.95	0.20-0.80	0.80-1.10	-	-	0.15(min)	-
IC-8620	0.15-0.25	0.65-0.95	0.20-0.80	0.40-0.60	0.40-0.70	0.15-0.25	-	-
IC-8630	0.25-0.35	0.65-0.95	0.20-0.80	0.40-0.60	0.40-0.70	0.15-0.25	-	-
IC-8735[3]	0.30-0.38	0.30-0.70	0.20-1.00	0.35-0.90	0.35-0.75	0.15-0.40	-	-
IC-8640	0.35-0.45	0.70-1.05	0.20-0.80	0.40-0.60	0.40-0.70	0.15-0.25	-	-
IC-52100	0.95-1.10	0.25-0.55	0.20-0.80	1.30-1.60	-	-	-	-
IC-Nitralloy 135M	0.35-0.45	0.40-0.70	0.20-0.80	1.40-1.80	-	0.30-0.45	-	0.85-1.20
IC-1020	0.15-0.25	0.30-0.60	0.20-1.00	-	-	-	-	-
IC-1030	0.25-0.35	0.70-1.00	0.20-1.00	-	-	-	-	-
IC-1040	0.35-0.45	0.70-1.00	0.20-1.00	-	-	-	-	-
IC-1050	0.45-0.55	0.70-1.00	0.20-1.00	-	-	-	-	-

1 Phosphorus 0.04% max; sulfur 0.04% max. except for compositions noted[3]
2 Phosphorus 0.025% max; sulfur 0.025% max.
3 Not identical to similar wrought metal designations

3.3 Condition.

*3.3.1 Annealed or normalized and tempered. Castings shall be furnished in the annealed or the normalized and tempered condition specified in table III.

*3.4 Response to heat treatment. Tensile specimens cut from sample castings or coupons shall be capable of meeting the mechanical properties of table III after oil quenching and tempering as appropriate for the respective composition. Water quenching is not permissible except for the low carbon compositions, nor tempering at temperatures below 700° F unless otherwise specified. Mechanical properties of castings required for conditions other than shown in table III shall be as specified in the contract or order (see 6.2) or on the drawing for the castings.

3.5 Surface roughness. When specified, roughness of surfaces shall not exceed 125 roughness height rating. Surface roughness shall be interpreted in accordance with the provisions of ANSI B 46.1.

3.6 Soundness. Castings shall comply with the specified radiographic standards selected by design personnel from ASTM E 192. The required casting quality shall be specified by class and grade in accordance with MIL-C-6021.

3.7 Decarburization. Unless otherwise specified, decarburization (partial plus complete) shall not exceed 0.003 inch from the surfaces of as received castings.

*3.7.1 Carbon restoration is permitted provided that the carbon content of the restored area is within the range of carbon content specified for the casting and no layer of decarburized material remains between the surface and core. Annealing and carbon restoration may be accomplished in one operation.

3.7.2 Castings which are to be case hardened by carburizing during final heat treatment need not have the carbon restored provided that the depth of decarburization does not exceed the minimum specified case depth requirement.

TABLE III. Mechanical properties.

Composition number	Condition	Hardness of castings (Rockwell or equivalent)	Minimum properties		
			Tensile strength (psi)	Yield strength (0.2% offset) (psi)	Elongation (4 × D) (percent)
IC-4130	Annealed Heattreated	B90 max -	- 115000	- 115000	- 7.0
IC-4140	Annealed Heattreated	C20 max -	- 180000	- 145000	- 5.0
IC-4335M	Annealed Heattreated	C20 max -	- 200000	- 180000	- 5.0
IC-4340	Annealed Heattreated	C20 max -	- 200000	- 180000	- 5.0
IC-4620	Annealed Heattreated	B95 max -	- 120000	- 100000	- 10.0
IC-6150	Annealed Heattreated	C20 max -	- 190000	- 170000	- 4.0
IC-8620	Annealed Heattreated	B90 max -	- 105000	- 85000	- 10.0
IC-8630	Annealed Heattreated	B90 max -	- 150000	- 115000	- 7.0
IC-8735	Annealed Heattreated	B90 max -	- 200000	- 180000	- 5.0
IC-8640	Annealed Heattreated	C20 max -	- 180000	- 145000	- 5.0

TABLE III. Mechanical properties. - Continued

Composition number	Condition	Hardness of castings (Rockwell or equivalent)	Minimum properties		
			Tensile strength (psi)	Yield strength (0.2% offset) (psi)	Elongation (4 × D) (percent)
IC-52100	Annealed Heattreated	B100 max -	- -	- -	- -
Nitralloy IC-135	Heattreated[1]	-	135000	100000	8.0
IC-1020	As cast Annealed	B80 max -	- 60000	- 40000	- 35.0
IC-1030	As cast Annealed Heattreated	B85 max B75 max -	- 65000 85000	- 45000 60000	- 25.0 10.0
IC-1040	As cast Annealed Heattreated	B95 max B85 max -	- 75000 100000	- 48000 90000	- 25.0 10.0
IC-1050	As cast Annealed Heattreated	C20 max B95 max -	- 90000 125000	- 50000 100000	- 20.0 5.0

1 Minimum tempering temperature at least 50F above nitriding temperature.

*3.8 Repairing of defects. Castings shall not be welded, plugged or repaired in any manner without written permission from the procuring activity.

*3.8.1 When permitted in writing by purchaser, defects in castings may be removed and the castings repaired by welding provided the weld repair area has properties comparable to those of the parent metal. Repair welds shall be subjected to the same inspection and acceptance standards required of the casting, and weld repair area shall be suitably marked to facilitate inspection. The repair welding shall be performed prior to any heat treatment specification and to any nondestructive testing specified.

3.9 Dimensions. Castings shall conform to the drawings specified in the contract or order (see 6.2) with respect to dimensions and tolerances.

3.9.1 Tolerances. Unless otherwise specified, critical dimensions on castings shall have as cast nominal tolerances of ±0.005 inch per inch (of size). Unless otherwise indicated on the drawings, all tolerances are absolute and shall be reduced by the amount of the measuring error.

*3.10 Identification marking. Castings shall be identified by any suitable method with the melt or inspection lot number and in addition, when specified on the drawings, shall be marked to show the drawing or part number. The markings shall have no deleterious effect on serviceability.

3.11 Workmanship. Castings shall be uniform in quality and condition, free from cold shuts, fins, laps, foreign materials, and other injurious defects. Castings shall be well cleaned to produce the necessary finish.

4. QUALITY ASSURANCE PROVISIONS

*4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

*4.1.1 Verification of foundry process. Unless otherwise specified, castings shall be provided under radiographic control. This shall consist of radiographic examination of castings under proper foundry technique, which will produce castings free from harmful internal imperfections, as established for each part number and of production castings as necessary to ensure maintenance of satisfactory quality.

*4.1.2 Initial production castings inspection. When specified (see 3.1.1), inspection of a sample of production castings shall be performed at the designated testing agency. Unless otherwise specified, two initial production coupons or castings shall be subjected to the examinations and tests specified herein and such inspection as is necessary to determine compliance with the requirements of the contract (see 6.2).

4.2 Sampling.

4.2.1 Lot.

4.2.1.1 Lot for chemical analysis, soundness, and decarburization. A lot shall consist of all castings poured from the same master heat, from a group of individual melts from the same master heat, or from an individual melt submitted for inspection at one time.

*4.2.1.2 Lot for hardness, tensile, surface roughness, workmanship, and dimensional inspections. The lot shall consist of all castings of the same part number, from the same master heat, and in the same condition submitted for inspection at one time.

4.2.1.3 Lot for carbon restoration. A lot shall consist of all carbon restored castings processed in the same heat treatment operation.

4.2.1.4 Castings shall be properly separated by lots when presented for acceptance.

4.2.2 Sampling for lot acceptance inspection.

4.2.2.1 Sampling for visual and dimensional examination. Sampling of castings for dimensional, identification marking, and workmanship inspection shall be in accordance with the provisions of MIL-STD-105, inspection level II, and acceptable quality level (AQL) 1.5 percent defective (see 6.2).

4.2.2.2 Sampling for soundness, decarburization, and carbon restoration. Sampling for soundness and defects shall be as specified in MIL-C-6021 for the class of castings specified. One sample from each lot shall be taken for test for decarburization and carbon restoration (see 6.2).

4.2.2.3 Sampling for packaging, packing, and marking. A random sample of shipping containers for the inspection of 4.3.3 shall be selected by the inspector in accordance with the provisions of MIL-STD-105, inspection level II, AQL 4.0 percent defective (see 6.2).

4.2.2.4 Sampling for tests.

*4.2.2.4.1 For chemical analysis. When specified, three samples shall be taken from each master heat and one sample from each remelting master heat in accordance with methods 111 or 112 of FED-STD-151 or other recognized methods for chemical analysis (see 4.2.1.1).

4.2.2.4.2 Response to heattreatment. Three cast tensile test specimens shall be supplied to represent each lot of castings and shall be in the same condition as the castings unless the castings are delivered in the final use condition, the test specimens shall, before testing, be heat-treated to the condition in which the castings will go into service. Test bars shall be in accordance with ASTM E 8. Lot acceptance will be based on the tensile strength and hardness of the test bars and the hardness of the castings.

4.2.2.4.3 Rejection criteria for tests. Failure of any sample to conform to the chemical analysis requirements or tension tests shall reject the remelted master heat or the lot of castings represented.

4.2.2.4.4 For surface roughness and hardness. Sampling of castings for surface roughness and hardness shall be in accordance with the provisions of MIL-STD-105, inspection level II, and AQL 1.5 percent defective.

4.3 Lot acceptance inspection.

4.3.1 Visual and dimensional examination. Sample castings selected in accordance with 4.2.2.1 shall be inspected to determine conformance to the dimensional requirements of 3.9, the identification marking of 3.10, and the workmanship requirements of 3.11.

4.3.2 Soundness inspection. Sample castings selected in accordance with 4.2.2.2 shall be subjected to radiographic inspection in accordance with the requirements specified (see 3.6).

4.3.3 Examination of packaging. The preservation, packaging, and packing of castings and marking of containers selected in accordance with 4.2.2.3 shall be examined for conformance to the requirements of this specification and the contract or order.

4.3.4 Place of inspections. Unless otherwise specified (see 6.2), inspection and tests shall be conducted at the place of manufacture. Initial production castings (see 4.1.1) shall be inspected at the laboratory or activity designated by the procuring activity.

4.3.5 Tests. The methods of test for chemical composition, shall be in accordance with FED-STD-151.

4.3.5.1 Chemical composition. Chemical analysis shall be in accordance with method 111.2 or 112 of FED-STD-151.

4.3.5.2 Tensile tests. Tensile tests shall be conducted in accordance with ASTM E 8. Round specimens should be used where practicable.

*4.3.5.3 Surface roughness. Sample castings shall be inspected in accordance with NAS 823 or ANSI B 46.1.

4.3.5.4 Hardness test. Hardness tests shall be conducted in accordance with ASTM E 18.

4.3.5.5 Decarburization and carbon restoration. Transverse sections of finished castings selected in accordance with 4.2.2.2 shall be properly mounted, polished, etched, and examined at a magnification of 500 diameters for conformance to the requirements of 3.7.

5. PACKAGING

5.1 Preservation. Preservation shall be in accordance with level A or commerical, as specified in the contract or order (see 6.2).

5.1.1 Level A.

5.1.1.1 Cleaning. Castings shall be cleaned in accordance with method C-1 of MIL-P-116.

5.1.1.2 Drying. Casting shall be dried in accordance with one or more of the applicable procedures of MIL-P-116.

5.1.1.3 Preservative application. Immediately after cleaning and drying, castings shall be coated with type P-2 preservative in accordance with MIL-P-116 and wrapped in a greaseproof wrap.

5.1.1.4 Intermediate pack. When specified in the contract or order (see 6.2), the castings shall be packed in folding boxes, setup boxes, metal-stayed boxes, or fiber boxes conforming to PPP-B-566, PPP-B-676, or PPP-B-636. All seams and joints, including manufacturer's joints, shall be covered with water-resistant tape conforming to PPP-T-76.

5.1.1.5 Cushioning. When specified in the contract or order (see 6.2), castings shall be protected on all sides with sufficient thickness of cushioning material conforming to PPP-C-1120.

5.1.2 Commercial. Preservation shall be in accordance with FED-STD-356.

5.2 Packing. Packing shall be level A or B or commercial, as specified in the contract or order (see 6.2).

5.2.1 Intermediate packs per pack. The number of intermediate packs per pack shall be as specified in the contract or order (see 6.2).

5.2.2 Level A. Castings that have been preserved as described in 5.1.1 shall be packed in cleated plywood boxes, nailed wood boxes, or wirebound boxes conforming to PPP-B-601 (Overseas type), PPP-B-621 (class 2), and PPP-B-585 (class 3), respectively. Shipping containers shall be lined with a sealed waterproofed bag, or its equivalent, made of material conforming to MIL-B-121 for case liners. The seams and closures shall be sealed with water-resistant material conforming to the requirements of MMM-A-260. The gross shipping weight shall not exceed 200 pounds.

5.2.3 Level B. Castings that have been preserved as described in 5.1.1 shall be packed in wirebound, wood cleated plywood, or nailed wood boxes, conforming to PPP-B-585 (class 1), PPP-B-601 (domestic type), and PPP-B-621 (class 1), respectively. The gross shipping weight shall not exceed 200 pounds.

*5.2.4 Commercial. Packing shall be in accordance with FED-STD-356.

5.3 Marking.

5.3.1 Level A or B. In addition to any special marking required by the contract or order (see 6.2), intermediate packs and shipping containers shall be marked in accordance with MIL-STD-129.

5.3.2 Commerical. Marking shall be in accordance with FED-STD-356.

6. NOTES

*6.1 Intended use. Castings purchased under this specification are intended primarily for use in the manufacture and assembly of military equipment which requires small, sound, high quality, and intricate precision castings.

6.2 Ordering data. Procurement documents should specify the following:

a. Title, date, and number of this specification.

b. The composition and condition of castings required (see 1.2, 3.2, and 3.3).

c. Mechanical properties when special (see 3.4). Location of test bars from castings should be indicated on the drawing.

d. Applicable drawings or dimensions of castings (see 3.9)

e. Details as to radiographic (internal soundness) requirements (see 3.6).

f. Place of inspection and test, if different from 4.3.4. Number of initial production castings and designated testing agency (see 4.1.1).

g. Level of preservation and packing required (see 5.1 and 5.2).

h. Intermediate pack and cushioning material when required (see 5.1.1.4 and 5.1.1.5).

i. Whether level A or B or commercial packing is required (see 5.2).

j. Number of intermediate packs per pack required (see 5.2.1)

k. Special marking when required (see 5.3.1)

l. Special requirements (see 6.3).

m. Decarburization and carbon restoration requirements if different from 3.7.

n. Acceptable quality levels if different from 4.2.2.

6.3 Special requirements. Among the special requirements that may be applied to castings produced under this specification are impact tests. In addition, simulated service or destructive tests may be required.

6.4 Definitions. The following definitions apply to this specification.

*6.4.1 Master heat. A master heat is the metal of a single furnace charge which may be poured directly into castings or may be poured into bars, shot, or ingots for remelting or metal blended as in 6.4.1.1.

*6.4.1.1 Metal from two or more master heats may be blended provided that the composition of each master heat to be blended is within the limits of table I for the respective composition and that the total weight of metal blended does not exceed 10,000 pounds. Ingot and bars may be blended together, shot may be blended, but shot shall not be blended with ingot or bars. When two or more master heats are blended, the resultant blend shall be considered a master heat.

*6.4.2 Individual melt. An individual melt is metal remelted from a portion of a master heat for pouring castings. If alloying elements other than those required for carburizing of deoxidizing are added to an individual melt, that melt shall be considered an individual master heat.

*6.5 Supersession data. This specification includes the requirements of MIL-C-10005(Ord), dated 12 September 1949, and MIL-S-22146(NOrd), dated 31 August 1959.

*6.6 The margins of this specification are marked with asterisks to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

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MIL-S-22141B Steel, Investment Castings Alloy and Carbon

NAME OF ORGANIZATION AND ADDRESS	CONTRACT NUMBER
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1. HAS ANY PART OF THE DOCUMENT CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?
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