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AEROSPACE MATERIAL SPECIFICATION

SAE AMS-S-22141

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Steel, Investment Castings Alloy and Carbon

NOTICE

This document has been taken directly from U.S. Military Specification MIL-S-22141B, Amendment 1, Notice 1 and contains only minor editorial and format changes required to bring it into conformance with the publishing requirements of SAE technical standards. The initial release of this document is intended to replace MIL-S-22141B, Amendment 1, Notice 1. Any part numbers established by the original specification remain unchanged.

The original Military Specification was adopted as an SAE standard under the provisions of the SAE Technical Standards Board (TSB) Rules and Regulations (TSB 001) pertaining to accelerated adoption of government specifications and standards. TSB rules provide for (a) the publication of portions of unrevised government specifications and standards without consensus voting at the SAE Committee level, and (b) the use of the existing government specification or standard format.

Under Department of Defense policies and procedures, any qualification requirements and associated qualified products lists are mandatory for DOD contracts. Any requirement relating to qualified products lists (QPL's) has not been adopted by SAE and is not part of this technical report.

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)

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TABLE I. Compositions and conditions

Composition number[1]	Conditions
IC-4130	As annealed, or heattreated
IC-4140	As annealed, or heattreated
IC-4335M	As annealed, or heattreated
IC-4340	As annealed, or heattreated
IC-4620	As annealed, or heattreated
IC-6150	As annealed, or heattreated
IC-8620	As annealed, or heattreated
IC-8630	As cast, annealed, or heattreated
IC-8735	As annealed, or heattreated
IC-8640	As annealed, or heattreated
IC-52100	As 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.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2694 Repair Welding of Aerospace Castings

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

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

2.3 ANSI Publications:

Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

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

2.4 NAS Publications:

Available from National Standards Association, 1321 14th Street, NW, Washington, D.C. 20005.

NAS 823 Surface Comparison Standard

2.5 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MMM-A-260	Adhesive, Water-resistant, (For Sealing Waterproofed Paper)
PPP-B-566	Box, Folding, Paperboard
PPP-B-585	Box, Wood, Wireboard
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)

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

FED-STD-151	Metal, Test Methods
FED-STD-356	Commercial Packaging of Supplies and Equipment

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

2.6 Uniform Classification Committee Agency:

Available from Uniform Classification Committee, Room 1106, 222 South Riverside Plaza, Chicago, IL 60606.

Uniform Freight Classification Rules

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.

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.

TABLE II. Chemical requirements.[1]

Composition number[3]	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[2]	0.30-0.38	0.60-1.00	0.50-1.00	-	-	0.65-1.00	0.14 (max)	-
IC-4340[2]	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[2]	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.
2 Phosphorus 0.025% max; sulfur 0.025% max.
3 Not identical to similar wrought metal designations

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.

3.8 Repairing of defects:

Castings, except IC-52100 and IC - Nitralloy 135M, may be weld repaired in accordance with the requirements of AMS 2694, but shall not be weld repaired in any other manner without written permission from the procuring activity.

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.

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	B90 max	-	-	-
	Heattreated	-	150000	115000	7.0
IC-4140	Annealed	C20 max	-	-	-
	Heattreated	-	180000	145000	5.0
IC-4335M	Annealed	C20 max	-	-	-
	Heattreated	-	200000	180000	5.0
IC-4340	Annealed	C20 max	-	-	-
	Heattreated	-	200000	180000	5.0
IC-4620	Annealed	B95 max	-	-	-
	Heattreated	-	120000	100000	10.0
IC-6150	Annealed	C20 max	-	-	-
	Heattreated	-	190000	170000	4.0
IC-8620	Annealed	B90 max	-	-	-
	Heattreated	-	105000	85000	10.0
IC-8630	Annealed	B90 max	-	-	-
	Heattreated	-	150000	115000	7.0
IC-8735	Annealed	B90 max	-	-	-
	Heattreated	-	200000	180000	5.0
IC-8640	Annealed	C20 max	-	-	-
	Heattreated	-	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 x D) (percent)
IC-52100	Annealed	B100 max	-	-	-
	Heattreated	-	-	-	-
Nitralloy IC-135	Heattreated[1]	-	135000	100000	8.0
IC-1020	As cast	B80 max	-	-	-
	Annealed	-	60000	40000	35.0
IC-1030	As cast	B85 max	-	-	-
	Annealed	B75 max	65000	45000	25.0
	Heattreated	-	85000	60000	10.0
IC-1040	As cast	B95 max	-	-	-
	Annealed	B85 max	75000	48000	25.0
	Heattreated	-	100000	90000	10.0
IC-1050	As cast	C20 max	-	-	-
	Annealed	B95 max	90000	50000	20.0
	Heattreated	-	125000	100000	5.0

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

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. Proper foundry techniques must be established that will produce castings for each part number, that will be free from harmful imperfections. Until this is accomplished, all castings made will be subjected to radiographic examination. After these techniques are established, production castings will also be subjected to radiographic examination 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 and 6.4).

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: A minimum of three cast tensile test specimens from the same master heat as the lot of castings represented, shall be heat treated with the castings lot and tested to determine the acceptability of the castings. 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 (see 4.2.1.2).

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 plate of manufacture. Initial production castings (see 4.1.2) shall be inspected at the laboratory or activity designated by the procuring activity.

4.3.5 Tests: The method 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 commercial, 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.