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# Standard Specification for Castings, Investment, Carbon and Low Alloy Steel for General Application, and Cobalt Alloy for High Strength at Elevated Temperatures<sup>1</sup>

This standard is issued under the fixed designation A732/A732M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 1. Scope\*

1.1 This specification covers carbon and low-alloy steel and cobalt alloy castings made by the investment casting process.

1.2 Fifteen grades of steel and two cobalt alloy grades are covered.

1.3 Supplementary requirements of an optional nature are provided for use at the option of the purchaser. The supplementary requirements shall apply only when specified individually by the purchaser in the purchase order or contract.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

## 2. Referenced Documents

2.1 *ASTM Standards*:<sup>2</sup>

[A370 Test Methods and Definitions for Mechanical Testing of Steel Products](#)

[A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys](#)

[A957 Specification for Investment Castings, Steel and Alloy, Common Requirements, for General Industrial Use](#)

[A994 Guide for Editorial Procedures and Form of Product Specifications for Steel, Stainless Steel, and Related Alloys](#)

[A997 Practice for Investment Castings, Surface Acceptance Standards, Visual Examination](#)

[E21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials](#)

[E139 Test Methods for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials](#)

## 3. Ordering Information

3.1 Orders for castings under this specification should include the following information:

3.1.1 Quantity,

3.1.2 ASTM designation and issue date,

3.1.3 Grade designation ([Tables 1 and 2](#)), and

3.1.4 Description of casting by part, pattern, or drawing number. (Dimensional tolerances and machined surfaces shall be indicated on the casting drawing.).

3.2 The purchaser should specify any of the following information to describe adequately the desired material:

3.2.1 Heat-treat condition (see [5.1](#) and [5.2](#)),

3.2.2 Repair welding (see [Section 8](#) and [Specification A957](#)),

3.2.3 Source inspection, if any (see [Specification A957](#)), and

3.2.4 Supplementary requirements required (marking, certification, mechanical properties, NDT, and the like).

## 4. General Requirements

4.1 Material furnished to this specification shall conform to the requirements of [Specification A957](#), including any supplementary requirements that are indicated on the purchase order. Failure to comply with the requirements of [Specification A957](#) constitutes nonconformance with this specification. In case of conflict of this specification and [Specification A957](#), this specification shall prevail.

## 5. Heat Treatment

5.1 Steel castings shall be heat treated either by full annealing, normalizing, normalizing and tempering, or quenching and tempering to obtain the specified properties or other properties that have been agreed upon within each grade. In this latter instance, [Supplementary Requirement S23](#) shall be used.

5.1.1 Heat treatment shall be performed after the castings have been allowed to cool below the transformation range.

<sup>1</sup> This specification is under the jurisdiction of ASTM committee [A01](#) on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee [A01.18](#) on Castings.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

\*A Summary of Changes section appears at the end of this standard

**TABLE 1 Chemical Requirements**

Grade	1A	2A,2Q	3A,3Q	4A,4Q	5N	6N	7Q	8Q
Type	Low Carbon IC 1020 <sup>4</sup>	Medium Carbon IC 1030	Medium Carbon IC 1040	Medium Carbon IC 1050	Vanadium IC 6120	Manganese Molybdenum IC 4020	Chromium Molybdenum IC 4130	Chromium Molybdenum IC 4140
Carbon	0.15 to 0.25	0.25 to 0.35	0.35 to 0.45	0.45 to 0.55	0.30 max	0.35 max	0.25 to 0.35	0.35 to 0.45
Manganese	0.20 to 0.60	0.70 to 1.00	0.70 to 1.00	0.70 to 1.00	0.70 to 1.00	1.35 to 1.75	0.40 to 0.70	0.70 to 1.00
Phosphorus, max	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Sulfur, max	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Silicon	0.20 to 1.00	0.20 to 1.00	0.20 to 1.00	0.20 to 1.00	0.20 to 0.80	0.20 to 0.80	0.20 to 0.80	0.20 to 0.80
Nickel								
Chromium							0.80 to 1.10	0.80 to 1.10
Molybdenum						0.25 to 0.55	0.15 to 0.25	0.15 to 0.25
Vanadium					0.05 to 0.15			
<i>Residual Elements:</i>								
Copper	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Nickel	0.50	0.50	0.50		0.50	0.50		0.50
Chromium	0.35	0.35	0.35		0.35	0.35		
Molybdenum + Tungsten	0.25				0.25			
Tungsten		0.10	0.10	0.10		0.25	0.10	0.10
Total content of these residual elements	1.00	1.00	1.00	0.60	1.00	1.00	0.60	1.00

  

Grade	9Q	10Q	11Q	12Q	13Q	14Q	15A
Type	Chrome Nickel Molybdenum IC 4330	Chrome Nickel Molybdenum IC 4340	Nickel Molybdenum IC 4620	Chromium Vanadium IC 6150	Chrome Nickel Molybdenum IC 8620	Chrome Nickel Molybdenum IC 8630	Chromium IC 52100
Carbon	0.25 to 0.35	0.35 to 0.45	0.15 to 0.25	0.45 to 0.55	0.15 to 0.25	0.25 to 0.35	0.95 to 1.10
Manganese	0.40 to 0.70	0.70 to 1.00	0.40 to 0.70	0.65 to 0.95	0.65 to 0.95	0.65 to 0.95	0.25 to 0.55
Phosphorus, max	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Sulfur, max	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Silicon	0.20 to 0.80	0.20 to 0.80	0.20 to 0.80	0.20 to 0.80	0.20 to 0.80	0.20 to 0.80	0.20 to 0.80
Nickel	1.65 to 2.00	1.65 to 2.00	1.65 to 2.00		0.40 to 0.70	0.40 to 0.70	
Chromium	0.70 to 0.90	0.70 to 0.90		0.80 to 1.10	0.40 to 0.70	0.40 to 0.70	1.30 to 1.60
Molybdenum	0.20 to 0.30	0.20 to 0.30	0.20 to 0.30		0.15 to 0.25	0.15 to 0.25	
Vanadium				0.15 min			
<i>Residual Elements:</i>							
Copper	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Nickel				0.50			0.50
Chromium			0.35				
Molybdenum + Tungsten				0.10			
Tungsten	0.10	0.10	0.10		0.10	0.10	0.10
Total content of these residual elements	0.60	1.00	1.00	1.00	1.00	1.00	0.60

<sup>4</sup> Investment Casting (IC) numbers are to be used only for nomenclature comparison.

**TABLE 2 Chemical Requirements-Cobalt Alloys**

Grade	21	31
Carbon	0.20–0.30	0.45–0.55
Manganese, max.	1.00	1.00
Silicon, max	1.00	1.00
Phosphorus, max	0.040	0.040
Sulfur, max	0.040	0.040
Chromium	25.0–29.0	24.5–26.5
Nickel	1.7–3.8	9.5–11.5
Cobalt	remainder	remainder
Molybdenum	5.0–6.0	...
Tungsten	...	7.0–8.0
Iron, max.	3.00	2.00
Boron	0.007 max	0.005–0.015

5.2 Cobalt alloy castings shall be supplied in the as-cast condition unless otherwise agreed upon by supplier and purchaser.

5.3 Definitions of terms relating to heat treatment shall be in accordance with Terminology A941.

## 6. Chemical Composition

6.1 The castings shall conform to the requirements for chemical composition specified in Table 1 and Table 2.

## 7. Quality

7.1 The surface of the casting shall be examined visually to meet the requirements of Practice A997. Acceptance criteria to be mutually agreed upon between supplier and purchaser.

7.2 The castings shall not be peened or plugged or impregnated.

## 8. Repair by Welding

8.1 Welding shall be accomplished with a filler metal that produces a weld deposit with a chemical composition similar to the casting. Castings ordered in the annealed condition or for subsequent hardening shall be annealed after weld repairs. Castings ordered heat treated shall be post weld heat treated in accordance with the qualified welding procedure after weld

repairs with the exception of Grades 1A and 2A where post weld heat treatment is optional.

8.2 Welds shall be subject to the same quality standards as used to inspect the castings.

## 9. Keywords

9.1 alloy steel; carbon steel; cobalt alloys; investment castings; steel castings

## SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall not apply unless specified in the purchase order. A list of standardized supplementary requirements for use at the option of the purchaser is included in Specification **A957**. Those ordinarily considered suitable for use with this specification are given below, together with additional supplementary requirements that are applicable only to this specification. Other supplementary requirements enumerated in Specification **A957** may be used with this specification upon agreement between supplier and purchaser.

### S1. Magnetic Particle Inspection

### S2. Radiographic Inspection

### S3. Liquid Penetrant Inspection

### S6. Certification

### S7. Prior Approval of Major Weld Repairs

### S8. Marking

### S10. Hardness Test

S10.1 Hardness measurements at specified locations of the castings shall be made in accordance with Test Methods and Definitions **A370** and reported.

### S13. Unspecified Elements

### S16. Weld Repair Charts

### S19. Decarburization

### S23. Mechanical Properties

S23.1 Mechanical properties other than those specified in **Table S24.1** may be ordered for each of the grades. The properties shall be agreed upon between the supplier and the purchaser.

### S24. Tension Test (Castings Heat Treated by Supplier)

S24.1 Tensile properties shall be determined from cast material representing each master heat or sub heat. The results shall conform to the requirements specified in **Table S24.1**, or

**TABLE S24.1 Tensile Requirements**

Grade	Tensile strength, min		Yield strength, min		Elongation, in 2-in. [50-mm] or 4 diameters	Heat Treatment
	ksi	[MPa]	ksi	[MPa]		
1A	60	[414]	40	[276]	24	A <sup>A</sup>
2A	65	[448]	45	[310]	25	A
2Q	85	[586]	60	[414]	10	Q T <sup>B</sup>
3A	75	[517]	48	[331]	25	A
3Q	100	[689]	90	[621]	10	Q T
4A	90	[621]	50	[345]	20	A
4Q	125	[862]	100	[689]	5	Q T
5N	85	[586]	55	[379]	22	N T <sup>C</sup>
6N	90	[621]	60	[414]	20	N T
7Q	150	[1030]	115	[793]	7	Q T
8Q	180	[1241]	145	[1000]	5	Q T
9Q	150	[1030]	115	[793]	7	Q T
10Q	180	[1241]	145	[1000]	5	Q T
11	120	[827]	100	[689]	10	Q T
12Q	190	[1310]	170	[1172]	4	Q T
13Q	105	[724]	85	[586]	10	Q T
14Q	150	[1030]	115	[793]	7	Q T
15A <sup>D</sup>	...	...	...	...	...	A

<sup>A</sup> Annealed.

<sup>B</sup> Quenched and tempered.

<sup>C</sup> Normalized and tempered.

<sup>D</sup> Hardness Rockwell B, 100 max.