



Designation: **A957/A957M – 20 A957/A957M – 21**

# Standard Specification for Investment Castings, Steel and Alloy, Common Requirements, for General Industrial Use<sup>1</sup>

This standard is issued under the fixed designation A957/A957M; 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 reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This specification covers a group of requirements that are mandatory for castings produced by the investment casting process to meet the metallurgical requirements of the following steel casting specifications issued by ASTM.

ASTM Designation	Title of Specification
<b>A27/A27M</b>	Steel Castings, Carbon, for General Application
<b>A128/A128M</b> <b>A148/A148M</b>	Steel Castings, Austenitic Manganese Steel Castings, High-Strength, for Structural Purposes
<b>A297/A297M</b>	Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat-Resistant, for General Application
<b>A447/A447M</b>	Steel Castings, Chromium-Nickel-Iron Alloy (25-12 Class), for High-Temperature Service
<b>A494/A494M</b> <b>A560/A560M</b> <b>A732/A732M</b>	Castings, Nickel and Nickel Alloy Castings, Chromium-Nickel Alloy Castings, Investment, Carbon and Low-Alloy Steel for General Application, and Cobalt Alloy for High Strength at Elevated Temperatures
<b>A743/A743M</b>	Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion-Resistant, for General Application
<b>A744/A744M</b>	Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service
<b>A747/A747M</b>	Steel Castings, Stainless, Precipitation Hardening
<b>A890/A890M</b>	Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application
<b>A915/A915M</b>	Steel Castings, Carbon and Alloy, Chemical Requirements Similar to Standard Wrought Grades
<b>A958/A958M</b>	Steel Castings, Carbon and Alloy, with Tensile Requirements, Chemical Requirements Similar to Standard Wrought Grades
<b>A1002</b>	Castings, Nickel-Aluminum Ordered Alloy

<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.

Current edition approved July 1, 2020 May 1, 2021. Published August 2020 May 2021. Originally approved in 1996. Last previous edition approved in 2018 2020 as A957/A957M – 18a: A957/A957M – 20. DOI: 10.1520/A0957\_A0957M-20:10.1520/A0957\_A0957M-21.

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

1.2 This specification also covers a group of supplementary requirements that may be applied to the above specifications as indicated therein. These are provided for use when additional testing or inspection is desired, and apply only when specified individually by the purchaser in the order.

1.3 When investment castings are ordered, the requirements stated in this specification form an integral part of the material specification. In cases of conflict, the requirements of this specification shall take precedence over the individual material specification requirements.

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 nonconformance with the standard.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

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

- A27/A27M Specification for Steel Castings, Carbon, for General Application
- A128/A128M Specification for Steel Castings, Austenitic Manganese
- A148/A148M Specification for Steel Castings, High Strength, for Structural Purposes
- A297/A297M Specification for Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application
- A370 Test Methods and Definitions for Mechanical Testing of Steel Products
- A380/A380M Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
- A447/A447M Specification for Steel Castings, Chromium-Nickel-Iron Alloy (25-12 Class), for High-Temperature Service
- A488/A488M Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel
- A494/A494M Specification for Castings, Nickel and Nickel Alloy
- A560/A560M Specification for Castings, Chromium-Nickel Alloy
- A609/A609M Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof
- A732/A732M Specification for Castings, Investment, Carbon and Low-Alloy Steel for General Application, and Cobalt Alloy for High Strength at Elevated Temperatures
- A743/A743M Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application
- A744/A744M Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service
- A747/A747M Specification for Steel Castings, Stainless, Precipitation Hardening
- A751 Test Methods and Practices for Chemical Analysis of Steel Products
- A800/A800M Practice for Estimating Ferrite Content of Stainless Steel Castings Containing Both Ferrite and Austenite
- A890/A890M Specification for Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application
- A903/A903M Specification for Steel Castings, Surface Acceptance Standards, Magnetic Particle and Liquid Penetrant Inspection
- A915/A915M Specification for Steel Castings, Carbon, and Alloy, Chemical Requirements Similar to Standard Wrought Grades
- A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys
- A958/A958M Specification for Steel Castings, Carbon and Alloy, with Tensile Requirements, Chemical Requirements Similar to Standard Wrought Grades
- A967/A967M Specification for Chemical Passivation Treatments for Stainless Steel Parts
- A991/A991M Test Method for Conducting Temperature Uniformity Surveys of Furnaces Used to Heat Treat Steel Products
- A997 Practice for Investment Castings, Surface Acceptance Standards, Visual Examination
- A1002 Specification for Castings, Nickel-Aluminum Ordered Alloy
- A1058 Test Methods for Mechanical Testing of Steel Products—Metric
- A1067/A1067M Specification for Test Coupons for Steel Castings
- A1080/A1080M Practice for Hot Isostatic Pressing of Steel, Stainless Steel, and Related Alloy Castings
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

<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.

E94/E94M Guide for Radiographic Examination Using Industrial Radiographic Film  
E125 Reference Photographs for Magnetic Particle Indications on Ferrous Castings  
E165/E165M Practice for Liquid Penetrant Testing for General Industry  
E186 Reference Radiographs for Heavy-Walled (2 to 4½ in. (50.8 to 114 mm)) Steel Castings  
E192 Reference Radiographs of Investment Steel Castings for Aerospace Applications  
E280 Reference Radiographs for Heavy-Walled (4½ to 12 in. (114 to 305 mm)) Steel Castings  
E340 Practice for Macroetching Metals and Alloys  
E353 Test Methods for Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys  
E354 Test Methods for Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys  
E446 Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness  
E709 Guide for Magnetic Particle Testing  
E2660 Digital Reference Images for Investment Steel Castings for Aerospace Applications  
2.2 SAE Standards:<sup>3</sup>  
AMS 2750 Pyrometry  
ARP 1341 Determining Decarburization and Carburization in Finished Parts of Carbon and Low-Alloy Steel

### 3. Terminology

#### 3.1 Definitions:

3.1.1 The definitions in Test Methods and Definitions A370, Test Methods, Practices, and Terminology A751, Terminology A941, and Test Methods A1058 are applicable to this specification and to those listed in 1.1.

#### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *investment casting, n*—a metal casting that is produced in a mold obtained by investing (surrounding) an expendable pattern with a ceramic slurry that is allowed to solidify. The expendable pattern may consist of wax, plastic, or other material and is removed prior to filling the mold with liquid metal.

3.2.2 *master heat, n*—a quantity of metal processed in a single furnace or refining vessel at one time in such a manner as to produce the desired composition and properties.

3.2.3 *sub-heat, n*—a portion of a master heat remelted without additional processing for pouring into castings. Synonyms—*melt, production heat*.

### 4. Materials and Manufacture

4.1 When the purchaser imposes the requirements of this specification, the manufacturer is responsible for compliance with the specification requirements during the production and processing of the casting by themselves and any of their subcontractors.

4.2 *Melting Process*—Master heats shall be made by the electric furnace process, with or without separate refining such as argon-oxygen-decarburization (AOD), vacuum-oxygen-degassing (VOD), vacuum-induction-melting (VIM), and so forth, unless otherwise specified in the individual specification or agreed upon between the customer and producer. Master heats may be used directly for producing castings or converted into ingot, bar, shot, or other suitable form, not including gates and risers from casting production, for later remelting as a sub-heat.

4.3 *Re-Melting Process*—Sub-heats shall be produced from master heat metal in suitable batch sizes by electric induction furnace, with or without atmosphere protection such as vacuum or inert gas, unless otherwise specified in the individual specification or agreed upon between the customer and producer. Revert (gates, sprues, risers, and rejected castings) shall not be re-melted except in master heats.

#### 4.4 Sampling:

4.4.1 If castings are poured directly from one or more master heats, then the samples for chemical and other required testing shall also be poured directly from each of the master heats.

<sup>3</sup> Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, <http://www.sae.org>.

4.4.2 If castings are poured from a sub-heat, then the samples for chemical and other required testing shall also be poured from a sub-heat of that same master heat, but not necessarily from the same sub-heat as the castings. The sub-heat used for the test samples shall be produced using the same melting practices and additions as used to produce the castings.

4.4.3 Unless otherwise specified by the purchaser, test specimens may be taken from castings or from coupons cast integrally with the castings, in the same molds as the castings, or in separate molds.

#### 4.5 *Heat Treatment:*

4.5.1 Castings shall be heat treated in the working zone of a furnace that has been surveyed in accordance with Test Method **A991/A991M** or AMS 2750.

4.5.2 When using furnaces surveyed in accordance with Test Method **A991/A991M**, the following requirements apply for heat treatments above 2000 °F [1100 °C]. When castings are heat treated at temperatures above 2000 °F [1100 °C], then the working zone shall have been established by a survey performed at not more than 25 °F [15 °C] below nor more than 200 °F [110 °C] above the minimum heat treatment temperature specified for the grade. If a minimum heat treatment temperature is not specified for the grade, then the survey temperature shall be not more than 50 °F [30 °C] below nor more than 175 °F [100 °C] above the furnace set point used.

4.5.3 When using furnaces surveyed in accordance with AMS 2750, there are no additional requirements beyond those stated in AMS 2750.

4.5.4 The maximum variation in measured temperature, as determined by the difference between the highest temperature and the lowest temperature, shall be as agreed between the purchaser and producer, except that during production heat treatment no portion of the furnace shall be below the minimum specified temperature nor above the maximum specified temperature for the grade being processed.

## 5. Chemical Composition

5.1 *Chemical Analysis*—Chemical analysis of materials covered by this specification shall be in accordance with Test Methods, Practices, and Terminology **A751**.

5.2 *Heat Analysis*—An analysis of samples obtained in accordance with 4.4 or Supplementary Requirement S20, as appropriate, shall be made by the manufacturer to determine the percentages of the elements specified in the individual specification for the grade being poured. When drillings are used, they shall be taken not less than 1/16 in. [2 mm] beneath the surface. The chemical composition thus determined shall conform to the requirements in the individual specification for the grade being poured.

5.3 *Product Analysis*—A product analysis may be made by the purchaser from material representing each master heat, sub-heat, lot, or casting. The analysis shall be made on representative material. Samples for carbon analysis of carbon and alloy steel shall be taken no closer than 1/16 in. [2 mm] to a cast surface, except that castings too thin for this shall be analyzed on representative material. The chemical composition thus determined shall meet the requirements specified in the applicable specification for the grade involved, or shall be subject to rejection by the purchaser, except that the chemical composition determined for carbon and low-alloy steel and stainless steel, stainless steel, and nickel and cobalt based castings may vary from the specified limits by the amounts shown in **Table 1** and **Table 2**, and **Table 3**, respectively. The product analysis tolerances of **Table 1** and **Tables 1-3** are not applicable as acceptance criteria for heat analysis by the casting manufacturer. When comparing product and heat analysis for other than carbon and low-alloy steels, and stainless steels, the reproducibility data R2 in Test Methods **E353** or **E354**, as applicable, shall be taken into consideration.

5.4 *Unspecified Elements*—When chemical analysis for elements not specified for the grade ordered is desired, Supplementary Requirement S13 may be specified.

NOTE 1—All commercial metals contain small amounts of various elements in addition to those that are specified. It is neither practical nor necessary to specify limits for every unspecified element that might be present, despite the fact that the presence of many of these elements is often routinely determined by the producer.

**TABLE 1 Product Analysis Tolerances – Carbon and Low-Alloy Steels**

Element	Range, % <sup>A</sup>	Tolerances <sup>B,C</sup> Over Maximum or Under Minimum Limit, %
C	up to 0.65 above 0.65	$0.03 \times \% C_L + 0.02$ 0.04
Mn	up to 1 above 1	$0.08 \times \% Mn_L + 0.01$ 0.09
Si	up to 0.60 above 0.60	$0.22 \times \% Si_L - 0.01$ 0.15
P	all	$0.13 \times \% P_L + 0.005$
S	all	$0.36 \times \% S_L + 0.001$
Ni	up to 2 above 2	$0.10 \times \% Ni_L + 0.03$ 0.25
Cr	up to 2 above 2	$0.07 \times \% Cr_L + 0.04$ 0.18
Mo	up to 0.6 above 0.6	$0.04 \times \% Mo_L + 0.03$ 0.06
V	up to 0.25 above 0.25	$0.23 \times \% V_L + 0.004$ 0.06
W	up to 0.10 above 0.10	$0.08 \times \% W_L + 0.02$ 0.02
Cu	up to 0.15 above 0.15	$0.18 \times \% Cu_L + 0.02$ 0.05
Al	up to 0.10 above 0.10	$0.08 \times \% Al_L + 0.02$ 0.03

<sup>A</sup> The range denotes the composition limits up to which tolerances are computed by the equation, and above which the tolerances are given by a constant.

<sup>B</sup> The subscript <sub>L</sub> for the elements in each equation indicates that the limits of the element specified by the applicable specification are to be inserted into the equation to calculate the tolerance for the upper limit and the lower limit (if applicable), respectively. Examples of computing tolerances are presented in footnote C.

<sup>C</sup> To illustrate the computation of the tolerance, consider the manganese maximum of 0.70 for an 0.30 carbon grade 65-35 in Specification A27/A27M. The maximum permissible deviation is  $(0.08 \times 0.70 + 0.01) = 0.066$ . Therefore, the highest acceptable product analysis is 0.766. Similarly, for an 0.20 carbon grade 70-40 in Specification A27/A27M, the maximum manganese content is 1.40; thus, the highest acceptable product analysis is  $(1.40 + 0.09) = 1.49$ .

## ASTM A957/A957M-21

**5.5 Grade Substitution**—Grade substitution is not permitted. Grade substitution occurs when the material being supplied contains one or more elements that are not specified for the supplied material such that the material conforms to the requirements of a different grade.

## 6. Mechanical Test Requirements

6.1 The individual product specifications vary as to whether mechanical tests are required; for this reason, and to determine specific test requirements, the individual product specification should be reviewed. If mechanical testing is required by the product specification, sampling shall be in accordance with 4.4 or with Supplementary Requirement S21, as appropriate.

6.2 Unless otherwise specified by the purchaser, when mechanical properties are required by the product specification, test coupons may be taken from castings, may be cast integrally with the castings, or may be cast in separate molds made of the same material used for the production molds, cast in the same foundry and melted using the same foundry practices as those used for the castings, in accordance with Specification A1067/A1067M, Fig. 1, Fig. 2, Fig. 3, or Fig. 4, except when Supplementary Requirement S15 is specified. The test coupon in Specification A1067/A1067M, Fig. 4 shall be employed only for austenitic alloy castings with cross sections less than 2½ in. [65 mm].<sup>4</sup>

NOTE 2—Test Coupons for Large and Heavy Steel Castings—The test coupons in Specification A1067/A1067M, Fig. 1, are to be used for large and heavy steel castings. However, at the option of the foundry, the cross-sectional area and length of the standard coupon may be increased as desired.

NOTE 3—Bend Bar—If a bend bar is required, an alternate design (as shown by dotted lines in Specification A1067/A1067M, Fig. 1) is indicated.

<sup>4</sup> Information on the relationship of mechanical properties determined on test coupons obtained as specified in 6.2 with those obtained from the casting may be found in *The Steel Casting Handbook*, Fifth Edition, Steel Founders' Society of America, 1980, pp. 15–35 through 15–43.



TABLE 2 Product Analysis Tolerances – Stainless Steels

Elements	Limit or Maximum of Specified Range, %	Tolerance Over the Maximum Limit or Under the Minimum Limit	Elements	Limit or Maximum of Specified Range, %	Tolerance Over the Maximum Limit or Under the Minimum Limit
Element	Limit or Maximum of Specified Range, %	Tolerance Over the Maximum Limit or Under the Minimum Limit	Element	Limit or Maximum of Specified Range, %	Tolerance Over the Maximum Limit or Under the Minimum Limit
Carbon	to 0.010, incl	0.002	Titanium	to 1.00, incl	0.05
	over 0.010 to 0.030, incl	0.005		over 1.00 to 3.00, incl	0.07
	over 0.030 to 0.20, incl	0.01	Cobalt	over 0.05 to 0.50, incl	0.01 <sup>A</sup>
	over 0.20 to 0.60, incl	0.02		over 0.50 to 2.00, incl	0.02
Manganese	over 0.60 to 1.20, incl	0.03	over 2.00 to 5.00, incl	0.05	
	to 1.00, incl	0.03	Columbium plus tantalum (niobium plus tantalum)	to 1.50, incl	0.05
	over 1.00 to 3.00, incl	0.04			
	over 3.00 to 6.00, incl	0.05			
	over 6.00 to 10.00, incl	0.06			
over 10.00 to 15.00, incl	0.10	Tantalum	to 0.10, incl	0.02	
over 15.00 to 20.00, incl	0.15				
Phosphorus	to 0.040, incl	0.005	Copper	to 0.50, incl	0.03
	over 0.040 to 0.20, incl	0.010		over 0.50 to 1.00, incl	0.05
Sulfur	to 0.040, incl	0.005		over 1.00 to 3.00, incl	0.10
	over 0.040 to 0.20, incl	0.010		over 3.00 to 5.00, incl	0.15
	over 0.20 to 0.50, incl	0.020	over 5.00 to 10.00, incl	0.20	
Silicon	to 1.00, incl	0.05	Aluminum	to 0.15, incl	–0.005, +0.01
	over 1.00 to 3.00, incl	0.10		over 0.15 to 0.50, incl	0.05
	over 3.00 to 6.00, incl	0.15		over 0.50 to 2.00, incl	0.10
Chromium	over 4.00 to 10.00, incl	0.10	Nitrogen	to 0.02, incl	0.005
	over 10.00 to 15.00, incl	0.15		over 0.02 to 0.19, incl	0.01
	over 15.00 to 20.00, incl	0.20		over 0.19 to 0.25, incl	0.02
	over 20.00 to 30.00, incl	0.25		over 0.25 to 0.35, incl	0.03
				over 0.35 to 0.45, incl	0.04
Nickel	to 1.00, incl	0.03	over 0.45 to 0.55, incl	0.05	
	to 1.00, incl	0.03	Tungsten	to 1.00, incl	0.03
	over 1.00 to 5.00, incl	0.07		to 1.00, incl	0.03
	over 1.00 to 5.00, incl	0.07	Tungsten	over 1.00 to 2.00, incl	0.05
	over 5.00 to 10.00, incl	0.10	Vanadium	to 0.50, incl	0.03
	over 10.00 to 20.00, incl	0.15		over 0.50 to 1.50, incl	0.05
over 20.00 to 30.00, incl	0.20	Selenium	all	0.03	
Molybdenum	over 0.20 to 0.60, incl	0.03			
	over 0.60 to 2.00, incl	0.05			
	over 2.00 to 8.00, incl	0.10			

<sup>A</sup> Product analysis limits for cobalt under 0.05 % have not been established, and the manufacturer should be consulted for those limits.

NOTE 4—Specification A1067/A1067M, Fig 2—Pour through head; cover molten head with powdered charcoal, coke dust, and so forth, immediately after pouring, in order to keep head fluid as long as possible.

NOTE 5—Specification A1067/A1067M, Fig 4—Coupons produced in this manner are suitable for austenitic alloys only. The mold may be preheated for pouring to produce a sound coupon.

6.3 Choice of testing track from the options listed in Test Methods A1058 when material is ordered to an M-suffix (SI units) product standard should be identified by the purchaser in the ordering information. If the choice of test track is not specified in the order, then the default ASTM track shall be used as noted in Test Methods A1058.

6.4 The coupon from which the test specimen is taken shall be heat treated in production furnaces to the same procedure as the castings it represents.

6.5 The specimens may be cast to shape or machined from coupons to dimensions in accordance with Test Methods and Definitions A370 or the ICI-type bar shown in Specification A1067/A1067M, Fig. 3.



TABLE 3 Product Analysis Tolerances – Nickel and Cobalt Base Alloys

Element	Limit or Maximum of Specified Element, %	Variation Under Min or Over Max	Element	Limit or Maximum of Specified Element, %	Variation Under Min or Over Max		
Carbon	up to 0.02, incl	0.005	Aluminum	up to 0.10, incl	0.02		
	over 0.02 to 0.20, incl	0.01		over 0.10 to 0.50, incl	0.05		
	over 0.20 to 0.60, incl	0.02		over 0.50 to 2.00, incl	0.10		
	over 0.60 to 1.00, incl	0.03		over 2.00 to 5.00, incl	0.20		
Manganese	up to 1.00, incl	0.03	Iron	over 5.00 to 10.00, incl	0.25		
	over 1.00 to 3.00, incl	0.04		over 10.00 to 15.00, incl	0.30		
	over 3.00 to 6.00, incl	0.07		Boron	up to 0.01, incl	0.002	
	over 6.00 to 10.00, incl	0.10			over 0.01 to 0.05, incl	0.005	
Silicon	up to 0.05, incl	0.02	over 0.05 to 0.15, incl		0.010		
	over 0.05 to 0.25, incl	0.03	Copper		up to 0.20, incl	0.02	
	over 0.25 to 0.50, incl	0.04		over 0.20 to 0.50, incl	0.03		
	over 0.50 to 1.00, incl	0.05		over 0.50 to 5.00, incl	0.04		
over 1.00 to 4.50, incl	0.10	over 5.00 to 10.00, incl		0.05			
Phosphorus	all	0.005	over 10.00 to 20.00, incl	0.10			
Sulfur	up to 0.02, incl	0.003	over 20.00 to 30.00, incl	0.15			
	over 0.02 to 0.06, incl	0.005	over 30.00 to 50.00, incl	0.30			
Chromium	up to 5.00, incl	0.10	over 30.00 to 40.00, incl	0.45			
	over 5.00 to 15.00, incl	0.15	Vanadium	up to 0.20, incl	0.02		
	over 15.00 to 25.00, incl	0.25		over 0.20 to 0.50, incl	0.03		
	over 25.00 to 35.00, incl	0.30		over 0.50 to 5.00, incl	0.04		
	over 35.00 to 45.00, incl	0.40		over 5.00 to 10.00, incl	0.05		
	over 45.00 to 50.00, incl	0.50		over 10.00 to 20.00, incl	0.10		
Nickel	up to 1.00, incl	0.05		over 20.00 to 30.00, incl	0.15		
	over 1.00 to 5.00, incl	0.10	over 30.00 to 40.00, incl	0.20			
	over 5.00 to 10.00, incl	0.15	over 40.00 to 60.00, incl	0.25			
	over 10.00 to 20.00, incl	0.20	over 60.00 to 80.00, incl	0.30			
	over 20.00 to 30.00, incl	0.25	over 80.00 to 99.00, incl	0.35			
	over 30.00 to 40.00, incl	0.30	Zirconium	up to 0.10, incl	0.01		
	over 40.00 to 60.00, incl	0.35		over 0.10 to 0.20, incl	0.02		
	over 60.00 to 80.00, incl	0.45	Yttrium	up to 0.050, incl	0.005		
over 80.00 to 99.00, incl	0.60	over 0.050 to 0.10, incl		0.010			
Cobalt	up to 0.10, incl	0.01	over 0.10 to 0.20, incl	0.015			
	over 0.10 to 0.20, incl	0.02	Lanthanum	up to 0.10, incl	0.01		
	over 0.20 to 1.00, incl	0.03		over 0.10 to 0.20, incl	0.02		
	over 1.00 to 5.00, incl	0.05	Cerium	up to 0.20, incl	0.01		
	over 5.00 to 10.00, incl	0.10		up to 0.050, incl	0.005		
	over 10.00 to 15.00, incl	0.15	over 0.050 to 0.10, incl	0.010			
	over 15.00 to 20.00, incl	0.20	over 0.10 to 0.20, incl	0.015			
	over 20.00 to 25.00, incl	0.25	Hafnium	up to 1.50, incl	0.05		
	over 25.00 to 30.00, incl	0.30		over 1.50 to 3.00, incl	0.10		
	over 30.00 to 35.00, incl	0.35	Rhenium	up to 1.50, incl	0.05		
	over 35.00 to 50.00, incl	0.50		over 1.50 to 3.00, incl	0.10		
	Molybdenum	up to 1.00, incl	0.03	over 3.00 to 5.00, incl	0.15		
		over 1.00 to 3.00, incl	0.05	over 5.00 to 7.00, incl	0.20		
		over 3.00 to 5.00, incl	0.10	Platinum	up to 0.50, incl	0.03	
over 5.00 to 20.00, incl		0.15	Oxygen		up to 0.010, incl	0.005	
over 20.00 to 30.00, incl		0.25		Nitrogen	up to 0.02, incl	0.005	
over 30.00 to 40.00, incl	0.35	over 0.02 to 0.19, incl	0.01				
Tungsten	up to 1.00, incl	0.04	over 0.19 to 0.25, incl		0.02		
	over 1.00 to 3.00, incl	0.10	over 0.25 to 0.35, incl		0.03		
	over 3.00 to 5.00, incl	0.15	over 0.35 to 0.45, incl	0.04			
	over 5.00 to 10.00, incl	0.20	over 0.45 to 0.60, incl	0.05			
over 10.00 to 20.00, incl	0.25	Magnesium	up to 0.10, incl	0.01			
Niobium <sup>A</sup> and/or Tantalum	up to 1.50, incl		0.05	Lead	up to 0.01, incl	0.002	
	over 1.50 to 3.00, incl		0.10		Tin	up to 0.01, incl	0.002
	3.00 to 5.00, incl		0.15			over 0.01 to 0.05, incl	0.005
	over 5.00 to 7.00, incl	0.20	Zinc			up to 0.01, incl	0.002
over 7.00 to 10.00, incl	0.25	over 0.01 to 0.05, incl		0.005			
over 10.00 to 13.00, incl	0.30	Titanium	up to 0.10, incl	0.02			
Titanium	up to 0.10, incl		0.02	over 0.10 to 0.50, incl	0.03		
	over 0.10 to 0.50, incl		0.03	over 0.50 to 1.00, incl	0.04		
	over 0.50 to 1.00, incl		0.04	over 1.00 to 2.00, incl	0.05		
	over 1.00 to 2.00, incl	0.05					