STEEL CASTINGS HANDBOOK

SUPPLEMENT 2

2009
SUMMARY OF STANDARD
SPECIFICATIONS FOR
STEEL CASTINGS

STEEL FOUNDERS' SOCIETY
OF AMERICA

Steel Castings Handbook
Supplement 2

Summary of Standard Specifications
For Steel Castings - 2009

PREFACE

Supplement 2 will be revised at regular intervals. Supplement 2 is only a summary that is useful in comparing the general requirements in different types of specifications. When ordering, an up-to-date original specification should be used.

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ORDERING STEEL CASTINGS

Overview

When making inquiries or ordering parts, all pertinent information must be stated on both the inquiry and order. This information should include all of the following components.

1. Casting shape – either by drawing or pattern. Drawings should include dimensional tolerances, indications of surfaces to be machined, and datum points for locating. If only a pattern is provided, then the dimensions of the casting are as predicted by the pattern.
2. Material specification and grade (e.g. ASTM A 27/A 27M – 95 Grade 60-30 Class 1).
3. Number of parts.
4. Supplementary requirements (e.g. ASTM A 781/A 781M – 95 S2 Radiographic Examination).
   A. Test methods (e.g. ASTM E 94)
   B. Acceptance criteria (e.g. ASTM E 186 severity level 2, or MSS SP-54-1995).
5. Any other information that might contribute to the production and use of the part.

To produce a part by any manufacturing process it is necessary to know the design of the part, the material to be used and the testing required. These three elements are discussed in detail in the following sections.

Design

Background

To obtain the highest quality product, the part should be designed to take advantage of the flexibility of the casting process. The foundry must have either the part drawing or pattern equipment and know the number of parts to be made. To take advantage of the casting process, the foundry should also know which surfaces are to be machined and where datum points are located. Reasonable dimensional tolerances must be indicated where a drawing is provided. Tolerances are normally decided by agreement between the foundry and customer. SFSA Supplement 3 represents a common staring point for such agreements. Supplement 3 is not a specification and care should be taken to reach agreement on what tolerances are required. Close cooperation between the customers' design engineers and the foundry's casting engineers is essential, to optimize the casting design, in terms of cost and performance. Additional guidelines for casting design are given in "Steel Castings Handbook" and Supplement 1,3, and 4 of the "Steel Castings Handbook".

Minimum Section Thickness

The rigidity of a section often governs the minimum thickness to which a section can be designed. There are cases however when a very thin section will suffice, depending upon strength and rigidity calculations, and when castability becomes the governing factor. In these cases it is necessary that a limit of minimum section thickness per length be adopted in order for the molten steel to completely fill the mold cavity.

Molten steel cools rapidly as it enters a mold. In a thin section close to the gate, which delivers the hot metal, the mold will fill readily. At a distance from the gate, the metal may be too cold to fill the same thin section. A minimum thickness of 0.25" (6 mm) is suggested for design use when conventional steel casting techniques are employed. Wall thicknesses of 0.060" (1.5 mm) and sections tapering down to 0.030" (0.76 mm) are common for investment castings.

Draft

Draft is the amount of taper or the angle, which must be allowed on all vertical faces of a pattern to permit its removal from the sand mold without tearing the mold walls. Draft should be added to the design dimensions but metal thickness must be maintained.

Regardless of the type of pattern equipment used, draft must be considered in all casting designs. Draft can be eliminated by the use of cores; however, this adds significant costs. In cases where the amount of draft may affect the subsequent use of the casting, the drawing should specify whether this draft is to be added to or subtracted from the casting dimensions as given.

The necessary amount of draft depends upon the size of the casting, the method of production, and whether molding is by hand or machine. Machine molding will require a minimum amount of draft. Interior surfaces in green sand molding usually require more draft than exterior surfaces. The amount of draft recommended under normal conditions is about 3/16 inch per foot (approximately 1.5 degrees), and this allowance would normally be added to design dimensions.

Parting Line

Parting parallel to one plane facilitates the production of the pattern as well as the production of the mold. Patterns with straight parting lines, parting lines parallel to a single plane, can be produced more easily and at lower cost than patterns with irregular parting lines.

Casting shapes that are symmetrical about one centerline or plane readily suggest the parting line. Such casting design simplifies molding and coring, and should be used wherever possible. They should always be made as "split patterns" which require a minimum of handwork in the mold, improve casting finish, and reduce costs.

Cores

A core is a separate unit from the mold and is used to create openings and cavities that cannot be made by the pattern alone. Every attempt should be made by the designer to eliminate or reduce the number of cores needed for a particular design to reduce the final cost of the casting. The minimum diameter of a core that can be successfully used in steel castings is dependent upon three factors; the thickness of the metal section surrounding the core, the length of the core, and the special precautions and procedures used by the foundry.

The adverse thermal conditions to which the core is subjected increase in severity as the metal thickness surrounding the core increases and the core diameter decreases. These increasing amounts of heat from the heavy section must be dissipated through the core. As the severity of the thermal condition increases, the cleaning of the castings and core removal becomes much more difficult and expensive.

The thickness of the metal section surrounding the core and the length of the core affect the bending stresses induced in the core by buoyancy forces and therefore the ability of the foundry to obtain the tolerances required. If the size of the core is large enough, rods can often be used to strengthen the core. Naturally, as the metal thickness and the core length increase, the amount of reinforcement required to resist the bending stresses also increases. Therefore, the minimum diameter core must also increase to accommodate the extra reinforcing required.

The cost of removing cores from casting cavities may become prohibitive when the areas to be cleaned are inaccessible. The casting design should provide for openings sufficiently large enough to permit ready access for the removal of the core.

Internal Soundness/Directional Solidification

Steel castings begin to solidify at the mold wall, forming a continuously thickening envelope as heat is dissipated through the mold-metal interface. The volumetric contraction which occurs within a cross section of a solidifying cast member must be compensated by liquid feed metal from an adjoining heavier section, or from a riser which serves as a feed metal reservoir and which is placed adjacent to, or on top of, the heavier section.

The lack of sufficient feed metal to compensate for volumetric contraction at the time of solidification is the cause of shrinkage cavities. They are found in sections which, owing to design, must be fed through thinner sections. The thinner sections solidify too quickly to permit liquid feed metal to pass from the riser to the thicker sections.

Machining

In the final analysis, the foundry's casting engineer is responsible for giving the designer a cast product that is capable of being transformed by machining to meet the specific requirements intended for the function of the part. To accomplish this goal a close relationship must be maintained between the customer's engineering and purchasing staff and the casting producer. Jointly, and with a cooperative approach, the following points must be considered.

1. The molding process, its advantages and its limitations.
2. Machining stock allowance to assure clean up on all machined surfaces.
3. Design in relation to clamping and fixturing devices to be used during machining.
4. Selection of material specification and heat treatment.
5. Quality of parts to be produced.

Layout

It is imperative that every casting design when first produced be checked to determine whether all machining requirements called for on the drawings may be attained. This may be best accomplished by having a complete layout of the sample casting to make sure that adequate stock allowance for machining exists on all surfaces requiring machining. For many designs of simple configuration that can be measured with a simple rule, a complete layout of the casting may not be necessary. In other cases, where the machining dimensions are more complicated, it may be advisable that the casting be checked more completely, calling for target points and the scribing of lines to indicate all machined surfaces.

Material

The material to be used to produce the part must be identified in the order. Material for steel castings is generally ordered to ASTM requirements, although other specifications may be used. This supplement contains a summary of the scope, chemical composition requirements and mechanical property requirements of these material or product specifications. Many requirements are common to several specifications and are given in ASTM A 781/A 781M, ASTM A 703/A 703M, ASTM A 957, ASTM A 985, and ISO 4990.

ASTM A 781/A 781M – 97	CASTINGS, STEEL AND ALLOY, COMMON REQUIREMENTS, FOR GENERAL INDUSTRIAL USE
	This specification covers a group of requirements that are mandatory requirements of the following steel casting specifications issued by American Society of Testing and Materials (ASTM). If the product specification specifies different requirements, the product specification shall prevail. ASTM Designations: A 27/A 27M, A 128/A 128M, A 148/A 148M, A 297/A 297M, A 447/A 447M, A 486/A 486M, A 494/A 494M, A 560/A 560M, A 743/A 743M, A 744/A 744M, A 747/A 747M, A 890/A 890M, A 915/A 915M, and A 958.
ASTM A 703/A 703M – 97	STEEL CASTINGS, GENERAL REQUIREMENTS, FOR PRESSURE CONTAINING PARTS
	This specification covers a group of common requirements that, unless otherwise specified in an individual specification, shall apply to steel castings for pressure-containing parts under each of the following ASTM specifications. ASTM Designations: A 216/A 216M, A 217/A 217M, A 351/A 351M, A 352/A 352M, A 389/A 389M, A 487/A 487M, A 985, A 990, and A 995.
ASTM A 957 – 96	INVESTMENT CASTINGS, STEEL AND ALLOY, COMMON REQUIREMENTS, FOR GENERAL INDUSTRIAL USE
	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 Designations: A 27/A 27M, A 148/A 148M, A 297/A 297M, A 447/A 447M, A 494/A 494M, A 560/A 560M, A 732/A 732M, A 743/A 743M, A 744/A 744M, A 747/A 747M, A 890/A 890M, and A 915/A 915M.
ASTM A 985 – 98	STEEL INVESTMENT CASTINGS GENERAL REQUIREMENTS, FOR PRESSURE-CONTAINING PARTS
	This specification covers a group of common requirements, which are mandatory for steel castings produced by the investment casting process for pressure-containing parts under each of the following ASTM specifications. ASTM Designations: A 216/A 216M, A 217/A 217M, A 351/A 351M, A 352/A 352M, A 389/A 389M, and A 487/A 487M.
ISO 4990	STEEL CASTINGS – GENERAL TECHNICAL DELIVERY REQUIREMENTS

Tests

Testing ensures that the material meets the requirements of the specification; consequently, testing is mandatory. More frequent testing or other tests may be imposed by use of supplementary requirements of product specifications or general requirement specifications. The least testing done consistent with the goals allows for the most economical product.

In addition to specifying test methods, acceptance criteria must be agreed on. The more testing and tighter the acceptance criteria, the more expensive the steel casting produced, without necessarily increasing the quality or serviceability of the steel casting. Hence, the extent of testing and acceptance criteria should be based on the design and service requirements.

The mechanical properties required are obtained from test bars cast separately from or attached to the castings to which they refer. The mechanical properties obtained represent the quality of steel, but do not necessarily represent the properties of the castings themselves. Solidification conditions and rate, if cooling during heat treatment, affect the properties of the casting, which in turn are influenced by casting thickness, size, and shape. In particular, the hardenability of some grades may restrict the maximum size at which the required mechanical properties are obtainable.

SUMMARY OF MATERIAL SPECIFICATIONS FOR CARBON AND ALLOY CAST STEELS

The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code makes extensive use of the ASTM specifications with slight modifications. For the sake of comparison, the ASME specifications use the preface SA so that SA 216 is related to ASTM A 216/A 216M. However, while ASTM A 216/A 216M could be used for the sake of comparison of grades, ASME SA 216 contained in Section II, must be used when complying with the code.

The American Iron and Steel Institute (AISI) and the Society of Automotive Engineers (SAE) developed a four number wrought alloy designation system, which is used extensively. These steels have been identified in the AISI classification by a numerical index system that is partially descriptive of the composition. The first digit indicates the type to which the steel belongs. A "1" indicates a carbon steel, a "2" indicates a nickel steel, and a digit greater than "2" indicates alloys other than nickel or alloy combinations. For low alloy steels, the second digit indicates the approximate percentage of the predominant alloy element. Usually the last two or three digits indicate the average carbon content in "points", or hundredths of a percent. Thus, "2340" indicates a nickel steel of approximately 3% nickel (3.25 to 3.75) and 0.40% carbon (0.38 to 0.43). The basic numerals for the various types of AISI steels (including plain-carbon steels) are listed in the table below. The basic numbering system adopted by the Society of Automotive Engineers is quite similar, differing only in minor details. The SAE Handbook should be consulted for comparison.

AISI Classification System

Series Designation	**Type**
10xx	Nonresulphurized carbon steel grades
11xx	Resulphurized carbon steel grades
12xx	Rephosphorized and resulphurized carbon steel grades
13xx	Manganese 1.75%
15xx	Manganese over 1.00 to 1.65%
23xx	Nickel 3.50%
25xx	Nickel 5.00%
31xx	Nickel 1.25% - Chromium 0.65%
33xx	Nickel 3.50% - Chromium 1.55%
40xx	Molybdenum 0.25%
41xx	Chromium 0.50 or 0.95% - Molybdenum 0.12 or 0.20%
43xx	Nickel 1.80% - Chromium 0.50 to 0.80% - Molybdenum 0.25%
44xx	Molybdenum 0.40 or 0.53%
46xx	Nickel 1.55 or 1.80% - Molybdenum 0.20 or 0.25%
47xx	Nickel 1.05% - Chromium 0.45% - Molybdenum 0.20%
48xx	Nickel 3.50% - Molybdenum 0.25%
50xx	Chromium 0.28 or 0.40%
51xx	Chromium 0.80, 0.90, 0.95, 1.00 or 1.05%
5xxxx	Carbon 1.00% - Chromium 0.50, 1.00 or 1.45%
61xx	Chromium 0.80 or 0.95% - Vanadium 0.10% or 0.15% min.
81xx	Nickel 0.30 – Chromium 0.40 - Molybdenum 0.12
86xx	Nickel 0.55% - Chromium 0.50 or 0.65% - Molybdenum 0.20%
87xx	Nickel 0.55% - Chromium 0.50% - Molybdenum 0.25%
88xx	Nickel 0.55% - Chromium 0.50% - Molybdenum 0.35%
92xx	Manganese 0.85% - Silicon 2.00%
93xx	Nickel 3.25% - Chromium 1.20% - Molybdenum 0.12%
B	Denotes boron steel (e.g. 51B60)
BV	Denotes boron-vanadium steel (e.g. TS 43BV12 or TS 43BV14)
L	Denotes leaded steel (e.g. 10L18)

Needless to say, this list representing as it does, a standardization and simplification of thousands of alloy-steel compositions, is a very valuable aid to the specification and choice of alloy steels for various applications. Many of these steels were developed for specific applications, and their continual satisfactory performance has resulted

in a considerable degree of standardization of application among these compositions. These designations can be ordered in castings through the use of ASTM A 148/A 148M, A 915/A 915M, or A 958 but care must be used to select a grade with compatible mechanical properties. Also the wrought composition must be modified, especially the silicon and manganese content to allow for casting.

Below is a list of carbon and alloy cast steel specifications, with summary details on the following pages. Note that the values given in the summary of the specifications are stated with either U.S. Conventional Units (USCS) or Metric (SI) units, and are to be regarded separately. Units given in brackets are SI units. The values stated in each system are not exact equivalents (soft conversion); therefore, each system must be used independently of the other. Combining values from the two systems, by using conversion equations (hard conversion), may result in nonconformance with the specification. Also note that the values in the table are given in a minimum over maximum format. This means that if the value is a minimum it will be listed in the upper portion of the specification's table row and in the lower portion of the row if it is a maximum value. Finally, note that tables and their footnotes may be split across two or more pages.

AAR M-201-92	Steel Castings
ABS 2/1.5	Hull Steel Castings
ABS 2/3.9	Steel Castings for Machinery, Boilers, and Pressure Vessels
ASTM A 27/A 27M – 08	Steel Castings, Carbon, for General Application
ASTM A 148/A 148M – 08	Steel Castings, High Strength, for Structural Purposes
ASTM A 216/A 216M – 07	Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A 217/A 217M – 07	Steel Castings, Martensitic Stainless and Alloy, for Pressure-containing Parts, Suitable for High-Temperature Service
ASTM A 352/A 352M – 06	Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service
ASTM A 356/A 356M – 07	Steel Castings, Carbon, Low Alloy and Stainless Steel, Heavy Walled for Steam Turbines
ASTM A 389/A 389M – 08	Steel Castings, Alloy, Specially Heat-treated, for Pressure-Containing Parts, Suitable for High-Temperature Service
ASTM A 487/A 487M – 07	Steel Castings, Suitable for Pressure Service
ASTM A 597 – 04	Cast Tool Steel
ASTM A 732/A 732M – 05	Castings, Investment, Carbon and Low Alloy, for General Application, and Cobalt Alloy for High Strength at Elevated Temperatures
ASTM A 757/A 757M – 04	Steel Castings, Ferritic and Martenistic for Pressure-Containing and Other Applications, for Low-Temperature Service
ASTM A 915/A 915M – 08	Steel Castings, Carbon, and Alloy, Chemical Requirements Similar to Standard Wrought Grades
ASTM A 958 – 06	Steel Castings, Carbon, and Alloy, with Tensile Requirements, Chemical Requirements Similar to Standard Wrought Grades
FEDERAL QQ-S-681F	Steel Castings
ISO 3755	Cast carbon steels for general engineering
ISO 4991	Steel castings for pressure purposes
ISO 9477	High strength cast steels for general engineering and structural purposes
ISO DIS 13521	Austenitic manganese steel castings
ISO WD 14737(c)	Cast carbon and low alloy steels for general use
MIL-C-24707/1	Castings, Ferrous, for Machinery and Structural Applications
MIL-C-24707/2	Castings, for Pressure Containing Parts Suitable for High Temperature Service
MIL-S-870B	Steel Castings, Molybdenum Alloy
MIL-S-15083B(NAVY)	Steel Castings
MIL-S-15464B(SHIPS)	Steel Alloy, Chromium-Molybdenum; Castings
MIL-S-23008D(SH)	Steel Castings, Alloy, High Yield Strength (HY-80 and HY-100)
MIL-S-46052A(MR)	Steel Castings, High Strength, Low Alloy
SAE J435c	Automotive Steel Castings

AAR M-201-92 STEEL CASTINGS

These specifications cover carbon and alloy steel castings for locomotive and car equipment and for miscellaneous use graded as A, B, C, D, and E. AAR Specification M-201 provides for all castings unless another AAR Specification for a particular product provides for a variation.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)								
Grade and UNS	Heat Treatment	Tensile Strength		Yield Strength		Elong %	Red A %	Other Tests[ABC] Hardness (BHN)	C	Mn	P	S	Si	Ni	Cr	Mo	Other
		ksi	MPa	Ksi	MPa												
A	Unannealed	60		30		22	30	108 160	0.32[D]	0.90[D]	0.04	0.04	1.50				
A	A or N	60		30		26	38	108 106	0.32[D]	0.90[D]	0.04	0.04	1.50				
B	N or NT	70		38		24	36	137 208	0.32[D]	0.90[D]	0.04	0.04	1.50				
C	NT or QT	90		60		22	45	179 241	0.32	1.85	0.04	0.04	1.50				
D	QT	105		85		17	35	211 285	0.32	1.85	0.04	0.04	1.50				
E	QT	120		100		14	30	241 311	0.32	1.85	0.04	0.04	1.50				

[A] Grades D and E steel - composition of the steel, except for coupler locks, shall produce in the standard Jominy test the minimum hardness at 7/16" from the quenched end for the carbon composition as follows, based on the initial composition: up to 0.25% carbon = 30 HRC minimum, 0.25-0.30% carbon = 33 HRC minimum, and 0.31-0.32% carbon = 35 HRC minimum

[B] Impact test - the steel shall possess properties determined by testing standard Charpy V-notch Type "A" specimens prepared as illustrated in Figure 11 in ASTM Designation A 370: grade B 15 ft-lbs @ 20 F, grade C (NT) 15 ft-lbs @ 0 F, grade C (QT) 20 ft-lbs @ -40 F, grade D 20 ft-lbs @ -40 F, and grade E 20 ft-lbs @ -40 F

[C] Dynamic tear and nil ductility test temperature (alternate impact property test): grade B 60 F, grade C (NT) 60 F, grade C (QT) -60 F, grade D -60 F, and grade E -60 F (see original specification for full details)

[D] Grades A and B steel – for each reduction of 0.01% carbon below the maximum specified, an increase of 0.04% manganese above the maximum specified will be permitted to a maximum of 1.2%

ABS 2/1.5 HULL STEEL CASTINGS

Requirements cover carbon-steel castings intended to be used in hull construction and equipment as distinguished from high-temperature applications.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)									
Grade and UNS	Heat Treatment	Tensile Strength		Yield Strength		Elong %	Red A %	Other Tests	C[B]	Mn	P	S	Si	SPECIFIED RESIDUAL ELEMENTS [A,D] (maximum percent)				
		ksi	MPa	Ksi	MPa									Ni	Cr	Mo	Cu	Al
Ordinary	A, N, or NT		415		205	25	40		0.23	0.70 1.60	0.040	0.040	0.60	0.40	0.30	0.15	0.30	
Special	A, N, or NT		415		205	25	40	Charpy 27J (20 ft.lbs)0°C(32°F)	0.23	0.70 1.60	0.035	0.035	0.60					0.020 0.10[C]

[A] Grain refining elements such as aluminum may be used at the discretion of the manufacturer. The content of such elements is to be reported.

[B] For non-welded castings, the maximum carbon content is to be 0.40%.

[C] Aluminum (acid soluable) = 0.015-0.080%

[D] Residual elements - .80% maximum

ABS 2/3.9 Requirements cover carbon-steel castings intended to be used in machinery, boiler and pressure-vessel construction, such as crankshafts, turbine casings and bedplates.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)								CHEMICAL COMPOSITION, % (maximum percent unless range given)									
Grade ASTM	Heat Treatment	Tensile Strength		Yield Strength		Elong Min %		Red A %	Other Tests	C	Mn	P	S	Si	SPECIFIED RESIDUAL ELEMENTS (maximum percent)				
		ksi	MPa	Ksi	MPa	Gauge Length 4d	Gauge Length 5d								Ni	Cr	Mo	Cu	Al
1 A27, Grade 60-30	A, N, or NT		415		205	24	22	35											
2 A27, Grade 70-36	A, N, or NT		485		250	22	20	30											
3 A216, Grade WCA	A, N, or NT		415		205	24	22	35											
4 A216, Grade WCB	A, N, or NT		485		250	22	20	35											

ASTM A 27/A 27M – 08 STEEL CASTINGS, CARBON, FOR GENERAL APPLICATION

This specification covers carbon steel castings for general applications that require up to 70 ksi (485 Mpa) minimum tensile - strength.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)						CHEMICAL COMPOSITION, % (maximum percent unless range given)										
Grade[A] and UNS	Heat Treatment	Tensile Strength		Yield Strength		Elong %[C]	Red A %	C[B]	Mn[B]	P	S	Si	SPECIFIED RESIDUAL ELEMENTS (maximum percent)				
		ksi	MPa	ksi	MPa								Ni	Cr	Mo	Cu	Total max %[E]
N-1								0.25	0.75	0.05	0.06	0.80	0.50	0.50	0.25	0.50	1.00
N-2(J03500)	A, N, NT, or QT							0.35	0.60	0.05	0.06	0.80	0.50	0.50	0.25	0.50	1.00
U-60-30 [415-205] (J02500)		60	415	30	205	22	30	0.25	0.75	0.05	0.06	0.80	0.50	0.50	0.25	0.50	1.00
60-30 [415-205] (J03000)	A, N, NT, or QT	60	415	30	205	24	35	0.30	0.60	0.05	0.06	0.80	0.50	0.50	0.25	0.50	1.00
65-35 [450-240] (J03001)	A, N, NT, or QT	65	450	35	240	24	35	0.30	0.70	0.05	0.06	0.80	0.50	0.50	0.25	0.50	1.00
70-36 [485-250] (J03501)	A, N, NT, or QT	70	485	36	250	22	30	0.35	0.70	0.05	0.06	0.80	0.50	0.50	0.25	0.50	1.00
70-40 [485-275] (J02501)[D]	A, N, NT, or QT	70	485	40	275	22	30	0.25	1.20	0.05	0.06	0.80	0.50	0.50	0.25	0.50	1.00

[A] Specify Class 1 or Class 2 `in addition to grade designation (see 9.2)
[B] For each reduction of 0.01% carbon below the maximum specified, an increase of 0.04% manganese above the maximum specified will be permitted to a maximum of 1.40% for grades 70-40 [485-275] and 1.00% for the other grades
[C] When ICI test bars are used in tensile testing as provided for in this specification, the gage length to reduced section diameter ratio shall be 4-1.
[D] Grade 70-40 [485-275] may be used to meet the requirement of Grade 70-36 [485-250] , when agreed upon between the manufacturer and the purchaser.
[E] Total content of residual elements. Supplementary requirement, not required unless stipulated by customer.

This specification covers carbon steel and alloy steel castings that are to be subjected to higher mechanical stresses than those covered in Specification A 27/A 27M.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)	
Grade and UNS	Heat Treatment	Tensile Strength		Yield Strength		Elong %[A]	Red A %	Other Tests A Impact	P	S
		ksi	MPa	ksi	MPa					
80-40 [550-275] (D50400)	A, N, NT, or QT	80	550	40	275	18	30		0.05	0.06
80-50 [550-345] (D50500)	A, N, NT, or QT	80	550	50	345	22	35		0.05	0.06
90-60 [620-415] (D50600)	A, N, NT, or QT	90	620	60	415	20	40		0.05	0.06
105-85 [725-585] (D50850)	A, N, NT, or QT	105	725	85	585	17	35		0.05	0.06
115-95 [795-655] (D50950)	A, N, NT, or QT	115	795	95	655	14	30		0.05	0.06
130-115 [895-795] (D51150)	A, N, NT, or QT	130	895	115	795	11	25		0.05	0.06
135-125 [930-860] (D51250)	A, N, NT, or QT	135	930	125	860	9	22		0.05	0.06
150-135 [1035-930] (D51350)	A, N, NT, or QT	150	1035	135	930	7	18		0.05	0.06
160-145 [1105-1000] (D51450)	A, N, NT, or QT	160	1105	145	1000	6	12		0.05	0.06
165-150 [1140-1035] (D51500)	A, N, NT, or QT	165	1140	150	1035	5	20		0.020	0.020
165-150L [1140-1035L] (D51501)	A, N, NT, or QT	165	1140	150	1035	5	20	20 ft-lb [27 J]	0.020	0.020
210-180 [1450-1240] (D51800)	A, N, NT, or QT	210	1450	180	1240	4	15		0.020	0.020
210-180L [1450-1240L] [B] (D51801)	A, N, NT, or QT	210	1450	180	1240	4	15	15 ft-lb [20 J]	0.020	0.020
260-210 [1795-1450] [B] (D52100)	A, N, NT, or QT	260	1795	210	1450	3	6		0.020	0.020
260-210L [1795-1450L] [B] (D52101)	A, N, NT, or QT	260	1795	210	1450	3	6	6 ft-lb [8 J]	0.020	0.020

[A] When ICI test bars are used in tensile testing as provided for in this specification, the gage length to reduced section diameter ratio shall be 4-1.
[B] These grades must be charpy tested as prescribed in Section 9, and with minimum values as shown in Table 3.

ASTM A 216/A 216M – 07 STEEL CASTINGS, CARBON, SUITABLE FOR FUSION WELDING, FOR HIGH TEMPERATURE SERVICE

This specification covers carbon steel castings for valves, flanges, fittings, or other pressure-containing parts for high-temperature service and of quality suitable for assembly with other castings or wrought-steel parts by fusion welding.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)						CHEMICAL COMPOSITION, % (maximum percent unless range given)											
Grade and UNS	Heat Treatment[A]	Tensile Strength		Yield Strength		Elong %	Red A %	C	Mn	P	S	Si	SPECIFIED RESIDUAL ELEMENTS (maximum percent)[E]					
		ksi	MPa	Ksi[F]	Mpa[G]								Ni	Cr	Mo	Cu	V	Total Content max %
WCA J02502	A, N, NT	60 85	415 585	30	205	24	35	0.25[B]	0.70[B]	0.04	0.045	0.60	0.50	0.50	0.20	0.30	0.03	1.00
WCB J03002	A, N, NT	70 95	485 655	36	250	22	35	0.30[C]	1.00[C]	0.04	0.045	0.60	0.50	0.50	0.20	0.30	0.03	1.00
WCC J02503	A, N, NT	70 95	485 655	40	275	22	35	0.25[D]	1.20[D]	0.04	0.045	0.60	0.50	0.50	0.20	0.30	0.03	1.00

[A] Quench and temper may only be applied if supplemental requirement S15 is specified
[B] For each reduction of 0.01% below the specified maximum carbon content, an increase of 0.04% manganese above the specified maximum will be permitted up to a maximum of 1.10%
[C] For each reduction of 0.01% below the specified maximum carbon content, an increase of 0.04% manganese above the specified maximum will be permitted up to a maximum of 1.28%
[D] For each reduction of 0.01% below the specified maximum carbon content, an increase of 0.04% manganese above the specified maximum will be permitted up to a maximum of 1.40%
[E] Not applicable when Supplementary Requirement S11 is specified
[F] Determine by either 0.2% offset method or 0.55 extension-under-load method.
[G] When ICI test bars are used in tensile testing as provided for in Specification A 703/A 703M, the gage length to reduced section diameter ratio shall be 4-1.

ASTM A 217/A 217M – 07 STEEL CASTINGS, MARTENSITIC STAINLESS AND ALLOY, FOR PRESSURE-CONTAINING PARTS, SUITABLE FOR HIGH-TEMPERATURE SERVICE

This specification covers martensitic stainless steel and alloy steel castings for values, flanges, fittings, and other pressure-containing parts intended primarily for high-temperature and corrosive service.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)						CHEMICAL COMPOSITION, % (maximum percent unless range given)																				
Grade and UNS	Heat Treatment	Tensile Strength		Yield Strength[A]		Elong	Red A	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	N	V	SPECIFIED RESIDUAL ELEMENTS (maximum percent)									
		ksi	MPa	ksi	MPa	%[B]	%												Al	Cu	Ni	Cr	Ti	W	V	Zr	Total Content max.
WC1 J12524	NT	65 90	450 620	35	240	24	35	0.25	0.50 0.80	0.04	0.045	0.60			0.45 0.65					0.50	0.50	0.35		0.10			1.00
WC4 J12082	NT	70 95	485 655	40	275	20	35	0.05 0.20	0.50 0.80	0.04	0.045	0.60	0.70 1.10	0.50 0.80	0.45 0.65					0.50				0.10			0.60
WC5 J22000	NT	70 95	485 655	40	275	20	35	0.05 0.20	0.40 0.70	0.04	0.045	0.60	0.60 1.00	0.50 0.90	0.90 1.20					0.50				0.10			0.60
WC6 J12072	NT	70 95	485 655	40	275	20	35	0.05 0.20	0.50 0.80	0.04	0.045	0.60		1.00 1.50	0.45 0.65					0.50	0.50			0.10			1.00
WC9 J21890	NT	70 95	485 655	40	275	20	35	0.05 0.18	0.40 0.70	0.04	0.045	0.60		2.00 2.75	0.90 1.20					0.50	0.50			0.10			1.00

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)						CHEMICAL COMPOSITION, % (maximum percent unless range given)																					
Grade and UNS	Heat Treatment	Tensile Strength		Yield Strength [A]		Elong	Red A												SPECIFIED RESIDUAL ELEMENTS (maximum percent)									
		ksi	MPa	ksi	MPa	% [B]	%	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	N	V	Al	Cu	Ni	Cr	Ti	W	V	Zr	Total Content max.
WC11 J11872	NT	80 105	550 725	50	345	18	45	0.15 0.21	0.50 0.80	0.020	0.015	0.30 0.60		1.00 1.50	0.45 0.65				0.01	0.35	0.50				0.03		1.00
C5 J42045	NT	90 115	620 795	60	415	18	35	0.20	0.40 0.70	0.04	0.045	0.75		4.00 6.50	0.45 0.65					0.50	0.50			0.10			1.00
C12 J82090	NT	90 115	620 795	60	415	18	35	0.20	0.35 0.65	0.04	0.045	1.00		8.00 10.00	0.90 1.20					0.50	0.50			0.10			1.00
C12A J84090	NT	85 110	585 760	60	415	18	45	0.08 0.12	0.30 0.60	0.030	0.010	0.20 0.50	0.40	8.0 9.5	0.85 1.05	0.060 0.10	0.030 0.070	0.18 0.25	0.02				0.01			0.01	
CA15 J91156	NT	90 115	620 795	65	450	18	30	0.15	1.00	0.040	0.040	1.50	1.00	11.5 14.0	0.50												

[A] Determine by either 0.2% offset method or 0.5% extension-under-load method.
[B] When ICI test bars are used in tensile testing as provided for in Specification A 703/A 703M, the gage length to reduced section diameter ratio shall be 4-1.

ASTM A 352/A 352M – 06 STEEL CASTINGS, FERRITIC AND MARTENSITIC, FOR PRESSURE-CONTAINING PARTS, SUITABLE FOR LOW-TEMPERATURE SERVICE

This specification covers steel castings for valves, flanges, fittings, and other pressure-containing parts intended primarily for low-temperature service.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)								CHEMICAL COMPOSITION, % (maximum percent unless range given)																	
Grade	Heat Treatment	Tensile Strength [C]		Yield Strength [D]		Elong [E]	Red. Area	Impact Tests [C,F]														SPECIFIED RESIDUAL ELEMENTS (maximum percent) [B]					
and UNS		ksi	MPa	ksi	MPa	%	%	Average [A]	Single	C	Si	Mn	P	S	Ni	Cr	Mo	Cu	V	Ni	Cr	Mo	Cu	V	Total Content Max
LCA J02504	NT or QT	60 85	415 585	30	205	24	35	13(-25) [18(-32)]	10[14]	0.25 [A]	0.60	0.70 [A]	0.04	0.045			0.20	0.30		0.50	0.50			0.03	1.00
LCB [A] J03003	NT or QT	65 90	450 620	35	240	24	35	13(-50) [18(-46)]	10[14]	0.30	0.60	1.00	0.04	0.045						0.50	0.50	0.20	0.30	0.03	1.00
LCC J02505	NT or QT	70 95	485 655	40	275	22	35	15(-50) [20(-46)]	10[16]	0.25 [A]	0.60	1.20 [A]	0.04	0.045						0.50	0.50	0.20	0.30	0.03	1.00
LC1 J12522	NT or QT	65 90	450 620	35	240	24	35	13(-75) [18(-59)]	10[14]	0.25	0.60	0.50 0.80	0.04	0.045			0.45 0.65								
LC2 J22500	NT or QT	70 95	485 655	40	275	24	35	15(-100) [20(-73)]	12[16]	0.25	0.60	0.50 0.80	0.04	0.045	2.00 3.00										
LC2-1 J42215	NT or QT	105 130	725 895	80	550	18	30	30(-100) [41(-73)]	25[34]	0.22	0.50	0.55 0.75	0.04	0.045	2.50 3.50	1.35 1.85	0.30 0.60								
LC3 J31550	NT or QT	70 95	485 655	40	275	24	35	15(-150) [20(-101)]	12[16]	0.15	0.60	0.50 0.80	0.04	0.045	3.00 4.00										
LC4 J41500	NT or QT	70 95	485 655	40	275	24	35	15(-175) [20(-115)]	12[16]	0.15	0.60	0.50 0.80	0.04	0.045	4.00 5.00										
LC9 J31300	QT	85	585	75	515	20	30	20(-320) [27(-196)]	15[20]	0.13	0.45	0.90	0.04	0.045	8.50 10.0	0.50	0.20	0.30	0.03						
CA6NM J91540	NT	110 135	760 930	80	550	15	35	20(-100) [27(-73)]	15[20]	0.06	1.00	1.00	0.04	0.03	3.5 4.5	11.5 14.0	0.4 1.0								

[A] For each reduction of 0.01% carbon below the maximum specified, an increase of 0.04% manganese above the maximum specified will be permitted up to a maximum of 1.10% for LCA), 1.28%doe LCB), and 1.40% for LCC).
[B] Specified Residual Elements-The total content of these elements is 1.00% maximum.
[C] See 1.2
[D] Determine by either 0.2% offset method or 0.5% extension-under-load method.
[E] When ICI test bars are used in tensile testing as provided for in Specification A 703/A 703M, the gage length to reduced section diameter ratio shall be 4-1.
[F] See Appendix X1

ASTM A 356/A 356M – 07 STEEL CASTINGS, CARBON, LOW ALLOY AND STAINLESS STEEL, HEAVY WALLED FOR STEAM TURBINES

This specification covers one grade of martensitic stainless steel and several grades of ferritic steel castings for cylinders (shells), value chests, throttle valves, and other heavy-walled castings for steam turbine applications.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)						CHEMICAL COMPOSITION, % [A] (maximum percent unless range given)														
Grade and UNS	Heat Treatment	Tensile Strength		Yield Strength		Elong %	Red A %	C	Mn	Si	P	S	Mo	Cr	Ni	V	Cb	N	Al	Ti	Zr
		Ksi	MPa	Ksi	MPa																
1 J03502	NT	70	485	36	250	20	35	0.35 [B]	0.70 [B]	0.60	0.035	0.030	.....	.....	.....	.....	.....	.....	.....	.....	.....
2 J12523	NT	65	450	35	240	22	35	0.25 [B]	0.70 [B]	0.60	0.035	0.030	0.45 0.65	.....	.....	.....	.....	.....	.....	.....	.....
5 J12540	NT	70	485	40	275	22	35	0.25 [B]	0.70 [B]	0.60	0.035	0.030	0.40 0.60	0.40 0.70	.....	.....	.....	.....	.....	.....	.....
6 J12073	NT	70	485	45	310	22	35	0.20	0.50 0.80	0.60	0.035	0.030	0.45 0.65	1.00 1.50	.....	.....	.....	.....	.....	.....	.....
8 J12073	NT	80	550	50	345	18	45	0.20	0.50 0.90	0.20 0.60	0.035	0.030	0.90 1.20	1.00 1.50	.....	0.05 0.15	.....	.....	.....	.....	.....
9 J21610	NT	85	585	60	415	15	45	0.20	0.50 0.90	0.20 0.60	0.035	0.030	0.90 1.20	1.00 1.50	.....	0.20 0.35	.....	.....	.....	.....	.....
10 J22090	NT	85	585	55	380	20	35	0.20	0.50 0.80	0.60	0.035	0.030	0.90 1.20	2.00 2.75	.....	.....	.....	.....	.....	.....	.....
12A [C] J80490	NT	85	585	60	415	20	.....	0.08 0.12	0.30 0.60	0.20 0.50	0.30	0.010	0.85 1.05	8.0 9.5	0.40	0.18 0.25	0.060 0.10	0.030 0.070	0.02	0.01	0.01
CA6NM J91540	NT	110	760	80	550	15	35	0.06	1.00	1.00	0.040	0.030	0.4 1.0	11.5 14.0	3.5 4.5	.....	.....	.....	.....	.....	.....

[A] Where ellipses appear in this table, there is no requirement.
[B] For each 0.01% reduction in carbon below the maximum specified, an increase of 0.04% points of manganese over the maximum specified for that element may be permitted up to 1.00%
[C] The designation of Grade 12, formerly covered by this specification has been changed to Grade 12A.

ASTM A 389/A 389M – 08 STEEL CASTINGS, ALLOY, SPECIALLY HEAT-TREATED, FOR PRESSURE-CONTAINING PARTS, SUITABLE FOR HIGH-TEMPERATURE SERVICE

This specification covers alloy steel castings, which have been subjected to special heat treatment, for valves, flanges, fittings, and other pressure-containing parts intended primarily for high-temperature service.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)						CHEMICAL COMPOSITION, % (maximum percent unless range given)							
Grade and UNS	Heat Treatment	Tensile Strength ksi	Tensile Strength MPa	Yield Strength A Ksi	Yield Strength A MPa	Elong % [B]	Red A %	C	Mn	P	S	Si	Cr	Mo	V
C23 J12080	NT	70	483	40	276	18	35	0.20	0.30 0.80	0.04	0.045	0.60	1.00 1.50	0.45 0.65	0.15 0.25
C24 J12092	NT	80	552	50	345	15	35	0.20	0.30 0.80	0.04	0.045	0.60	0.80 1.25	0.90 1.20	0.15 0.25

[A] Determine by either 0.2% offset method or 0.5% extension-under-load method.
[B] When ICI test bars are used in tensile testing as provided for in Specification A 703/A 703M, the gage length to reduced section diameter ratio shall be 4-1.

ASTM A 487/A 487M – 07 STEEL CASTINGS, SUITABLE FOR PRESSURE SERVICE

This specification covers low-alloy steels, and martenistic stainless steels in the normalized and tempered, or quenched and tempered condition suitable for pressure-containing parts. The weldability of the classes in the specification varies from readily weldable to weldable only with adequate precautions, and the weldability of each class should be considered prior to assembly by fusion welding.

GRADE		MECHANICAL PROPERTIES (min. unless range given)								CHEMICAL COMPOSITION, % (max. percent unless range given)																				
		Tensile Strength [H]		Yield Strength																			SPECIFIED RESIDUAL ELEMENTS (maximum percent)								
Grade	Class	Ksi	Mpa	ksi	Mpa	Elong %	Red Area %	Hardness (max) HRC (BHN)	Thickness (max) in [mm]	C	Mn	P	S	Si	Ni	Cr	Mo	V	B	Cu	Cu	Ni	Cr	Mo	Mo+W	W	V	Total Content
1 J13002	A B C	85 110 90 115 90	585 760 620 795 620	55 65 65	380 450 450	22 22 22	40 45 45	 22 (235)		0.30	1.00	0.04	0.045	0.80				0.04 0.12			0.50	0.50	0.35		0.25			1.00
2 J13005	A B C	85 110 90 115 90	585 760 620 795 620	53 65 65	365 450 450	22 22 22	35 40 40	 22 (235)		0.30	1.00 1.40	0.04	0.045	0.80			0.10 0.30				0.50	0.50	0.35			0.10	0.03	1.00
4 J13047	A B C D E	90 115 105 130 90 100 115	620 795 725 895 620 690 795	60 85 60 75 95	415 585 415 515 655	18 17 18 17 15	40 35 35 35 35	 22 (235) 22 (235) 		0.30	1.00	0.04	0.045	0.80	0.40 0.80	0.40 0.80	0.15 0.30				0.50					0.10	0.03	0.60
6 J13855	A B	115 120	795 825	80 95	550 655	18 12	30 25			0.05 0.38	1.30 1.70	0.04	0.045	0.80	0.40 0.80	0.40 0.80	0.30 0.40				0.50					0.10	0.03	0.60
7 [J] J12084	A	115	795	100	690	15	30		2.5 [63.5]	0.05 0.20	0.60 1.00	0.04	0.045	0.80	0.70 1.00	0.40 0.80	0.40 0.60	0.03 0.10	0.002 0.006	0.15 0.50	0.50						0.10		0.60

GRADE		MECHANICAL PROPERTIES (min. unless range given)								CHEMICAL COMPOSITION, % (max. percent unless range given)																				
		Tensile Strength[H]		Yield Strength																			SPECIFIED RESIDUAL ELEMENTS (maximum percent)							
Grade	Class	Ksi	Mpa	ksi	Mpa	Elong %	Red Area %	Hardness (max) HRC (BHN)	Thickness (max) in [mm]	C	Mn	P	S	Si	Ni	Cr	Mo	V	B	Cu	Cu	Ni	Cr	Mo	Mo+W	W	V	Total Content
8	A	85	585	55	380	20	35			0.05	0.50					2.00	0.90											
J22091		110	760	85						0.20	0.90	0.04	0.045	0.80		2.75	1.10				0.50					0.10	0.03	0.60
	B	105	725		585	17	30																					
				75																								
	C	100	690		515	17	35	22 (235)																				
9	A	90	620	60	415	18	35			0.05	0.60					0.75	0.15											
J13345										0.33	1.00	0.04	0.045	0.80		1.10	0.30				0.50	0.50				0.10	0.03	1.00
	B	105	725	85	585	16	35																					
	C	90	620	60	415	18	35	22 (235)																				
	D	100	690	75	515	17	35	22 (235)																				
	E	115	795	95	655	15	35																					
10	A	100	690	70	485	18	35				0.60				1.40	0.55	0.20											
J23015										0.30	1.00	0.04	0.045	0.80	2.00	0.90	0.40				0.50					0.10	0.03	0.60
	B	125	860	100	690	15	35																					
11	A	70	484	40	275	20	35			0.05	0.50				0.70	0.50	0.45											
J12082		95	655							0.20	0.80	0.04	0.045	0.60	1.10	0.80	0.65				0.50					0.10	0.03	0.50
	B	105	725	85	585	17	35																					
		130	895																									
12	A	70	485	40	275	20	35			0.05	0.40				0.60	0.50	0.90											
J22000		95	655							0.20	0.70	0.04	0.045	0.60	1.00	0.90	1.20				0.50					0.10	0.03	0.50
	B	105	725	85	585	17	35																					
		130	895																									
13	A	90	620	60	415	18	35				0.80				1.40		0.20											
J13080		115	795							0.30	1.10	0.04	0.045	0.60	1.75		0.30				0.50		0.40			0.10	0.03	0.75
	B	105	725	85	585	17	35																					
		130	895																									
14	A	120	825	95	655	14	30				0.80				1.40		0.20											
J15580		145	1000							0.55	1.10	0.04	0.045	0.60	1.75		0.30				0.50		0.40			0.10	0.03	0.75
16	A	70	485	40	275	22	35								1.00													
J31200		95	655							0.12[K]	2.10[K]	0.02	0.02	0.50	1.40						0.20		0.20	0.10		0.10	0.02	0.50
CA15	A	140	965	110	760	10	25									11.5												
J91171		170	1170	130	895					0.15	1.00	0.040	0.040	1.50	1.00	14.0	0.50				0.50					0.10	0.05	0.50
	B	90	620	65	450	18	30																					
		115	795																									
	C	90	620	60	415	18	35	22 (235)																				
	D	100	690	75	515	17	35	22 (235)																				
CA15M	A	90	620	65	450	18	30									11.5	0.15											
J91151		115	795							0.15	1.00	0.040	0.040	0.65	1.0	14.0	1.0				0.50					0.10	0.05	0.50
CA6NM	A	110	760	80	550	15	35								3.5	11.5	0.4											
J91540		135	930							0.06	1.00	0.04	0.03	1.00	4.5	14.0	1.0				0.50					0.10	0.05	0.50
	B	100	690	75	515	17	35	23 (255)[I]																				

[A] A = air, L = liquid
[B] Minimum temperature unless range is specified
[C] Double austenitize
[D] Double temper with the final temper at a lower temperature than the intermediate temper
[E] Air cool to below 200F [95C] after first temper
[F] Intermediate
[G] Final
[H] Minimum ksi, unless range is given
[I] Test methods and definitions A 370, Table 3a does not apply to CA6NM – the conversion given is based on CA6NM test coupons (for example, see ASTM STP 756)
[J] Proprietary steel composition
[K] For each reduction of 0.01% below the specified maximum carbon content, an increase of 0.40% manganese above the specified maximum will be permitted up to a maximum of 2.30%

ASTM A 597 – 99 CAST TOOL STEEL

This specification covers tool steel compositions for usable shapes cast by pouring directly into suitable molds and for master heats for remelting and casting.

GRADE	CHEMICAL COMPOSITION, % (maximum percent unless range given)										
Grade and UNS	C	Mn	P	S	Si	Ni	Cr	Mo	V	Co	W
CA-2	0.95						4.75	0.90	0.20		
T90102	1.05	0.75	0.03	0.03	1.50		5.50	1.40	0.50[A]		
CD-2	1.40						11.00	0.70	0.04	0.70	
T90402	1.60	1.00	0.03	0.03	1.50		13.00	1.20	1.00[A]	1.00[A]	
CD-5	1.35					0.40	11.00	0.70	0.35	2.50	
T90405	1.60	0.75	0.03	0.03	1.50	0.60[A]	13.00	1.20	0.55	3.50	
CS-5	0.50	0.60			1.75			0.20			
T91905	0.65	1.00	0.03	0.03	2.25		0.35	0.80	0.35		
CM-2	0.78						3.75	4.50	1.25		5.50
T11302	0.88	0.75	0.03	0.03	1.00	0.25	4.50	5.50	2.20	.25	6.75
CS-7	0.45	0.40			0.60		3.00	1.20			
T41907	0.55	0.80	0.03	0.03	1.00		3.50	1.60			
CH-12	0.30						4.75	1.25	0.20		1.00
T90812	0.40	0.75	0.03	0.03	1.50		5.75	1.75	0.50		1.70
CH-13	0.30						4.75	1.25	0.75		
T90813	0.42	0.75	0.03	0.03	1.50		5.75	1.75	1.20		
CO-1	0.85	1.00					0.40				0.40
T91501	1.00	3.00	0.03	0.03	1.50		1.00		0.30		0.60

[A] Optional element – tool steels have found satisfactory application, either with or without the element present; if desired they should be specified with order

ASTM A 732/A 732M – 05 CASTINGS, INVESTMENT, CARBON AND LOW ALLOY, FOR GENERAL APPLICATION, AND COBALT ALLOY FOR HIGH STRENGTH AT ELEVATED TEMPERATURES

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

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)														
Grade and UNS	Heat Treatment	Tensile Strength		Yield Strength		Elong %	Red A %	Other Tests Stress Rupture[B]	C	Mn	P	S	Si	Ni	Cr	Mo	V	Co	W	Fe	B	SPECIFIED RESIDUAL ELEMENTS (maximum percent)					
		ksi	MPa	Ksi	MPa																	Cu	Ni	Cr	Mo+W	W	Total Content
1A J02002	A[C]	60	414	40	276	24			0.15 0.25	0.20 0.60	0.04	0.045	0.20 1.00									0.50	0.50	0.35	0.25		1.00
2A J03011	A	65	448	45	310	25			0.25 0.35	0.70 1.00	0.04	0.045	0.20 1.00									0.50	0.50	0.35		0.10	1.00
2Q J03011	QT[D]	85	586	60	414	10			0.25 0.35	0.70 1.00	0.04	0.045	0.20 1.00									0.50	0.50	0.35		0.10	1.00
3A J04002	A	75	517	48	331	25			0.35 0.45	0.70 1.00	0.04	0.045	0.20 1.00									0.50	0.50	0.35		0.10	1.00

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)														SPECIFIED RESIDUAL ELEMENTS (maximum percent)					
Grade and UNS	Heat Treatment	Tensile Strength		Yield Strength		Elong %	Red A %	Other Tests Stress Rupture[B]	C	Mn	P	S	Si	Ni	Cr	Mo	V	Co	W	Fe	B	Cu	Ni	Cr	Mo+ W	W	Total Content
		ksi	MPa	Ksi	MPa																							
3Q J04002	QT	100	689	90	621	10			0.35 0.45	0.70 1.00	0.04	0.045	0.20 1.00									0.50	0.50	0.35		0.10	1.00
4A	A	90	621	50	345	20			0.45 0.55	0.70 1.00	0.04	0.045	0.20 1.00									0.50				0.10	0.60
4Q	QT	125	862	100	689	5			0.45 0.55	0.70 1.00	0.04	0.045	0.20 1.00									0.50				0.10	0.60
5N J13052	NT[E]	85	586	55	379	22			0.30	0.70 1.00	0.04	0.045	0.20 0.80				0.05 0.15					0.50	0.50	0.35	0.25		1.00
6N J13512	NT	90	621	60	414	20			0.35	1.35 1.75	0.04	0.045	0.20 0.80			0.25 0.55						0.50	0.50	0.35		0.25	1.00
7Q J13045	QT	150	1030	115	793	7			0.25 0.35	0.40 0.70	0.04	0.045	0.20 0.80		0.80 1.10	0.15 0.25						0.50	0.50			0.10	0.60
8Q J14049	QT	180	1241	145	1000	5			0.35 0.45	0.70 1.00	0.04	0.045	0.20 0.80		0.80 1.10	0.15 0.25						0.50	0.50			0.10	1.00
9Q J23055	QT	150	1030	115	793	7			0.25 0.35	0.40 0.70	0.04	0.045	0.20 0.80	1.65 2.00	0.70 0.90	0.20 0.30						0.50				0.10	0.60
10Q J24054	QT	180	1241	145	1000	5			0.35 0.45	0.70 1.00	0.04	0.045	0.20 0.80	1.65 2.00	0.70 0.90	0.20 0.30						0.50		0.35		0.10	1.00
11Q J12094	QT	120	827	100	689	10			0.15 0.25	0.40 0.70	0.04	0.045	0.20 0.80	1.65 2.00		0.20 0.30						0.50				0.10	1.00
12Q J15048	QT	190	1310	170	1172	4			0.45 0.55	0.65 0.95	0.04	0.045	0.20 0.80		0.80 1.10		0.15					0.50	0.50		0.10		1.00
13Q J12048	QT	105	724	85	586	10			0.15 0.25	0.65 0.95	0.04	0.045	0.20 0.80	0.40 0.70	0.40 0.70	0.15 0.25						0.50				0.10	1.00
14Q J13051	QT	150	1030	115	793	7			0.25 0.35	0.65 0.95	0.04	0.045	0.20 0.80	0.40 0.70	0.40 0.70	0.15 0.25						0.50				0.10	0.60
15A[F] J19966	A							HRB 100 max.	0.95 1.10	0.25 0.55	0.04	0.045	0.20 0.80		1.30 1.60							0.50	0.50			0.10	0.60
21	As cast	52[A]	360[A]			10		23.0 [160]	0.20 0.30	1.00	0.040	0.040	1.00	1.7 3.8	25 29	5 6		remainder		3.00	0.007						
31	As cast	55[A]	380[A]			10		30.0 [205]	0.45 0.55	1.00	0.040	0.040	1.00	9.5 11.5	24.5 26.5			remainder	7.0 8.0	2.00	0.005 0.015						

[A] Test at elevated temperature, 1500F [820C]
[B] Stress rupture test at 1500F [820C], stress units in ksi [MPa], the minimum rupture life is 15 hours with a minimum elongation in 4D of 5%
[C] Annealed.
[D] Quenched and tempered.
[E] Normalized and tempered
[F] Hardness Rockwell B, 100Max.

ASTM A 757/A 757M – 04

STEEL CASTINGS, FERRITIC AND MARTENISTIC FOR PRESSURE-CONTAINING AND OTHER APPLICATIONS, FOR LOW-TEMPERATURE SERVICE

This specification covers carbon and low-alloy steel castings for pressure-containing and other applications intended primarily for petroleum and gas pipelines in areas subject to low-ambient temperatures. Castings shall be heat treated by normalizing and tempering or liquid quenching and tempering. All classes are weldable under proper conditions. Hardenability of some grades may limit useable section size.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)															
Grade And UNS	Heat Treatment	Tensile Strength		Yield Strength		Elong %	Red A %	Other Tests[A] Impact[B]	C	Mn	P	S	Si	Ni	Cr	Mo	SPECIFIED RESIDUAL ELEMENTS Maximum %						
		Ksi	MPa	Ksi	MPa												V	Cu	Ni	Cr	Mo	W	Total Content %[E]
A1Q J03002	QT	65	450	35	240	24	35	13(-50) [17(-46)]	0.30	1.00	0.025	0.25	0.60				0.30	0.50	0.50	0.40	0.25		1.00
A2Q J02503	QT	70	485	40	275	22	35	15(-50) [20(-46)]	0.25[D]	1.20[D]	0.025	0.25	0.60				0.30	0.50	0.50	0.40	0.25		1.00
B2N, B2Q J22501	NT or QT	70	485	40	275	24	35	15(-100) [20(-73)]	0.25	0.50 0.80	0.025	0.25	0.60	2.0 3.0			0.30	0.50		0.40	0.25		1.00
B3N, B3Q J31500	NT or QT	70	485	40	275	24	35	15(-150) [20(-101)]	0.15	0.50 0.80	0.025	0.25	0.60	3.0 4.0			0.30	0.50		0.40	0.25		1.00
B4N, B4Q J41501	NT or QT	70	485	40	275	24	35	15(-175) [20(-115)]	0.15	0.50 0.80	0.025	0.25	0.60	4.0 5.0			0.30	0.50		0.40	0.25		1.00
C1Q J12582	QT 1100F	75	515	55	380	22	35	15(-50) [20(-46)]	0.25	1.20	0.025	0.25	0.60	1.5 2.0		0.15 0.30	0.30	0.50		0.40			1.00
D1N1, D1Q1 J22092	NT or QT	85 115	585 795	55	380	20	35	[C]	0.20	0.40 0.80	0.025	0.25	0.60		2.0 2.75	0.90 1.20	0.03	0.50	0.50			0.10	1.00
D1N2, D1Q2 J22092	NT or QT	95 125	655 860	75	515	18	35	[C]	0.20	0.40 0.80	0.025	0.25	0.60		2.0 2.75	0.90 1.20	0.03	0.50	0.50			0.10	1.00
D1N3, D1Q3 J22092	NT or QT	105 135	725 930	85	585	15	30	[C]	0.20	0.40 0.80	0.025	0.25	0.60		2.0 2.75	0.90 1.20	0.03	0.50	0.50			0.10	1.00
E1Q J42220	QT 1100F	90	620	65	450	22	40	30(-100) [41(-73)]	0.22	0.50 0.80	0.025	0.25	0.60	2.5 3.5	1.35 1.85	0.35 0.60	0.03	0.50					0.70
E2N1, E2Q1	NT or QT	90 120	620 825	70	485	18	35	30(-100) [41(-73)]	0.20	0.40 0.70	0.020	0.020	0.60	2.75 3.90	1.50 2.0	0.40 0.60	0.30	0.50				0.10	0.70
E2N2, E2Q2	NT or QT	105 135	725 930	85	585	15	30	20(-100) [27(-73)]	0.20	0.40 0.70	0.020	0.020	0.60	2.75 3.90	1.50 2.0	0.40 0.60	0.30	0.50				0.10	0.70
E2N3, E2Q3	NT QT	115 145	795 1000	100	690	13	30	15(-100) [20(-73)]	0.20	0.40 0.70	0.020	0.020	0.60	2.75 3.90	1.50 2.0	0.40 0.60	0.30	0.50				0.10	0.70
E3N J91550	NT	110	760	80	550	15	35	20(-100) [27(-73)]	0.06	1.00	0.030	0.030	1.00	3.5 4.5	11.5 14.0	0.40 1.0		0.50				0.10	0.50

[A] Refer to the original specification for additional information on toughness requirements and effective section size information
[B] See original specification for full details – units are in ft-lbs @ (F) and [J @ (C)]
[C] Requirements shall be subject to agreements between the manufacturer and the purchaser
[D] For each 0.01% carbon below the maximum specified, an increase of 0.04% manganese over the maximum specified will be permitted up to 1.40%
[E] Total residuals includes phosphorus and sulfur.

ASTM A 915/A 915M – 08 STEEL CASTINGS, CARBON, AND ALLOY, CHEMICAL REQUIREMENTS SIMILAR TO STANDARD WROUGHT GRADES

This specification covers carbon and low-alloy steel castings having chemical analyses similar to that of the standard wrought grades.

GRADE & HEAT TREATMENT		CHEMICAL COMPOSITION, % (maximum percent unless range given)							
Grade and UNS	Heat Treatment	C	Mn	P	S	Si	Ni	Cr	Mo
SC 1020 J02003	As cast, A, N, NT, or QT	0.18 0.23	0.40 0.80	0.040	0.040	0.30 0.60			
SC 1025 J02508	As cast, A, N, NT, or QT	0.22 0.28	0.40 0.80	0.040	0.040	0.30 0.60			
SC 1030 J03012	A, N, NT, or QT	0.28 0.34	0.50 0.90	0.040	0.040	0.30 0.60			
SC 1040 J04003	A, N, NT, or QT	0.37 0.44	0.50 0.90	0.040	0.040	0.30 0.60			
SC 1045 J04502	A, N, NT, or QT	0.43 0.50	0.50 0.90	0.040	0.040	0.30 0.60			
SC 4130 J13502	A, N, NT, or QT	0.28 0.33	0.40 0.80	0.035	0.040	0.30 0.60		0.80 1.10	0.15 0.25
SC 4140 J14045	A, N, NT, or QT	0.38 0.43	0.70 1.10	0.035	0.040	0.30 0.60		0.80 1.10	0.15 0.25
SC 4330 J23259	A, N, NT, or QT	0.28 0.33	0.60 0.90	0.035	0.040	0.30 0.60	1.65 2.00	0.70 0.90	0.20 0.30
SC 4340 J24053	A, N, NT, or QT	0.38 0.43	0.60 0.90	0.035	0.040	0.30 0.60	1.65 2.00	0.70 0.90	0.20 0.30
SC 8620 J12095	A, N, NT, or QT	0.18 0.23	0.60 1.00	0.035	0.040	0.30 0.60	0.40 0.70	0.40 0.60	0.15 0.25
SC 8625 J12595	A, N, NT, or QT	0.23 0.28	0.60 1.00	0.035	0.040	0.30 0.60	0.40 0.70	0.40 0.60	0.15 0.25
SC 8630 J13095	A, N, NT, or QT	0.28 0.33	0.60 1.00	0.035	0.040	0.30 0.60	0.40 0.70	0.40 0.60	0.15 0.25

ASTM A 958 – 06

STEEL CASTINGS, CARBON, AND ALLOY, WITH TENSILE REQUIREMENTS, CHEMICAL REQUIREMENTS SIMILAR TO STANDARD WROUGHT GRADES

This specification covers carbon and low-alloy steel castings having chemical analyses similar to that of the standard wrought grades.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)													CHEMICAL COMPOSITION, % (maximum percent unless range given)							
Grade and UNS	Heat Treatment	Tensile Requirements/Grade Suitability[AC]													C	Mn	P	S	Si	Ni	Cr	Mo
		65/35	70/36	80/40	80/50	90/60	105/85	115/96	130/115	135/125	150/135	160/145	165/150	210/180								
SC 1020 J02003	A, N, NT, or QT	X[A]	X												0.18 0.23	0.40 0.80	0.040	0.040	0.30 0.60			
SC 1025 J02508	A, N, NT, or QT	X	X												0.22 0.28	0.40 0.80	0.040	0.040	0.30 0.60			
SC 1030 J03012	A, N, NT, or QT	X	X	X	X										0.28 0.34	0.50 0.90	0.040	0.040	0.30 0.60			
SC 1040 J04003	A, N, NT, or QT	X[B]	X	X	X	X									0.37 0.44	0.50 0.90	0.040	0.040	0.30 0.60			
SC 1045 J04502	A, N, NT, or QT	X[B]	X[B]	X	X	X	X	X							0.43 0.50	0.50 0.90	0.040	0.040	0.30 0.60			
SC 4130 J13502	A, N, NT, or QT	X[B]	X[B]	X	X	X	X	X	X	X	X				0.28 0.33	0.40 0.80	0.035	0.040	0.30 0.60		0.80 1.10	0.15 0.25
SC 4140 J14045	A, N, NT, or QT	X[B]	X[B]	X[B]	X[B]	X	X	X	X	X	X	X	X		0.38 0.43	0.70 1.10	0.035	0.040	0.30 0.60		0.80 1.10	0.15 0.25
SC 4330 J23259	A, N, NT, or QT	X[B]	X[B]	X[B]	X[B]	X	X	X	X	X	X	X	X	X	0.28 0.33	0.60 0.90	0.035	0.040	0.30 0.60	1.65 2.00	0.70 0.90	0.20 0.30
SC 4340 J24053	A, N, NT, or QT	X[B]	X[B]	X[B]	X[B]	X[B]	X	X	X	X	X	X	X	X	0.38 0.43	0.60 0.90	0.035	0.040	0.30 0.60	1.65 2.00	0.70 0.90	0.20 0.30
SC 8620 J12095	A, N, NT, or QT	X[B]	X[B]	X	X	X	X	X							0.18 0.23	0.60 1.00	0.035	0.040	0.30 0.60	0.40 0.70	0.40 0.60	0.15 0.25
SC 8625 J12595	A, N, NT, or QT	X[B]	X[B]	X	X	X	X	X	X	X					0.23 0.28	0.60 1.00	0.035	0.040	0.30 0.60	0.40 0.70	0.40 0.60	0.15 0.25
SC 8630 J13095	A, N, NT, or QT	X[B]	X[B]	X	X	X	X	X	X	X	X				0.28 0.33	0.60 1.00	0.035	0.040	0.30 0.60	0.40 0.70	0.40 0.60	0.15 0.25

[A] X denotes that the properties may be achieved by at least one of the heat treatments referenced in 5. The effect of section thickness should be considered in making greade selections. The heat treatment requirements do not imply that all section thicknesses will be through hardened.
[B] These grades are likely to significantly exceed the minimum strength levels; therefore, problems may be experienced when trying to produce castings to low hardness values
[C] Tensile requirements for the different classes given in the table below

TENSILE REQUIREMENTS													
Class	**65/35**	**70/36**	**80/40**	**80/50**	**90/60**	**105/85**	**115/95**	**130/115**	**135/125**	**150/135**	**160/145**	**165/150**	**210/180**
Tensile (ksi)	65	70	80	80	90	105	115	130	135	150	160	165	210
Tensile [MPa]	450	485	550	550	620	725	795	895	930	1035	1105	1140	1450
Yield (ksi)	35	36	40	50	60	85	95	115	125	135	145	150	180
Yield [MPa]	240	250	275	345	415	585	655	795	860	930	1000	1035	1240
Elong. (%)	24	22	18	22	18	17	14	11	9	7	6	5	4
Red. A (%)	35	30	30	35	35	35	30	25	22	18	12	10	8

FEDERAL QQ-S-681F

STEEL CASTINGS

This specification covers mild-to-medium-strength carbon steel castings for general application as described in ASTM A 27 and high-strength steel castings for structural purposes as described in ASTM A 148.

Canceled May 20, 1985 – use ASTM A 27 and ASTM A 148

ISO 3755 CAST CARBON STEELS FOR GENERAL ENGINEERING

This International Standard specifies requirements for eight grades of heat-treated cast carbon steels for general engineering purposes. Four of the grades have a restricted chemical composition to ensure uniform weldability.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES[A] (minimum unless range given)							CHEMICAL COMPOSITION[H], % (maximum percent unless range given)										
Grade and UNS	Heat Treatment[B]	Tensile Strength		Yield Strength[D]		Elong[G] %	Red A %	Other Tests[G] Impact (J)	C[I]	Mn	P	S	Si	SPECIFIED RESIDUAL ELEMENTS Maximum %					
		ksi	MPa	ksi	Mpa									Ni[J]	Cr[J]	Mo[J]	Cu	V	Total Content %[J]
200-400			400 550		200	25	25	30			0.035	0.035							
200-400W[C]			400 550		200	25	25	45	0.25	1.00	0.035	0.035	0.60	0.40	0.35	0.15	0.40	*0.05*	1.00
230-450			450 600		230	22	22	25			0.035	0.035							
230-450W[C]			450 600		230	22	22	45	0.25	1.20	0.035	0.035	0.60	0.40	0.35	0.15	0.40	0.05	1.00
270-480			480 630		270[E]	18	18	22			0.035	0.035							
270-480W[C]			480 630		270[E]	18	18	22	0.25	1.20	0.035	0.035	0.60	0.40	0.35	0.15	0.40	0.05	1.00
340-550			550 700		340[F]	15	15	20			0.035	0.035							
340-550W[C]			550 700		340[F]	15	15	20	0.25	1.50	0.035	0.035	0.60	0.40	0.35	0.15	0.40	0.05	1.00

[A] See original specification for additional details on mechanical properties
[B] The type of heat-treatment is left to the discretion of the manufacturer, unless specifically agreed upon at the time of ordering
[C] The W-grades restrict the chemical composition and may be ordered to ensure uniform weldability
[D] If measurable, the upper yield stress, otherwise the 0.2% proof stress
[E] The casting will have an upper yield stress of [260 Mpa] and a tensile strength of [500-650 MPa] in sections from [28 mm] up to [40 mm]
[F] The casting will have an upper yield stress of [300 Mpa] and a tensile strength of [570-720 MPa] in sections from [28 mm] up to [40 mm]
[G] By choice, according to the order
[H] The choice of chemical composition in the non-weldable grades shall be left to the discretion of the manufacturer
[I] For each 0.01% reduction of carbon below 0.25%, an increase of 0.04% manganese above the maximum specified will be permitted, to a maximum of 1.20% for grade 200-400W and to 1.40% for grade 270-480W
[J] Maximum content of residual elements, the sum of which shall not exceed 1.00%

ISO 4991 STEEL CASTINGS FOR PRESSURE PURPOSES

This International Standard covers steel castings used for pressure purposes. It includes materials which are used for the manufacture of components subject to pressure vessel codes (see ISO/R831, ISO 2694 and ISO 5730) and for other pressure containing components not subject to codal requirements

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES AT ROOM TEMPERATURE [3] (minimum unless range given)							CHEMICAL COMPOSITION, % (m/m) [1),2)] (maximum percent unless range given)									
Grade and UNS	Heat Treatment[5]	R_e [6] Min N/mm²	R_m N/mm²	A Min %	Z [7] Min %	KV [7), 4)] Min J	KV [3), 4)] at °C	KV [3), 4)] Min J	C	Si	Mn	P	S	Cr	Mo	Ni	V	Nb
Unalloyed steels																		
C23-45A		240	450 600	22	35	27			0.25	0.60	1.20	0.035	0.035					
C23-45AH		240	150 300	22	35	27			0.25	0.60	1.20	0.035	0.035					
C23-45B		240	450 600	22	35	45			0.20	0.60	1.00 1.60	0.035	0.035					
C23-45BH		240	450 600	22	35	45			0.20	0.60	1.00 1.60	0.035	0.035					
C23-45BL		240	450 300	22			-40	27	0.20	0.60	1.00 1.60	0.030	0.030					
C26-52		280	520[10)] 670	18	30	35			0.25[8),9)]	0.60	1.20[8),9)]	0.035	0.035					
C26-52H		280	520[10)] 670	18	30	35			0.25[8),9)]	0.60	1.20[8),9)]	0.035	0.035					
C26-52L		280	520[10)] 670	18			-35	27	0.25[8)]	0.60	1.20[8)]	0.03	0.03					
Alloyed ferritic and martensitic steels																		
C28H		250	450 600	21	25	25			0.15 0.23	0.30 0.60	0.50 1.00	0.035	0.035	0.30	0.40 0.60			
C31L		370	550 700	16	30		-45	27	0.29	0.30 0.60	0.50 0.80	0.030	0.030	0.90 1.20	0.15 1.30			
C32H		290	490 640	18	35	27			0.10 0.20[10)]	0.30 0.60	0.50 0.80	0.035	0.035	1.00 1.50	0.45 0.65			
C33H		320	500 650	17	30	13			0.10 0.17	0.30 0.60	0.40 0.70	0.035	0.035	0.30 0.60	0.40 0.60	0.40	0.22 0.32	
C34AH		280	510 660	18	35	25			0.08 0.15	0.30 0.60	0.50 0.80	0.035	0.035	2.00 2.50	0.90 1.20			
C34BH		390	600 750	18	35	40			0.13 0.20	0.30 0.60	0.50 0.80	0.035	0.035	2.00 2.50	0.90 1.20			
C34BL		390	600 750	18			50	27	0.20	0.30 0.60	0.50 0.80	0.030	0.030	2.00 2.50	0.90 1.20			
C35BH		420	590 740	15	35	24			0.13 0.20	0.30 0.60	0.50 0.80	0.035	0.035	1.20 1.60[11)]	0.90 1.20	[12)]	0.15 0.35	
C37H		420	630 780	16	35	25			0.12 0.19	0.80	0.50 0.80	0.035	0.035	4.00 6.00	0.45 0.65			
C38H		420	630 780	16	35	20			0.10 0.17	0.80	0.50 0.80	0.035	0.035	8.00 10.0	1.00 1.30			
C39CH		450	620 770	14	30	20			0.10 0.17	0.80	1.00	0.035	0.035	11.5 13.5	0.50	1.00		
C39CNiH		360	540 690	18	35	35			0.05 0.10	0.80	0.40 0.80	0.035	0.035	11.5 13.0	0.20 0.50	0.80 1.80		

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES AT ROOM TEMPERATURE [3] (minimum unless range given)							CHEMICAL COMPOSITION, % (m/m) [1),2)] (maximum percent unless range given)									
Grade and UNS	Heat Treatment[5)]	R_e [6)] Min N/mm²	R_m N/mm²	A Min %	Z [7)] Min %	KV [7), 4)] Min J	KV [3), 4)] at °C	KV [3), 4)] Min J	C	Si	Mn	P	S	Cr	Mo	Ni	V	Nb
C39NiH		550	750 900	15	35	45			0.08	1.00	1.50	0.035	0.035	11.5 13.5	1.00	3.50 5.00		
C39NiL		550	750 900	15	35		-80	27	0.08	1.00	1.50	0.030	0.030	11.5 13.5	1.00	3.50 5.00		
C40H		540	740 880	15	20	21 [13)]			0.20 0.26	0.20 0.40	0.50 0.70	0.035	0.035	11.3 12.3	1.00 1.20	0.70 1.00	0.25 0.35	
C43L		300	460 610	20			-70	27	0.14	0.30 0.60	0.50 0.80	0.030	0.030			3.00 4.00		
C43C1L		380	520 670	20			-35	27	0.24	0.30 0.60	0.80 1.20	0.030	0.030		0.15 0.30	1.50 2.00		
C43E2aL		450	620 800	16			-80	27	0.22	0.60	0.40 0.80	0.030	0.030	1.35 2.00	0.35 0.60	2.50 3.50		
C43E2bL		655	800 950	13			-60	27	0.22	0.60	0.40 0.80	0.030	0.030	1.50 2.00	0.35 0.60	2.75 3.90		
Austenitic stainless steels																		
C46		210	440 640	30		[14)]			0.03	2.00	2.00	0.045	0.035	17.0 19.0		9.0 12.0		
C47		210	440 640	30		[14)]			0.07	2.00	2.00	0.045	0.035	18.0 21.0		8.0 11.0		
C47H		230	470 670	30		[14)]			0.04 0.10	2.00	2.00	0.045	0.035	18.0 21.0		8.0 12.0		
C47L		210	440 640	30			-195 [15)]	45	0.07	2.00	2.00	0.045	0.035	17.0. 20.0		9.0 12.0		
C50		210	440 640	25		[14)]			0.08	2.00	2.00	0.045	0.035	18.0 21.0		9.0 12.0		8x%C 1.0
C57		210	440 620	30		[14)]			0.03	2.00	2.00	0.045	0.035	17.0 21.0	2.0 2.5	9.0 13.0		
C60		210	440 640	30		[14)]			0.07	2.00	2.00	0.045	0.035	17.0 21.0	2.0 2.5	9.0 13.0		
C60H		230	470 670	30		[14)]			0.04 0.10	2.00	2.00	0.045	0.035	17.0 21.0	2.0 2.5	9.0 13.0		
C60Nb		210	440 640	25		[14)]			0.08	2.00	2.00	0.045	0.035	17.0 21.0	2.0 2.5	9.0 13.0		8x%C 1.0
C61LC		210	440 640	30		[14)]			0.03	2.00	2.00	0.045	0.035	17.0 21.0	2.5 3.0	9.0 13.0		
C61		210	440 640	30		[14)]			0.07	2.00	2.00	0.045	0.035	17.0 21.0	2.5 3.0	9.0 13.0		

1. Elements not quoted in this table shall not be intentionally added without the purchaser's agreement, other than for the purpose of finishing the heat treatment. For unalloyed steels, if not otherwise agreed, the following maximum values, in percentage, are applicable: Cr/0.40, Mo/0.15, Ni/0.40, V/0.03, Cu/0.40, (Cr+Mo+Ni+V Cu)/100

2. The permissible deviatons for the results of check-analysis on test blocks shall be as specified in ISO 4990.

3. R_e: yield strength (see footnote 5); R_m: tensile strength; A percentage elongation after fracture on original gage length $L_o=5.65\sqrt{S_o}$ (Where S_o is the original cross-sectional area); Z:reduction of area; KV: ISO V-notch impact strength.

4. The given minimum values apply for the average of three individual test results. One of the individual values may be below the specified minimum average value, provided it is not less than 70% of that value.

5. Refer to specifications for heat treatment requirements

6. The values of R_e shall be regarded as complied with if, in the case of non-austentic steels, the upper yield stress (R_{eH}), the total 0.5% total elongation proof stress($R_{t0.5}$) or the 0.2% proof test ($R_{p0.2}$) satisfy the specified values.

[7.] The minimum values for either Z or KV apply. Unless otherwise specified, the choice is lift to the manufacturer. However, the purchaser shall note that some national or ISO codes require the testing of impact specimens.
[8.] For each 0.0.01 % (m/m) C below the maximum carbon content, an increase of 0.04 % (m/m) Mn will be permitted up to a maximum manganese content of 1.40 % (m/m).
[9.] For certain applications and upon agreement at the time of the enquiry and order, this grade of steel can be supplied with a maximum carbon content of 0.30% (m/m) and a maximum manganese content of 0.90% (m/m).
[10.] If the minimum yield strength R_e is met, tensile strength (R_m) values down to 500 N/mm^2 should be regarded as acceptable.
[11.] For castings with thin sections, a minimum value of 1.00 % (m/m) Cr may be agreed upon.
[12.] Depending on the wall thickness, a nickel content of less than 1.00% (m/m) is permitted.
[13.] This type of steel is usually applied only at temperatures above 525° C.
[14.] Austenitic steels normally have a high toughness because of their structure.
[15.] Valid for an impact value of 45J. Normally, this value is also to be expected for the room temperature grade. If, however, the low temperature grade is ordered, the value has to be verified by testing.

ISO 9477 HIGH STRENGTH CAST STEELS FOR GENERAL ENGINEERING AND STRUCTURAL PURPOSES

This International Standard specifies requirements for four grades of heat-treated cast carbon and alloy steels for general engineering and structural purposes.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES[A] (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)		
Grade and UNS	Heat Treatment[B]	Tensile Strength		Yield Strength		Elong %	Red A %	Other Tests Impact (J)	P	S	Si
		ksi	MPa	ksi	MPa						
410-620			620 770		410	16	40	20	0.035	0.035	0.60
540-720			720 870		540	14	35	20	0.035	0.035	0.60
620-820			820 970		620	11	30	18	0.035	0.035	0.60
840-1030			1030 1180		840	7	22	15	0.035	0.035	0.60

[A] See original specification for additional details on mechanical properties
[B] The type of heat-treatment is left to the discretion of the manufacturer, unless specifically agreed upon at the time of ordering

ISO 13521 AUSTENITIC MANGANESE STEEL CASTINGS

This International Standard specifies austenitic manganese cast steels for wear resistant service. The grades covered by this International Standard will experience maximum service life in applications where the surface of the castings is subject to impact.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)							
Grade and UNS	Heat Treatment	Tensile Strength		Yield Strength		Elong %	Red A %	Other Tests[c]	C	Mn	P	S	Si	Ni	Cr	Mo
		ksi	MPa	ksi	MPa											
GX120MnMo7-1	ST & WQ								1.05 1.35	6.0 8.0	0.060	0.045	0.30 0.90			0.90 1.20
GX110MnMo12-1	ST & WQ								0.75 1.35	11.0 14.0	0.060	0.045	0.30 0.90			0.90 1.20
GX100Mn13[A]	ST & WQ								0.90 1.05	11.0 14.0	0.060	0.045	0.30 0.90			
GX120Mn13[A]	ST & WQ								1.05 1.35	11.0 14.0	0.060	0.045	0.30 0.90			
GX120MnCr13-2	ST & WQ								1.05 1.35	11.0 14.0	0.060	0.045	0.30 0.90		1.50 2.50	
GX120MnCr13-3	& WQ								1.05 1.35	11.0 14.0	0.060	0.045	0.30 0.90	3.0 4.0		

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)							
Grade and UNS	Heat Treatment	Tensile Strength		Yield Strength		Elong %	Red A %	Other Tests[C]	C	Mn	P	S	Si	Ni	Cr	Mo
		ksi	MPa	ksi	MPa											
GX120Mn17[A]	ST & WQ[B]								1.05 1.35	16.0 19.0	0.060	0.045	0.30 0.90			
GX90MnMo14	as cast								0.70 1.00	13.0 15.0	0.070	0.045	0.30 0.60			1.00 1.80
GX120MnCr17-2	ST & WQ								1.05 1.35	16.0 19.0	0.060	0.045	0.30 0.90		1.50 2.50	

[A] These grades are sometimes used for non-magnetic service
[B] For castings with thicknesses less than [45 mm] and containing less than 0.8% carbon, heat treatment is not required
[C] Bend test, hardness test, and microstructure shall be performed when agreed upon between the purchaser and the manufacturer – see original specification for more details

ISO 14737 CAST CARBON AND LOW ALLOY STEELS FOR GENERAL USE

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES AT ROOM TEMPERATURE (minimum unless range given)					CHEMICAL COMPOSITION, % (m/m) (maximum percent unless range given)									
Grade and UNS	Heat Treatment	Thickness t mm	Tensile test $R_{p0.2}$ min MPa	Tensile test R_m MPa	Tensile test A Min %	Impact Test KV Min J	C	Si	Mn	P	S	Cr	Mo	Ni	V	Nb
GS200	+N	100	200	400 550	25	45	0.18	0.60	1.20	0.030	0.025	0.30[A]	0.12[A]	0.40[A]	0.03[A]	0.30[A]
GS230	+N	100	230	450 600	22	45	0.22	0.60	1.20	0.030	0.025	0.30[A]	0.12[A]	0.40[A]	0.03[A]	0.30[A]
GS270	+N	100	270	480 630	18	27	0.24	0.60	1.30	0.030	0.025	0.30[A]	0.12[A]	0.40[A]	0.03[A]	0.30[A]
GS340	+N	100	340	550 700	15	20	0.30	0.60	1.50	0.030	0.025	0.30[A]	0.12[A]	0.40[A]	0.03[A]	0.30[A]
G20Mn5	+N	30	300	480 620	20	50	0.17 0.23	0.60	1.00 1.60	0.030	0.020[B]	0.30	0.15	0.80	0.05	0.30
	+QT	100	300	500 650	22	60	0.17 0.23	0.60	1.00 1.60	0.030	0.020[B]	0.30	0.15	0.80	0.05	0.30
G28Mn6	+N	250	260	520 670	18	31	0.25 0.32	0.60	1.20 1.80	0.030	0.025	0.30	0.15	0.40	0.05	0.30
	+QT1	100	450	600 750	14	35	0.25 0.32	0.60	1.20 1.80	0.030	0.025	0.30	0.15	0.40	0.05	0.30
	+QT2	50	550	700 850	10	31	0.25 0.32	0.60	1.20 1.80	0.030	0.025	0.30	0.15	0.40	0.05	0.30
G28MnMo6	+QT1	50	500	700 850	12	35	0.25 0.32	0.60	1.20 1.60	0.025	0.025	0.30	0.20 0.40	0.40	0.05	0.30
	+QT1	100	480	670 830	10	31	0.25 0.32	0.60	1.20 1.60	0.025	0.025	0.30	0.20 0.40	0.40	0.05	0.30
	+QT2	100	590	850 1000	8	27	0.25 0.32	0.60	1.20 1.60	0.025	0.025	0.30	0.20 0.40	0.40	0.05	0.30
G20Mo5	+QT2	100	245	440 590	22	27	0.15 0.23	0.60	0.50 1.00	0.025	0.020[B]	0.30	0.40 0.60	0.40	0.05	0.30
G10MnMoV6-3	+NT	50	380	500 650	22	60	0.12	0.60	1.20 1.80	0.025	0.020	0.30	0.20 0.40	0.40	0.05 0.10	0.30

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES AT ROOM TEMPERATURE (minimum unless range given)					CHEMICAL COMPOSITION, % (m/m) (maximum percent unless range given)									
Grade and UNS	Heat Treatment	Thickness t mm	Tensile test $R_{p0.2}$ min MPa	Tensile test R_m MPa	Tensile test A Min %	Impact Test KV Min J	C	Si	Mn	P	S	Cr	Mo	Ni	V	Nb
	+NT	50 100	350	480 630	22	60	0.12	0.60	1.20 1.80	0.025	0.020	0.30	0.20 0.40	0.40	0.05 0.10	0.30
	+NT	100 150	330	480 630	20	60	0.12	0.60	1.20 1.80	0.025	0.020	0.30	0.20 0.40	0.40	0.05 0.10	0.30
	+NT	150 250	330	450 600	18	60	0.12	0.60	1.20 1.80	0.025	0.020	0.30	0.20 0.40	0.40	0.05 0.10	0.30
	+QT	50	500	600 750	18	60	0.12	0.60	1.20 1.80	0.025	0.020	0.30	0.20 0.40	0.40	0.05 0.10	0.30
	+QT[c]	50 100	400	550 700	18	60	0.12	0.60	1.20 1.80	0.025	0.020	0.30	0.20 0.40	0.40	0.05 0.10	0.30
	+QT[c]	100 150	380	500 650	18	60	0.12	0.60	1.20 1.80	0.025	0.020	0.30	0.20 0.40	0.40	0.05 0.10	0.30
	+QT[c]	150 250	350	460 610	18	60	0.12	0.60	1.20 1.80	0.025	0.020	0.30	0.20 0.40	0.40	0.05 0.10	0.30
G20NiCrMo2-2	+N	100	200	550 700	18	10	0.18 0.23	0.60	0.60 1.00	0.035	0.030	0.40 0.60	0.15 0.25	0.40 0.70	0.05	0.30
	+QT1	100	430	700 850	15	25	0.18 0.23	0.60	0.60 1.00	0.035	0.030	0.40 0.60	0.15 0.25	0.40 0.70	0.05	0.30
	+QT2	100	540	820 970	12	25	0.18 0.23	0.60	0.60 1.00	0.035	0.030	0.40 0.60	0.15 0.25	0.40 0.70	0.05	0.30
G25NiCrMo2-2	+N	100	240	600 750	18	10	0.23 0.28	0.60	0.60 1.00	0.035	0.030	0.40 0.60	0.15 0.25	0.40 0.70	0.05	0.30
	+QT1	100	500	750 900	15	25	0.23 0.28	0.60	0.60 1.00	0.035	0.030	0.40 0.60	0.15 0.25	0.40 0.70	0.05	0.30
	+QT2	100	300	850 1000	12	25	0.23 0.28	0.60	0.60 1.00	0.035	0.030	0.40 0.60	0.15 0.25	0.40 0.70	0.05	0.30
G30NiCrMo2-2	+N	100	270	630 780	18	10	0.28 0.33	0.60	0.60 1.00	0.035	0.020	0.40 0.60	0.15 0.25	0.40 0.70	0.05	0.30
	+QT1	100	540	820 970	14	25	0.28 0.33	0.60	0.60 1.00	0.035	0.020	0.40 0.60	0.15 0.25	0.40 0.70	0.05	0.30
	+QT2	100	630	900 1050	11	25	0.28 0.33	0.60	0.60 1.00	0.035	0.020	0.40 0.60	0.15 0.25	0.40 0.70	0.05	0.30
G17CrMo5-5	+QT	100	315	490 690	20	27	0.15 0.20	0.60	0.50 1.00	0.025	0.020[B]	1.00 1.50	0.45 0.65	0.40	0.05	0.30
G17CrMo5-10	+QT	150	100	590 740	18	40	0.13 0.20	0.60	0.50 0.90	0.025	0.020[B]	2.00 2.50	0.90 1.20	0.40	0.05	0.30
G25CrMo4	+QT1	100	450	600 750	16	40	0.22 0.29	0.60	0.50 0.80	0.025	0.020[B]	0.80 1.20	0.15 0.25	0.40	0.05	0.30
	+QT1	100 250	300	550 700	14	27	0.22 0.29	0.60	0.50 0.80	0.025	0.020[B]	0.80 1.20	0.15 0.25	0.40	0.05	0.30
	+QT2	100	550	700 850	10	18	0.22 0.29	0.60	0.50 0.80	0.025	0.020[B]	0.80 1.20	0.15 0.25	0.40	0.05	0.30
G32CrMo4	+NT	100	270	630 780	16	10	0.28 0.35	0.60	0.50 0.80	0.025	0.020[B]	0.80 1.20	0.15 0.25	0.40	0.05	0.30
	+QT1	100	540	700 850	12	35	0.28 0.35	0.60	0.50 0.80	0.025	0.020[B]	0.80 1.20	0.15 0.25	0.40	0.05	0.30
	+QT1	100 150	480	620 770	10	27	0.28 0.35	0.60	0.50 0.80	0.025	0.020[B]	0.80 1.20	0.15 0.25	0.40	0.05	0.30

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES AT ROOM TEMPERATURE (minimum unless range given)					CHEMICAL COMPOSITION, % (m/m) (maximum percent unless range given)									
Grade and UNS	Heat Treatment	Thickness t mm	Tensile test $R_{p0.2}$ min MPa	Tensile test R_m MPa	Tensile test A Min %	Impact Test KV Min J	C	Si	Mn	P	S	Cr	Mo	Ni	V	Nb
	+QT1	150 250	330	620 770	10	16	0.28 0.35	0.60	0.50 0.80	0.025	0.020 [B]	0.80 1.20	0.15 0.25	0.40	0.05	0.30
	+QT2	100	350	800 950	10	18	0.28 0.35	0.60	0.50 0.80	0.025	0.020 [B]	0.80 1.20	0.15 0.25	0.40	0.05	0.30
G42CrMo4	NT	100	300	700 850	15	10	0.38 0.45	0.60	0.60 1.00	0.025	0.020 [B]	0.80 1.20	0.15 0.25	0.40	0.05	0.30
	+QT1	100	600	780 930	12	31	0.38 0.45	0.60	0.60 1.00	0.025	0.020 [B]	0.80 1.20	0.15 0.25	0.40	0.05	0.30
	+QT1	100 150	550	700 850	10	27	0.38 0.45	0.60	0.60 1.00	0.025	0.020 [B]	0.80 1.20	0.15 0.25	0.40	0.05	0.30
	+QT1	150 250	350	650 800	10	16	0.38 0.45	0.60	0.60 1.00	0.025	0.020 [B]	0.80 1.20	0.15 0.25	0.40	0.05	0.30
	+QT2	100	700	850 1000	10	18	0.38 0.45	0.60	0.60 1.00	0.025	0.020 [B]	0.80 1.20	0.15 0.25	0.40	0.05	0.30
G50CrMo4	+QT	100	750	900 1050	10	18	0.46 0.53	0.60	0.60 1.00	0.025	0.020 [B]	0.80 1.20	0.15 0.25	0.40	0.05	0.30
G30CrMoV6-4	+QT1	100	700	850 1000	14	45	0.27 0.34	0.60	0.60 1.00	0.025	0.020 [B]	1.30 1.70	0.30 0.50	0.40	0.05 0.15	0.30
	+QT1	100 150	550	750 900	12	27	0.27 0.34	0.60	0.60 1.00	0.025	0.020 [B]	1.30 1.70	0.30 0.50	0.40	0.05 0.15	0.30
	+QT1	150 250	350	650 800	12	20	0.27 0.34	0.60	0.60 1.00	0.025	0.020 [B]	1.30 1.70	0.30 0.50	0.40	0.05 0.15	0.30
	+QT2	100	750	900 1100	12	31	0.27 0.34	0.60	0.60 1.00	0.025	0.020 [B]	1.30 1.70	0.30 0.50	0.40	0.05 0.15	0.30
G35CrNiMo6-6	+N	150	550	800 950	12	31	0.32 0.38	0.60	0.60 1.00	0.025	0.020 [B]	1.40 1.70	0.15 0.35	1.40 1.70	0.05	0.30
	+N	150 250	500	750 900	12	31	0.32 0.38	0.60	0.60 1.00	0.025	0.020 [B]	1.40 1.70	0.15 0.35	1.40 1.70	0.05	0.30
	+QT1	100	700	850 1000	12	45	0.32 0.38	0.60	0.60 1.00	0.025	0.020 [B]	1.40 1.70	0.15 0.35	1.40 1.70	0.05	0.30
	+QT1	100 150	650	800 950	12	35	0.32 0.38	0.60	0.60 1.00	0.025	0.020 [B]	1.40 1.70	0.15 0.35	1.40 1.70	0.05	0.30
	+QT1	150 250	650	800 950	12	30	0.32 0.38	0.60	0.60 1.00	0.025	0.020 [B]	1.40 1.70	0.15 0.35	1.40 1.70	0.05	0.30
	+QT2	100	800	900 1050	10	35	0.32 0.38	0.60	0.60 1.00	0.025	0.020 [B]	1.40 1.70	0.15 0.35	1.40 1.70	0.05	0.30
G30NiCrMo7-3	+NT	100	550	760 900	12	10	0.28 0.33	0.60	0.60 0.90	0.035	0.030	0.70 0.90	0.20 0.30	1.65 2.00	0.05	0.30
	+QT1	100	690	930 1100	10	25	0.28 0.33	0.60	0.60 0.90	0.035	0.030	0.70 0.90	0.20 0.30	1.65 2.00	0.05	0.30
	+QT2	100	795	1030 1200	8	25	0.28 0.33	0.60	0.60 0.90	0.035	0.030	0.70 0.90	0.20 0.30	1.65 2.00	0.05	0.30
G40NiCrMo7-3	+NT	100	585	860 1100	10	10	0.38 0.43	0.60	0.60 0.90	0.035	0.030	0.70 0.90	0.20 0.30	1.65 2.00	0.05	0.30
	+QT1	100	760	1000 1140	8	25	0.38 0.43	0.60	0.60 0.90	0.035	0.030	0.70 0.90	0.20 0.30	1.65 2.00	0.05	0.30
	+QT2	100	795	1030 1200	8	25	0.38 0.43	0.60	0.60 0.90	0.035	0.030	0.70 0.90	0.20 0.30	1.65 2.00	0.05	0.30

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES AT ROOM TEMPERATURE (minimum unless range given)					CHEMICAL COMPOSITION, % (m/m) (maximum percent unless range given)									
Grade and UNS	Heat Treatment	Thickness t mm	Tensile test $R_{p0.2}$ min MPa	Tensile test R_m MPa	Tensile test A Min %	Impact Test KV Min J	C	Si	Mn	P	S	Cr	Mo	Ni	V	Nb
G32NiCrMo8-5-4	+QT1	100 250	700	850 1000	16	50	0.28 0.35	0.60	0.60 1.00	0.020	0.015	1.00 1.40	0.30 0.50	1.60 2.10	0.05	0.30
	+QT1	100 250	650	820 970	14	35	0.28 0.35	0.60	0.60 1.00	0.020	0.015	1.00 1.40	0.30 0.50	1.60 2.10	0.05	0.30
	+QT2	100	980	1050 1200	10	35	0.28 0.35	0.60	0.60 1.00	0.020	0.015	1.00 1.40	0.30 0.50	1.60 2.10	0.05	0.30

[A] Cr+Mo+Ni+V+Cu max. 100%
[B] For castings of ruling thickness<28 mm, S≤0.030% is permitted.
[C] Cooling in liquid

MIL-C-24707/1 CASTINGS, FERROUS, FOR MACHINERY AND STRUCTURAL APPLICATIONS

This specification covers steel castings for machinery and structural applications below 775 F where impact strength may be a consideration.

PREVIOUS SPECIFICATION MIL-S-15083B (grade)	REPLACEMENT SPECIFICATION MIL-C-24707/1 ASTM specification (grade)	FEDERAL GRADE QQ-S-681F ASTM specification (grade)	EQUIVALENT GRADE MIL-C-24707/1 ASTM specification (grade)
(CW)	A 757 (A1Q) or A 216 (WCA)	A 27 (N-1)	A 757 (A1Q) or A 216 (WCA) or A 217 (WC1)
(B)	A 757 (A1Q) or A 216 (WCA)	A 27 (N-2)	A 757 (A1Q) or A 216 (WCA) or A 217 (WC1)
(65-35)	A 757 (A1Q) or A 216 (WCB)	A 27 (U60-30)	A 757 (A1Q) or A 216 (WCB) or A 217 (WC1)
(70-36)	A 757 (A2Q) or A 216 (WCB, WCC)	A 27 (60-30)	A 757 (A1Q) or A 216 (WCB) or A 217 (WC1)
(80-40)	A 757 (A2Q) or A 487 (2 class A, B, C)	A 27 (65-35)	A 757 (A1Q) or A 216 (WCB) or A 217 (WC1)
(80-50)	A 757 (C1Q) or A 487 (2 class A, B, C)	A 27 (70-36)	A 757 (A2Q) or A 216 (WCB, WCC)
(90-60)	A 757 (E1Q) or A 487 (4 class A)	A 27 (70-40)	A 757 (A2Q) or A 216 (WCC)
(100-70)	A 757 (E2N1/E2Q1)	A 148 (80-40)	A 757 (A2Q) or A 487 (2 class A, B, C)
(105-85)	A 757 (E2N2/E2Q2) or A 487 (4 class B)	A 148 (80-50)	A 757 (C1Q) or A 487 (2 class A, B, C)
(120-95)	A 757 (E2N3/E2Q3) or A 487 (14 class A)	A 148 (90-60)	A 757 (E1Q) or A 487 (4 class A)
(150-125)	Special application only	A 148 (105-85)	A 757 (E2N2/E2Q2) or A 487 (4 class B)
		A 148 (120-95)	A 757 (E2N3/E2Q3) or A 487 (14 class A)

Additional notes for specification are as follows; see original military specification booklet for further information, including Quality Assurance Provisions. The specified residual elements shall be determined for carbon steels. When no impact requirement is given, there shall be a requirement of 20 ft-lbs @ 10 F; except for deck applications, which shall meet a requirement of 20 ft-lbs @ -20 F. When specified, the stress relieving temperature shall be 50 F [30 C] but not more than 100 F [60 C] below the tempering temperature; mechanical properties shall be determined after the stress relief heat treatment.

MIL-C-24707/2 CASTINGS, FOR PRESSURE CONTAINING PARTS SUITABLE FOR HIGH TEMPERATURE SERVICE

This specification covers alloy steel castings for machinery, structural, and pressure containing parts for high temperature applications.

PREVIOUS SPECIFICATION MIL specification (grade)	REPLACEMENT SPECIFICATION MIL-C-24707/2 ASTM specification (grade)
MIL-S-870B	A 217 (WC1)
MIL-S-15464B(SHIPS) (1)	A 217 (WC6)
MIL-S-15464B(SHIPS) (2)	A 217 (WC9)
MIL-S-15464B(SHIPS) (3)	A 389 (C23)

Additional notes for specification are as follows; see original military specification booklet for further information, including Quality Assurance Provisions. When specified, the stress relieving temperature shall be 50 F [30 C] but not more than 100 F [60 C] below the tempering temperature; mechanical properties shall be determined after the stress relief heat treatment.

MIL-S-870B STEEL CASTINGS, MOLYBDENUM ALLOY

Canceled January 27, 1989 – use MIL-C-24707/2, grade WC1

MIL-S-15083B(NAVY) STEEL CASTINGS

Canceled January 27, 1989 – use MIL-C-24707/1, ASTM A757, A216, A487

MIL-S-15464B(SHIPS) STEEL ALLOY, CHROMIUM-MOLYBDENUM; CASTINGS

Canceled January 27, 1989 – use MIL-C-24707/2, ASTM A217, A389

MIL-S-23008D(SH) STEEL CASTINGS, ALLOY, HIGH YIELD STRENGTH (HY-80 AND HY-100)

Canceled June 5, 2003-

MIL-S-46052A(MR) STEEL CASTINGS, HIGH STRENGTH, LOW ALLOY

This specification covers high strength, low alloy, steel castings.

Canceled May 31, 1983 – use ASTM A 148 / A148M

AUTOMOTIVE STEEL CASTINGS

These specifications cover steel castings used in the automotive and allied industries (last revised Oct 2002).

GRADE & HEAT TREATMENT		CHEMICAL COMPOSITION, % (maximum percent unless range given)					MECHANICAL PROPERTIES (minimum unless range given)						
New Grade	Old Grade	C	Mn	Si	P	S	Tensile Strength ksi	Tensile Strength MPa	Yield Strength Ksi	Yield Strength MPa	Elong %	Red A %	Other Tests Hardness (BHN)
0000	0022	0.12 0.22	0.50 0.90	0.60	0.040	0.045							187
415	0025	0.25	0.75[A]	0.80	0.040	0.045	60	415	30	205	22	30	187
450	0030	0.30	0.70[A]	0.80	0.040	0.045	65	450	35	240	24	35	131 187
585	0050A	0.40 0.50	0.50 0.90	0.80	0.040	0.045	85	585	45	310	16	24	170 229
690	0050B	0.40 0.50	0.50 0.90	0.80	0.040	0.045	100	690	70	485	10	15	207 255
550	080				0.040	0.045	80	550	50	345	22	35	163 207
620	090				0.040	0.045	90	620	60	415	20	40	187 241
725	0105				0.040	0.045	105	725	85	585	17	35	217 248
830	0120				0.040	0.045	120	830	95	655	14	30	248 311
1035	0150				0.040	0.045	150	1035	125	860	9	22	311 363
1205	0175				0.040	0.045	175	1205	145	999.7	6	21	363 415

[A] For each reduction of 0.01% carbon below the maximum specified, an increase of 0.04% manganese above the maximum specified will be permitted to a maximum of 1% manganese

SUMMARY OF MATERIAL SPECIFICATIONS FOR HIGH ALLOY CAST STEELS

The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code makes extensive use of ASTM specifications with slight modifications. For the sake of comparison the ASME specifications use the preface SA so that SA 351 is related to ASTM A 351/A 351M. However, while ASTM A 351/A 351M could be used for comparison of grades, the ASME SA 351 contained in Section II must be used when complying with the code.

Cast stainless steels are most often specified on the basis of composition using the alloy designation system adopted by the Alloy Casting Institute (ACI). These ACI alloy designations, e.g. CF-8M, have been adopted by ASTM and are preferred for cast alloy over the corresponding wrought steel designation of the American Iron and Steel Institute (AISI). The reason for this is that the grades intentionally have different compositions than their wrought counterparts.

The ranges of iron, chromium, and nickel for the cast alloy compositions most widely used are identified with a letter which is part of the ACI grade designation. The initial letter of the grade designation, C or H, indicates whether the alloy is intended primarily for aqueous corrosion service (C) or elevated temperature, i.e. heat-resistant, service (H). The second letter of the ACI designation denotes the nominal chromium-nickel type. As the nickel content of the grade increases, the letter in the ACI designation increases from A (lowest) to Z (highest). Numerals following the letters relate to the maximum carbon content of the corrosion-resistant (C) alloys. When used with heat resistant grades (H), the numerals are the midpoint of a 0.10 carbon range. If additional alloying elements are included in the grade, they are denoted by the addition of a letter to the ACI designation. Thus, CF-8M is an alloy for corrosion resistant service of the 19% Cr and 9% Ni type with a maximum carbon content of 0.08% and which contains molybdenum.

The CF grade alloys constitute the most technologically important and highest tonnage segment of corrosion-resistant casting production. These 19Cr-9Ni alloys are the cast counterparts of the 18Cr-8Ni or AISI 300 series wrought stainless steels. In general, the cast and wrought alloys possess equivalent resistance to corrosive media and they are frequently used in conjunction with each other.

Important differences do exist, however, between the cast CF grade alloys and their wrought AISI counterparts. Most significant among these is the difference in alloy microstructure in the end-use condition. The CF grade cast alloys are duplex ferrite-in-austenite and usually contain from 5 to 40% ferrite, depending on the particular alloy, whereas their wrought counterparts are fully austenitic. The ferrite in cast stainless with duplex structures is magnetic, a point that is often confusing when cast stainless steels are compared to their wrought counterparts by checking their attraction to a magnet. This difference in microstructures is attributable to the fact that the chemical compositions of the cast and wrought alloys are different by intent. Ferrite is present by intent in cast CF grade stainless steels for three reasons: to provide strength, to improve weldability, and to maximize resistance to corrosion in specific environments.

Below is a list of high alloy cast steel specifications, with summary details on the following pages. Note that the values given in the summary of the specifications are stated with either U.S. Conventional Units (USCS) or Metric (SI) units, and are to be regarded separately. Units given in brackets are SI units. The values stated in each system are not exact equivalents (soft conversion); therefore, each system must be used independently of the other. Combining values from the two systems, by using conversion equations (hard conversion), may result in nonconformance with the specification. Also note that the values in the table are given in a minimum over maximum format. This means that if the value is a minimum it will be listed in the upper portion of the specification's table row and in the lower portion of the row if it is a maximum value. Finally, note that tables and their footnotes may be split across two or more pages.

ASTM A 128/A128M – 07	Steel Castings, Austenitic Manganese
ASTM A 297/A 297M – 08	Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application
ASTM A 351/A 351M – 06	Castings, Austenitic, Austenitic-Ferritic, For Pressure-Containing Parts
ASTM A 447/A 447M – 07	Steel Castings, Chromium-Nickel-Iron Alloy (25-12 Class), for High-Temperature Service
ASTM A 494/A 494M – 08	Castings, Nickel and Nickel Alloy
ASTM A 560/A 560M – 05	Castings, Chromium-Nickel Alloy
ASTM A 743/A 743M – 06	Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application
ASTM A 744/A 744M – 06	Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service
ASTM A 747/A 747M – 07	Steel Castings, Stainless, Precipitation Hardening
ASTM A 890/A 890M – 07	Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application
ASTM A 990 – 08	Castings, Iron-Nickel-Chromium and Nickel Alloys, Specially Controlled for Pressure Retaining Parts for Corrosive Service
ISO 11972	Corrosion-resistant cast steels for general applications
ISO DIS 11973	Heat-resistant cast steels for general purposes
ISO 12725	Nickel and nickel alloy castings
ISO 19960	Cast Steels and alloys with special physical properties.
MIL-C-24707/3	Castings, Ferrous, Corrosion-Resistant, Austenitic, Chromium-Nickel
MIL-C-24707/6	Castings, Ferrous, Chromium Steel, for Pressure-Containing Parts Suitable for High-Temperature

ASTM A 128/A128M – 07 STEEL CASTINGS, AUSTENITIC MANGANESE

This specification covers Hadfield austenitic manganese steel castings and alloy modifications.

GRADE & HEAT TREATMENT[A]		CHEMICAL COMPOSITION, % (maximum percent unless range given)							
Grade[B] and UNS	Heat Treatment	C	Mn	P	S	Si	Ni	Cr	Mo
A J91109	Q	1.05 1.35	11.0 min	0.07		1.00			
B-1 J91119	Q	0.9 1.05	11.5 14.0	0.07		1.00			
B-2 J91129	Q	1.05 1.2	11.5 14.0	0.07		1.00			
B-3 J91139	Q	1.12 1.28	11.5 14.0	0.07		1.00			
B-4 J91149	Q	1.2 1.35	11.5 14.0	0.07		1.00			
C J91309	Q	1.05 1.35	11.5 14.0	0.07		1.00		1.5 2.5	
D J91459	Q	0.7 1.3	11.5 14.0	0.07		1.00	3.0 4.0		
E-1 J91249	Q	0.7 1.3	11.5 14.0	0.07		1.00			0.9 1.2
E-2 J91339	Q	1.05 1.45	11.5 14.0	0.07		1.00			1.8 2.1
F J91340	Q	1.05 1.35	6.0 8.0	0.07		1.00			0.9 1.2

[A] Section size precludes the use of all grades and the producer should be consulted as to grades practically obtainable for a particular design required. Final selection shall be by mutual agreement between manufacturer and purchaser.
[B] Unless otherwise specified, Grade A will be supplied.

ASTM A 297/A 297M – 08 STEEL CASTINGS, IRON-CHROMIUM AND IRON-CHROMIUM-NICKEL, HEAT RESISTANT, FOR GENERAL APPLICATION

This specification covers iron-chromium and iron-chromium-nickel alloy castings for heat-resistant service. The grades covered by this specification are general purpose alloys and no attempt has been made to include heat-resisting alloys used for special production application.

GRADE		MECHANICAL PROPERTIES (minimum unless range given)					CHEMICAL COMPOSITION, % (maximum percent unless range given)							
Grade and UNS	Heat Treatment[A]	Tensile Strength		Yield Strength		Elong[B] %	C	Mn	P	S	Si	Ni	Cr	Mo[C]
		ksi	MPa	ksi	MPa									
HF J92603		70	485	35	240	25	0.20 0.40	2.00	0.04	0.04	2.00	8.00 12.0	18.0 23.0	0.50
HH J93503		75	515	35	240	10	0.20 0.50	2.00	0.04	0.04	2.00	11.0 14.0	24.0 28.0	0.50
HI J94003		70	485	35	240	10	0.20 0.50	2.00	0.04	0.04	2.00	14.0 18.0	26.0 30.0	0.50
HK J94224		65	450	35	240	10	0.20 0.60	2.00	0.04	0.04	2.00	18.0 22.0	24.0 28.0	0.50
HE J93403		85	585	40	275	9	0.20 0.50	2.00	0.04	0.04	2.00	8.00 11.0	26.0 30.0	0.50

GRADE		MECHANICAL PROPERTIES (minimum unless range given)					CHEMICAL COMPOSITION, % (maximum percent unless range given)							
Grade and UNS	Heat Treatment[A]	Tensile Strength		Yield Strength		Elong[B]	C	Mn	P	S	Si	Ni	Cr	Mo[C]
		ksi	MPa	ksi	MPa	%								
HT N08605		65	450			4	0.35 0.75	2.00	0.04	0.04	2.50	33.0 37.0	15.0 19.0	0.50
HU N08004		65	450			4	0.35 0.75	2.00	0.04	0.04	2.50	37.0 41.0	17.0 21.0	0.50
HW N08001		60	415				0.35 0.75	2.00	0.04	0.04	2.50	58.0 62.0	10.0 14.0	0.50
HX N06006		60	415				0.35 0.75	2.00	0.04	0.04	2.50	64.0 68.0	15.0 19.0	0.50
HC J92605		55	380				0.50	1.00	0.04	0.04	2.00	4.00	26.0 30.0	0.50
HD J93005		75	515	35	240	8	0.50	1.50	0.04	0.04	2.00	4.00 7.00	26.0 30.0	0.50
HL N08604		65	450	35	240	10	0.20 0.60	2.00	0.04	0.04	2.00	18.0 22.0	28.0 32.0	0.50
HN J94213		63	435			8	0.20 0.60	2.00	0.04	0.04	2.00	23.0 27.0	19.0 23.0	0.50
HP N08705		62.5	430	34	235	4.5	0.35 0.75	2.00	0.04	0.04	2.50	33 37	24 28	0.50

[A] As-cast or as agreed upon by the manufacturer and purchaser
[B] When ICI test bars are used in tensile tests as provided for in this specification, the gage length to reduced section diameter ratio shall be 4:1
[C] Castings having a specified molybdenum range agreed upon by the manufacturer and the purchaser may also be furnished under these specifications

ASTM A 351/A 351M – 06 CASTINGS, AUSTENITIC, AUSTENITIC-FERRITIC, FOR PRESSURE-CONTAINING PARTS

This specification covers austenitic and austenitic-ferritic (duplex) steel castings for valves, flanges, fittings, and other pressure-containing parts.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)					CHEMICAL COMPOSITION, % (maximum percent unless range given)											
Grade and UNS	Heat Treatment[B]	Tensile Strength		Yield Strength[H]		Elong[D]	C	Mn	P	S	Si	Ni	Cr	Mo	N	Cb	Cu	V
		ksi	MPa	ksi	MPa	%												
CF3 J92700	ST	70	485	30	205	35.0	0.03	1.50	0.040	0.040	2.00	8.0 12.0	17.0 21.0	0.50				
CF3A[A] J92700	ST	77	530	35	240	35.0	0.03	1.50	0.040	0.040	2.00	8.0 12.0	17.0 21.0	0.50				
CF8 J92600	ST	70	485	30	205	35.0	0.08	1.50	0.040	0.040	2.00	8.0 11.0	18.0 21.0	0.50				
CF8A[A] J92600	ST	77	530	35	240	35.0	0.08	1.50	0.040	0.040	2.00	8.0 11.0	18.0 21.0	0.50				
CF3M J92800	ST	70	485	30	205	30.0	0.03	1.50	0.040	0.040	1.50	9.0 13.0	17.0 21.0	2.00 3.00				
CF3MA[A] J92800	ST	80	550	37	255	30.0	0.03	1.50	0.040	0.040	1.50	9.0 13.0	17.0 21.0	2.00 3.00				
CF8M J92900	ST	70	485	30	205	30.0	0.08	1.50	0.040	0.040	1.50	9.0 12.0	18.0 21.0	2.00 3.00				
CF3MN J92804	ST	75	515	37	255	35.0	0.03	1.50	0.040	0.040	1.50	9.0 13.0	17.0 21.0	2.00 3.00	0.10 0.20			

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)					CHEMICAL COMPOSITION, % (maximum percent unless range given)											
Grade and UNS	Heat Treatment[B]	Tensile Strength		Yield Strength[H]		Elong[D] %	C	Mn	P	S	Si	Ni	Cr	Mo	N	Cb	Cu	V
		ksi	MPa	ksi	MPa													
CF8C J92710	ST	70	485	30	205	30.0	 0.08	 1.50	 0.040	 0.040	 2.00	9.0 12.0	18.0 21.0	 0.50		[E]		
CF-10 J92590	ST	70	485	30	205	35.0	0.04 0.10	 1.50	 0.040	 0.040	 2.00	8.0 11.0	18.0 21.0	 0.50				
CF-10M J92901	ST	70	485	30	205	30.0	0.04 0.10	 1.50	 0.040	 0.040	 1.50	9.0 12.0	18.0 21.0	2.00 3.00				
CH8 J93400	ST	65	450	28	195	30.0	 0.08	 1.50	 0.040	 0.040	 1.50	12.0 15.0	22.0 26.0	 0.50				
CH10 J93401	ST	70	485	30	205	30.0	0.04 0.10	 1.50	 0.040	 0.040	 2.00	12.0 15.0	22.0 26.0	 0.50				
CH20 J93402	ST	70	485	30	205	30.0	0.04 0.20	 1.50	 0.040	 0.040	 2.00	12.0 15.0	22.0 26.0	 0.50				
CK20 J94202	ST	65	450	28	195	30.0	0.04 0.20	 1.50	 0.040	 0.040	 1.75	19.0 22.0	23.0 27.0	 0.50				
HK30 J94203	As cast	65	450	30	240	10.0	0.25 0.35	 1.50	 0.040	 0.040	 1.75	19.0 22.0	23.0 27.0	 0.50				
HK40 J94204	As cast	62	425	30	240	10.0	0.35 0.45	 1.50	 0.040	 0.040	 1.75	19.0 22.0	23.0 27.0	 0.50				
HT30 N08030	As cast	65	450	28	195	15.0	0.25 0.35	 2.00	 0.040	 0.040	 2.50	33.0 37.0	13.0 17.0	 0.50				
CF10MC J92971	ST	70	485	30	205	20.0	 0.10	 1.50	 0.040	 0.040	 1.50	13.0 16.0	15.0 18.0	1.75 2.25		[F]		
CN7M N08007	ST	62	425	25	170	35.0	 0.07	 1.50	 0.040	 0.040	 1.50	27.5 30.5	19.0 22.0	2.00 3.00			3.0 4.0	
CN3MN J94651	ST	80	550	38	260	35.0	 0.03	 2.00	 0.040	 0.010	 1.00	23.5 25.5	20.0 22.0	6.0 7.0	0.18 0.26		0.75	
CE8MN	ST [C]	95	655	65	450	25.0	 0.08	 1.00	 0.040	 0.040	 1.50	8.0 11.0	22.5 25.5	3.0 4.5	0.10 0.30			
CG6MMN J93790	ST	85	585	42.5	295	30.0	 0.06	4.00 6.00	 0.040	 0.030	 1.00	11.50 13.50	20.50 23.50	1.50 3.00	0.20 0.40	0.10 0.30		0.10 0.30
CG8M J93000	ST	75	515	35	240	25.0	 0.08	 1.50	 0.04	 0.04	 1.50	9.0 13.0	18.0 21.0	3.0 4.0				
CF10SMnN J92972	ST	85	585	42.5	295	30.0	 0.10	7.00 9.00	 0.060	 0.03	3.50 4.50	8.0 9.0	16.0 18.0		0.08 0.18			
CT15C N08151	As cast	63	435	25	170	20.0	0.05 0.15	0.15 1.50	 0.03	 0.03	0.15 1.50	31.0 34.0	19.0 21.0			0.50 1.50		
CK3MCuN J93254	ST [C]	80	550	38	260	35.0	 0.025	 1.20	 0.045	 0.010	 1.00	17.5 19.5	19.5 20.5	6.0 7.0	0.18 0.24		0.50 1.00	
CE20N[A,G] J92802	ST [C]	85	550	40	275	30.0	 0.20	 1.50	 0.040	 0.040	 1.50	8.0 11.0	23.0 26.0	 0.50	0.08 0.20			
CG3M J92999	ST	75	515	35	240	25.0	 0.03	 1.50	 0.04	 0.04	 1.50	9.0 13.0	18.0 21.0	3.0 4.0				

[A] Because of thermal instability of Grades CF3A, CF3MA, CF8A, and CE20N they are not recommended for service at temperatures above 800 F [425 C]
[B] ST = to be solution treated
[C] Refer to original specification for additional information on heat treatment requirements
[D] When ICI test bars are used in tensile tests as provided for in Specification A 985/A 985M, the gage length to reduced section diameter ratio shall be 4:1
[E] Grade CF8C shall have a columbium content of not less than 8 times the carbon content but not over 1.00%
[F] Grade CF10MC shall have a columbium content of not less than 10 times the carbon content but not over 1.20%
[G] Grade shall be quenched in water or the castings may be furnace cooled to 2050°F(1120°C) minimum, held for 15 minutes minimum and then quenched in water or rapidly cooled by other means.
[H] Determine by the 0.2% offset method.

ASTM A 447/A 447M – 07 STEEL CASTINGS, CHROMIUM-NICKEL-IRON ALLOY (25-12 CLASS), FOR HIGH-TEMPERATURE SERVICE

This specification covers iron-base, heat-resisting alloy castings of the 25% chromium, 12% nickel class, intended for structural elements, containers, and supports in electric furnaces, petroleum still tube supports, and for similar applications up to 2000 F [1095 C]. The purchaser should inform the manufacturer when the service temperatures are to exceed 1800 F [980 C].

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)				CHEMICAL COMPOSITION, % (maximum percent unless range given)								
Grade And UNS	Heat Treatment[A]	Tensile Strength[BC]		Red A %	Other Tests[DE] Magnetic Permeability	C	Mn	P	S	Si	Ni[F]	Cr	N	Fe[G]
		ksi	MPa											
I J93303	As cast	80	550	9	1.70	0.20 0.45	2.50	0.05	0.05	1.75	10.00 14.00	23.00 28.00	0.20	
II J93303	As cast	80	550	4	1.05	0.20 0.45	2.50	0.05	0.05	1.75	10.00 14.00	23.00 28.00	0.20	

[A] As agreed upon by manufacturer and purchaser
[B] Properties after aging
[C] Short term, high temperature tensile property requirements for the grades are as follows: Type I is to be agreed upon by manufacturer and producer, and Type II is to have a minimum of 20 ksi [140 MPa] tensile strength and a minimum elongation of 8%
[D] The stress rupture test for the grades is as follows with the tensile stress being sustained for at least 16h: Type I at 5 ksi [34 MPa] and Type II at 8 ksi [55 MPa]
[E] Refer to original specification for details; note that out of the four tests (tension after aging, magnetic permeability, stress rupture, and short time high-temperature) the purchaser shall specify no more than two tests
[F] Commercial nickel usually carries a small amount of cobalt, and within the usual limits cobalt shall be counted as nickel
[G] The manufacturer and purchaser may agree upon allowable limits of iron and other elements

ASTM A 494/A 494M – 08 CASTINGS, NICKEL AND NICKEL ALLOY

This specification covers nickel, nickel-copper, nickel-copper-silicon, nickel-molybdenum, nickel chromium, and nickel- molybdenum-chromium alloy castings for corrosion resistant service.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)					CHEMICAL COMPOSITION, % (maximum percent unless range given)														
Grade And UNS	Heat Treatment	Tensile Strength		Yield Strength		Elong [E] %	C	Mn	Si	P	S	Cu	Mo	Fe	Ni	Cr	Cb	W	V	Bi	Sn
		ksi	MPa	ksi	MPa																
CZ-100 N02100	As cast	50	345	18	125	10.0	1.00	1.50	2.00	0.03	0.03	1.25		3.00	95.0 min						
M-35-1 [A] N24135	As cast	65	450	25	170	25.0	0.35	1.50	1.25	0.03	0.03	26.0 33.0			bal.		0.5				
M-35-2 N04020	As cast	65	450	30	205	25.0	0.35	1.50	2.00	0.03	0.03	26.0 33.0		3.50	bal.		0.5				
M-30H N24030	As cast	100	690	60	415	10	0.30	1.50	2.7 3.7	0.03	0.03	27.0 33.0		3.50	bal.		[B]				
M-25S [C,D] N24025	As cast or age-hardened [F]						0.25	1.50	3.5 4.5	0.03	0.03	27.0 33.0		3.50	bal.						
M-30C [A] N24130	As cast	65	450	32.5	225	25	0.30	1.50	1.0 2.0	0.03	0.03	26.0 33.0		3.50	bal.		1.0 3.0				
N3M J30003	ST	76	525	40	275	20.0	0.30	1.00	0.50	0.040	0.300		30.0 33.0	3.00	bal.	1.0			[B]		
N-7M J30007	ST	76	525	40	275	20.0	0.07	1.00	1.00	0.040	0.030		30.0 33.0	3.0	bal.	1.0			[B]		
N-12MV N30012	ST	76	525	40	275	6.0	0.12	1.00	1.00	0.040	0.030		26.0 30.0	4.0 6.0	bal.	1.00			0.20 0.60		
CY-40 N06040	As cast or ST	70	485	28	195	30.0	0.40	1.50	3.00	0.03	0.03			11.0	bal.	14.0 17.0	[B]	[B]	[B]		
CW-12MW N30002	ST	72	495	40	275	4.0	0.12	1.00	1.00	0.040	0.030	[B]	16.0 18.0	4.5 7.5	bal.	15.5 17.5	[B]	3.75 5.25	0.20 0.40		
CW-6M N30107	ST	72	495	40	275	25.0	0.07	1.00	1.00	0.040	0.030	[B]	17.0 20.0	3.0	bal.	17.0 20.0	[B]	[B]	[B]		
CW-2M N26455	ST	72	495	40	275	20.0	0.02	1.00	0.80	0.03	0.03	[B]	15.0 17.5	2.0	bal.	15.0 17.5	[B]	1.0	[B]		
CW-6MC N26625	ST	70	485	40	275	25.0	0.06	1.00	1.00	0.015	0.015	[B]	8.0 10.0	5.0	bal.	20.0 23.0	3.15 4.50	[B]	[B]		
CY5SnBiM N26055	As cast						0.05	1.5	0.5	0.03	0.03		2.0 3.5	2.0	bal.	11.0 14.0				3.0 5.0	3.0 5.0
CX2M N260022	ST	72	495	39	270	40	0.02	1.00	0.50	0.20	0.20	[B]	15.0 16.5	1.5	bal.	22.0 24.0	[B]	[B]	[B]		
CX2MW N26022	ST	80	550	45	280	30.0	0.02	1.00	0.08	0.025	0.025	[B]	12.5 14.5	2.0 6.0	bal.	20.0 22.5	[B]	2.5 3.5	0.35		
CU5MCuC N28820	ST [F]	75	520	35	240	20.0	0.050	1.0	1.0	0.030	0.030	1.50 3.50	2.5 3.5	bal.	38.0 44.0	19.5 23.5	0.60 1.20	[B]	[B]		

[A] When weldability is needed, Grade M-35-1 or M-30C should be ordered
[B] For information only
[C] Minimum age-hardened 300 BHN

[D] M-25S, while machinable in the "as cast" condition is capable of being solution treated for improved machinability; it may be subsequently age-hardened to the specified hardness and finished machined or ground
[E] When ICI test bars are used in tensile tests as provided for per Specification A 732/A 732M, the gage length to reduced section diameter ratio shall be 4:1
[F] Refer to original specification for additional information on heat treatment requirements

ASTM A 560/A 560M – 05 CASTINGS, CHROMIUM-NICKEL ALLOY

This specification covers chromium-nickel alloy castings intended for heat resisting and elevated-temperature corrosion applications such as structural members, containers, supports, hangers, spacers and the like in corrosive environments up to 2000 F [1090 C].

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)						CHEMICAL COMPOSITION, % (maximum percent unless range given)[D]												
Grade And UNS	Heat Treatment[A]	Tensile Strength ksi	Tensile Strength MPa	Yield Strength ksi	Yield Strength MPa	Elong %	Other Tests	C	Mn	Si	S	P	N	N+C	Fe	Ti	Al	Cb	Cr	Ni
50 Cr-50 Ni R20500	As cast	80	550	50	340	5.0	[B]	0.10	0.30	1.00	0.02	0.02	0.30		1.00	0.50	0.25		48.0 52.0	bal
60 Cr-40 Ni R20600	As cast	110	760	85	590		[C]	0.10	0.30	1.00	0.02	0.02	0.30		1.00	0.50	0.25		58.0 62.0	bal
50 Cr-50 Ni-Cb R20501	As cast	80	550	50	345	5.0		0.10	0.30	0.50	0.02	0.02	0.16	0.20	1.00	0.50	0.25	1.4 1.7	47.0 52.0	bal

[A] Heat treatment as agreed upon by manufacturer and purchaser
[B] Impact, unnotched Charpy, 50 ft-lbs [78J] minimum
[C] Impact, unnotched Charpy, 10 ft-lbs [14J] minimum
[D] The total of the Cr, Ni, and Cb contents must exceed 97.5%

ASTM A 743/A 743M – 06 CASTINGS, IRON-CHROMIUM, IRON-CHROMIUM-NICKEL, CORROSION RESISTANT, FOR GENERAL APPLICATION

This specification covers iron-chromium and iron-chromium-nickel-alloy castings for general corrosion-resistant application. The grades covered by this specification represent types of alloy castings suitable for broad ranges of application which are intended for a wide variety of corrosion environments.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)													
Grade and UNS	Heat Treatment[A]	Tensile Strength ksi	Tensile Strength Mpa	Yield Strength Ksi	Yield Strength Mpa	Elong[D] %	Red A %	Other Tests	C	Mn	Si	P	S	Cr	Ni	Mo	Cb	Se	Cu	W	V	N
CF-8 J92600	ST	70[E]	485[E]	30[E]	205[E]	35		[B]	0.08	1.50	2.00	0.04	0.04	18.0 21.0	8.0 11.0							
CG-12 J93001	ST	70	485	28	195	35			0.12	1.50	2.00	0.04	0.04	20.0 23.0	10.0 13.0							
CF-20 J92602	ST	70	485	30	205	30			0.20	1.50	2.00	0.04	0.04	18.0 21.0	8.0 11.0							
CF-8M J92900	ST	70	485	30	205	30		[B]	0.08	1.50	2.00	0.04	0.04	18.0 21.0	9.0 12.0	2.0 3.0						
CF-8C J92710	ST	70	485	30	205	30		[B]	0.08	1.50	2.00	0.04	0.04	18.0 21.0	9.0 12.0		[G]	0.2 0.35				
CF-16F J92701	ST	70	485	30	205	25			0.16	1.50	2.00	0.17	0.04	18.0 21.0	9.0 12.0	1.50						

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)													
Grade and UNS	Heat Treatment[A]	Tensile Strength ksi	Tensile Strength Mpa	Yield Strength Ksi	Yield Strength Mpa	Elong[D] %	Red A %	Other Tests	C	Mn	Si	P	S	Cr	Ni	Mo	Cb	Se	Cu	W	V	N
CF-16Fa	ST	70	485	30	205	25			0.16	1.50	2.00	0.04	0.20 0.40	18.0 21.0	9.0 12.0	0.4 0.8						
CH-10 J93401	ST	70	485	30	205	30			0.10	1.50	2.00	0.04	0.04	22.0 26.0	12.0 15.0							
CH-20 J93402	ST	70	485	30	205	3 0			0.20	1.50	2.00	0.04	0.04	22.0 26.0	12.0 15.0							
CK-20 J94202	ST	65	450	28	195	30			0.20	2.00	2.00	0.04	0.04	23.0 27.0	19.0 22.0							
CE-30 J93423	ST	80	550	40	275	10			0.30	1.50	2.00	0.04	0.04	26.0 30.0	8.0 11.0							
CA-15 J91150	NT or A	90	620	65	450	18	30	[C]	0.15	1.00	1.50	0.04	0.04	11.5 14.0	1.00	0.50						
CA-15M J91151	NT or A	90	620	65	450	18	30	[C]	0.15	1.00	0.65	0.040	0.040	11.5 14.0	1.0	0.15 1.00						
CB-30 J91803	N or A	65	450	30	205			[C]	0.30	1.00	1.50	0.04	0.04	18.0 21.0	2.00				[H]			
CC-50 J92615	N or A	55	380					[C]	0.50	1.00	1.50	0.04	0.04	26.0 30.0	4.00							
CA-40 J91153	NT or A	100	690	70	485	15	25	[C]	0.20 0.40	1.00	1.50	0.04	0.04	11.5 14.0	1.0	0.50						
CA-40F J91154	NT or A	100	690	70	485	12		[C]	0.20 0.40	1.00	1.50	0.04	0.20 0.40	11.5 14.0	1.0	0.5						
CF-3 J92500	As cast or ST	70	485	30	205	35		[B]	0.03	1.50	2.00	0.04	0.04	17.0 21.0	8.0 12.0							
CF10SMnN J92972	ST	85	585	42	290	30			0.10	7.0 9.0	3.50 4.50	0.060	0.030	16.0 18.0	8.0 9.0							0.08 0.18
CF-3M J92800	As cast or ST	70	485	30	205	30		[B]	0.03	1.50	1.50	0.04	0.04	17.0 21.0	9.0 13.0	2.0 3.0						
CF3MN J92804	As cast or ST	75	515	37	255	35			0.03	1.50	1.50	0.040	0.040	17.0 21.0	9.0 13.0							0.10 0.20
CG6MMN J93790	ST	85	585	42	290	30			0.006	4.0 6.0	1.00	0.04	0.03	20.5 23.5	11.5 13.5	1.50 3.00	0.10 0.30			0.10 0.30	0.20 0.40
CG-3M J92999	ST	75	515	35	240	25		[B]	0.03	1.50	1.50	0.04	0.04	18.0 21.0	9.0 13.0	3.0 4.0						
CG-8M J93000	ST	75	520	35	240	25			0.08	1.50	1.50	0.04	0.04	18.0 21.0	9.0 13.0	3.0 4.0						
CN3M J94652	ST	63	435	25	170	30			0.03	2.0	1.0	0.03	0.03	20.0 22.0	23.0 27.0	4.5 5.5						
CN-3MN J94651	ST	80	550	38	260	35			0.03	2.00	1.00	0.040	0.010	20.0 22.0	23.5 15.5	6.0 7.0			0.75			0.18 0.26
CN-7M N08007	ST	62	425	25	170	35			0.07	1.50	1.50	0.04	0.04	19.0 22.0	27.5 30.5	2.0 3.0			3.0 4.0			
CN-7MS J94650	ST	70	485	30	205	35			0.07	1.00	2.50 3.50	0.04	0.03	18.0 20.0	22.0 25.0	2.5 3.0			1.5 2.0			
CA-6NM J91540	NT	110	755	80	550	15	35	[C]	0.06	1.00	1.00	0.04	0.03	11.5 14.0	3.5 4.5	0.40 1.0						

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)													
Grade and UNS	Heat Treatment[A]	Tensile Strength ksi	Tensile Strength Mpa	Yield Strength Ksi	Yield Strength Mpa	Elong[D] %	Red A %	Other Tests	C	Mn	Si	P	S	Cr	Ni	Mo	Cb	Se	Cu	W	V	N
CA-6N J91650	NT	140	965	135	930	15	50	[C]	0.06	0.50	1.00	0.02	0.02	10.5 12.5	6.0 8.0							
CA-28MWV[F] J91422	QT or A	140	965	110	760	10	24	[C]	0.20 0.28	0.50 1.00	1.0	0.030	0.030	11.0 12.5	0.50 1.00	0.90 1.25				0.90 1.25	0.20 0.30	
CK-3MCuN J93254	ST	80	550	38	260	35			0.025	1.20	1.00	0.045	0.010	19.5 20.5	17.5 19.5	6.0 7.0			0.50 1.00			0.18 0.24
CK-35MN	ST	83	570	41	280	35			0.035	2.0	1.00	0.035	0.020	22.0 24.0	20.0 22.0	6.0 6.8			0.40			0.21 0.32
CB-6 J91804	NT	115	790	85	580	16	35		0.06	1.00	1.00	0.04	0.03	15.5 17.5	3.5 5.5	0.5						

[A] Refer to original specification for additional heat treatment information
[B] Supplementary intergranular corrosion test if specified by the customer
[C] Supplementary requirement for hardness tests when desired by the purchaser
[D] When ICI test bars are used in tensile tests as provided for in this specification, the gage length to reduced section diameter ratio shall be 4:1
[E] For low ferrite or nonmagnetic castings of this grade, the following values shall apply: tensile strength, min, 65 ksi [450 MPa]; yield point, min, 28 ksi [195 MPa]
[F] These mechanical properties apply only when heat-treatment (1) has been used
[G] Grade CF-8C shall have a columbium content of not less than 8 times the carbon content and not more than 1.0% - if a columbium plus tantalum alloy in the approximate Cb:Ta ratio of 3:1 is used for stabilizing this grade, the total columbium-plus-tantalum content shall not be less than nine times the carbon content and shall not exceed 1.1%
[H] For Grade CB-30 a copper content of 0.90 to 1.20% is optional

ASTM A 744/A 744M – 06 CASTINGS, IRON-CHROMIUM-NICKEL, CORROSION RESISTANT, FOR SEVERE SERVICE

This specification covers iron-chromium-nickel-alloy, stainless steel castings intended for particularly corrosive applications.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)										
Grade and UNS	Heat Treatment[A]	Tensile Strength ksi	Tensile Strength MPa	Yield Strength ksi	Yield Strength MPa	Elong[B] %	Red A %	Other Tests[C]	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	N
CF-8 J92600	ST	70[E]	485[E]	30[E]	205[E]	35			0.08	1.50	0.04	0.04	2.00	8.0 11.0	18.0 21.0				
CF-8M J92900	ST [D]	70	485	30	205	30			0.08	1.50	0.04	0.04	2.00	9.0 12.0	18.0 21.0	2.0 3.0			
CF-8C J92710	ST	70	485	30	205	30			0.08	1.50	0.04	0.04	2.00	9.0 12.0	18.0 21.0		[F]		
CF-3 J92500	ST	70	485	30	205	35			0.03[G]	1.50	0.04	0.04	2.00	8.0 12.0	17.0 21.0				
CF-3M J92800	ST [D]	70	485	30	205	30			0.03[G]	1.50	0.04	0.04	1.50	9.0 13.0	17.0 21.0	2.0 3.0			
CG-3M J92999	ST	75	515	35	240	25			0.03	1.50	0.04	0.04	1.50	9.0 13.0	18.0 21.0	3.0 4.0			
CG-8M J93000	ST [D]	75	520	35	240	25			0.08	1.50	0.04	0.04	1.50	9.0 13.0	18.0 21.0	3.0 4.0			
CN-7M N08007	ST	62	425	25	170	35			0.04	1.50	0.04	0.04	1.50	27.5 30.5	19.0 22.0	2.0 3.0		3.0 4.0	
CN-7MS J94650	ST	70	485	30	205	35			0.07	1.00	0.04	0.03	2.50 3.50	22.0 25.0	18.0 20.0	2.5 3.0		1.5 2.0	
CN-3MN J94651	ST	80	550	38	260	35			0.03	2.00	0.040	0.010	1.00	23.5 25.5	20.0 22.0	6.00 7.00		0.75	0.18 0.26
CK3MCuN J93254	ST	80	550	38	260	35			0.025	1.20	0.045	0.010	1.0	17.5 19.5	19.5 20.5	6.0 7.0		0.50 1.00	0.180 0.240

[A] Refer to original specification for additional heat treatment information
[B] When ICI test bars are used in tensile tests as provided for in this specification, the gage length to reduced section diameter ratio shall be 4:1
[C] Supplementary intergranular corrosion test if specified by the customer
[D] For optimum tensile strength, ductility and corrosion resistance, the solution annealing temperature should be in excess of 1900 F [1040 C]
[E] For low ferrite or nonmagnetic castings of this grade, the following values shall apply: tensile strength, min, 65 ksi [450 MPa]; yield point, min, 28 ksi [195 MPa]
[F] Grade CF-8C shall have a columbium content of not less than 8 times the carbon content and not more than 1.0% - if a columbium-plus-tantalum alloy in the approximate Cb:Ta ration of 3:1 is used for stabilizing this grade, the total columbium-plus-tantalum content shall not be less than 9 times the carbon content sand shall not exceed 1.1%
[G] For purposes of determining conformance with this specification, the observed or calculated value for carbon content shall be rounded to the nearest 0.01% in accordance with rounding method of Recommended Practice E29

ASTM A 747/A 747M – 07 STEEL CASTINGS, STAINLESS, PRECIPITATION HARDENING

This specification covers iron-chromium-nickel-copper corrosion-resistant steel castings, capable of being strengthened by precipitation hardening heat treatment.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)									
Grade and UNS	Heat Treatment	Tensile Strength		Yield Strength		Elong %	Red A %	Other Tests Hardness (HBN)	C	Mn	P	S	Si	Ni	Cr	Cu	Cb	N
		ksi	MPa	ksi	MPa													
CB7Cu-1 J92180	H-900[A]	170	1170	145	1000	5		375	0.07	0.70	0.035	0.03	1.00	3.60 4.60	15.50 17.70	2.50 3.20	0.15[B] 0.35[B]	0.05[C]
	H-925[A]	175	1205	150	1035	5		375										
	H-1025[A]	150	1035	140	965	9		311										
	H-1075[A]	145	1000	115	795	9		277										
	H-1100[A]	135	930	110	760	9		269										
	H-1150[A]	125	860	97	670	10		269										
	H-1150M							310 Max										
	H-1150DBL							310 Max										
CB7Cu-2 J92110	H-900[A]	170	1170	145	1000	5		375	0.07	0.70	0.035	0.03	1.00	4.50 5.50	14.0 15.50	2.50 3.20	0.15[B] 0.35[B]	0.05[C]
	H-925[A]	175	1205	150	1035	5		375										
	H-1025[A]	150	1035	140	965	9		311										
	H-1075[A]	145	1000	115	795	9		277										
	H-1100[A]	135	930	110	760	9		269										
	H-1150[A]	125	860	97	670	10		269										
	H-1150M							310 Max										
	H-1150DBL							310 Max										

[A] All mechanical properties are supplementary and are not required unless stipulated by the customer, see original specification for additional information
[B] When the H900 condition is ordered, the minimum Cb shall not apply
[C] To be determined and reported when specified by the order or contract

ASTM A 890/A 890M – 07 CASTINGS, IRON-CHROMIUM-NICKEL-MOLYBDENUM CORROSION-RESISTANT, DUPLEX (AUSTENITIC/FERRITIC) FOR GENERAL APPLICATION

This specification covers a group of cast duplex stainless steels (austenitic/ferritic).

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES[B] (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)										
Grade and UNS	Heat Treatment[A]	Tensile Strength		Yield Strength		Elong %	Red A %	Other Tests	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	N	W
		ksi	MPa	ksi	Mpa														
1A CD4MCu J93370	ST	100	690	70	485	16			0.04	1.00	0.040	0.040	1.00	4.75 6.00	24.5 26.5	1.75 2.25	2.75 3.25		
1B CD4MCuN J93372	ST	100	690	70	485	16			0.04	1.0	0.04	0.04	1.0	4.7 6.0	24.5 26.5	1.7 2.3	2.7 3.3	0.10 0.25	
1C[C] CD3MCuN J93373	ST	100	690	65	450	25			0.030	1.20	0.030	0.030	1.10	5.6 6.7	24.0 26.7	2.9 3.8	1.40 1.90	0.22 0.33	
2A CE8MN J93345	ST	95	655	65	450	25			0.08	1.00	0.04	0.04	1.50	8.00 11.00	22.5 25.5	3.00 4.50		0.10 0.30	
3A CD6MN J93371	ST	95	655	65	450	25			0.06	1.00	0.040	0.040	1.00	4.00 6.00	24.0 27.0	1.75 2.50	1.00	0.15 0.25	
4A CD3MN J92205	ST	90	620	60	415	25			0.03	1.50	0.04	0.020	1.00	4.5 6.5	21.0 23.5	2.5 3.5		0.10 0.30	
5A[C] J93404	ST	100	690	75	515	18			0.03	1.50	0.04	0.04	1.00	6.0 8.0	24.0 26.0	4.0 5.0		0.10 0.30	
6A[C] J93380	ST	100	690	65	450	25			0.03	1.00	0.030	0.025	1.00	6.5 8.5	24.0 26.0	3.0 4.0	0.5 1.0	0.20 0.30	0.5 1.0

[A] See original specification for additional details on heat treatment
[B] Tensile requirement is a supplementary requirement, see original specification for additional details
[C] %Cr + 3.3% Mo +16% N ≥ 40

ASTM A 990 – 08

CASTINGS, IRON-NICKEL-CHROMIUM AND NICKEL ALLOYS, SPECIALLY CONTROLLED FOR PRESSURE RETAINING PARTS FOR CORROSIVE SERVICE

This specification covers iron-nickel-chromium and nickel alloy castings specially processed with restricted melt practices, weldability testing and nondestructive examination (NDE) requirements.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)										
Grade and UNS	Heat Treatment[A]	Tensile Strength ksi	Tensile Strength MPa	Yield Strength ksi	Yield Strength MPa	Elong %	Red A %	Other Tests[B]	C	Mn	P	S	Si	Ni	Cr	Mo	Fe	W	Cu
CW-2M	ST	72	495	40	275	20.0			0.020	1.00	0.030	0.015	0.80	Bal.	15.0 17.5	15.0 17.5	2.00	1.00	
CN3MCu	ST	62	425	25	170	35			0.030	1.50	0.030	0.015	1.00		19.0 22.0	2.0 3.0	Bal		3.0 3.5
M35-1	As cast	65	450	25	170	25			0.35	1.50	0.030	0.015	1.25				3.5		26.0 33.0

[A] See original specification for additional details on heat treatment
[B] See original specification for additional details on Nondestructive Examination Requirements

ISO 11972

CORROSION-RESISTANT CAST STEELS FOR GENERAL APPLICATIONS

This International Standard specifies cast steels for general corrosion-resistant applications. The grades covered by this International Standard represent types of alloy steel castings suitable for broad ranges of application which are intended for a wide variety of corrosion applications.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)								CHEMICAL COMPOSITION, % (maximum percent unless range given)										
Grade and UNS	Heat Treatment[A]	Tensile Strength ksi	Tensile Strength Mpa	Yield Strength ksi	Yield Strength Mpa	Elong %	Red A %	Other Tests Impact (J)	Other Tests Ruling Thickness (mm)	C	Mn	P	S	Si	Ni	Cr	Mo	N	Nb	Cu
GX 12 Cr 12	A & T		620		450	14		20	150	0.15	0.8	0.035	0.025	0.8	1.0	11.5 13.5	0.5			
GX 8 CrNiMo 12 1	A & T		590		440	15		27	300	0.10	0.8	0.035	0.025	0.8	0.8 1.8	11.5 13.0	0.2 0.5			
GX 4 CrNi 12 4 (QT 1)	A & T		750		550	15		45	300	0.06	1.5	0.035	0.025	1.0	3.5 5.0	11.5 13.0	1.0			
GX 4 CrNi 12 4 (QT 2)	A & T		900		830	12		35	300	0.06	1.5	0.035	0.025	1.0	3.5 5.0	11.5 13.0	1.0			
GX 4 CrNiMo 16 5 1	A & T		760		540	15		60	300	0.06	0.8	0.035	0.025	0.8	4.0 6.0	15.0 17.0	0.7 1.5			
GX 2 CrNi 18 10	ST		440		180	30		80	150	0.03	1.5	0.040	0.030	1.5	9.0 12.0	17.0 19.0				
GX 2 CrNiN 18 10	ST		510		230	30		80	150	0.03	1.5	0.040	0.030	1.5	9.0 12.0	17.0 19.0		0.10 0.20		
GX 5 CrNi 19 9	ST		440		180	30		60	150	0.07	1.5	0.040	0.030	1.5	8.0 11.0	18.0 21.0				
GX 6 CrNiNb 19 10	ST		440		180	25		40	150	0.08	1.5	0.040	0.030	1.5	9.0 12.0	18.0 21.0			8xC 1.00	

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)								CHEMICAL COMPOSITION, % (maximum percent unless range given)										
Grade and UNS	Heat Treatment[A]	Tensile Strength		Yield Strength		Elong %	Red A %	Other Tests		C	Mn	P	S	Si	Ni	Cr	Mo	N	Nb	Cu
		ksi	Mpa	ksi	Mpa			Impact (J)	Ruling Thickness (mm)											
GX 2 CrNiMo 19 11 2	ST		440		180	30		80	150	0.03	1.5	0.040	0.030	1.5	9.0 12.0	17.0 20.0	2.0 2.5			
GX 2 CrNiMoN 19 11 2	ST		510		230	30		80	150	0.03	1.5	0.040	0.030	1.5	9.0 12.0	17.0 20.0	2.0 2.5	0.10 0.20		
GX 5 CrNiMo 19 11 2	ST		440		180	30		60	150	0.07	1.5	0.040	0.030	1.5	9.0 12.0	17.0 20.0	2.0 2.5			
GX 6 CrNiMoNb 19 11 2	ST		440		180	25		40	150	0.08	1.5	0.040	0.030	1.5	9.0 12.0	17.0 20.0	2.0 2.5		8xC 1.00	
GX 2 CrNiMo 19 11 3	ST		440		180	30		80	150	0.03	1.5	0.040	0.030	1.5	9.0 12.0	17.0 20.0	3.0 3.5			
GX 2 CrNiMoN 19 11 3	ST		510		230	30		80	150	0.03	1.5	0.040	0.030	1.5	9.0 12.0	17.0 20.0	3.0 3.5	0.10 0.20		
GX 5 CrNiMo 19 11 3	ST		440		180	30		60	150	0.07	1.5	0.040	0.030	1.5	9.0 12.0	17.0 20.0	3.0 3.5			
GX 2 CrNiCuMoN 26 5 3 3	ST		650		450	18		50	150	0.03	1.5	0.035	0.025	1.0	4.5 6.5	25.0 27.0	2.5 3.5	0.12 0.25		2.5 3.5
GX 2 CrNiMoN 26 5 3	ST		650		450	18		50	150	0.03	1.5	0.035	0.025	1.0	4.5 6.5	25.0 27.0	2.5 3.5	0.12 0.25		

[A] See original specifications for additional information

ISO 11973 HEAT-RESISTANT CAST STEELS FOR GENERAL PURPOSES

This International Standard covers cast steels for heat resistant service.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)								CHEMICAL COMPOSITION, % (maximum percent unless range given)																
Grade and UNS	Heat Treatment	Tensile Strength		Yield Strength		Elong %	Red A %	Other Tests		C	Mn	P	S	Si	Ni	Cr	Mo	Nb	Co	W	N	N+C	W	Fe
		ksi	MPa	ksi	MPa			Hardness (HBN)	Use Temp. (C)[C]															
GX 30 CrSi 7	A or as cast								750	0.20 0.35	0.50 1.00	0.040	0.040	1.00 2.50	0.50	6.00 8.00	0.50							
GX 40 CrSi 13	A							300[B]	850	0.30 0.50	0.50 1.00	0.040	0.030	1.00 2.50	1.00	12.00 14.00	0.50							
GX 40 CrSi 17	A							300[B]	900	0.30 0.50	0.50 1.00	0.040	0.030	1.00 2.50	1.00	16.00 19.00	0.50							
GX 40 CrSi 24	A							300[B]	1050	0.30 0.50	0.50 1.00	0.040	0.030	1.00 2.50	1.00	23.00 26.00	0.50							
GX 40 CrSi 28	A							320[B]	1100	0.30 0.50	0.50 1.00	0.040	0.030	1.00 2.50	1.00	27.00 30.00	0.50							
GX 130 CrSi 29	A							400[B]	1100	1.20 1.40	0.50 1.00	0.040	0.030	1.00 2.50	1.00	27.00 30.00	0.50							

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)								CHEMICAL COMPOSITION, % (maximum percent unless range given)															
Grade and UNS	Heat Treatment	Tensile Strength		Yield Strength		Elong %	Red A %	Other Tests		C	Mn	P	S	Si	Ni	Cr	Mo	Nb	Co	W	N	N+C	W	Fe
		ksi	MPa	ksi	MPa			Hardness (HBN)	Use Temp. (C)[C]															
GX 25 CrNiSi 18-9	As cast		450		230	15			900	0.15 0.35	2.00	0.040	0.030	1.00 2.50	8.00 10.00	17.00 19.00	0.50								
GX 25 CrNiSi 20-14	As cast		450		230	10			900	0.15 0.35	2.00	0.040	0.030	1.00 2.50	13.00 15.00	19.00 21.00	0.50								
GX 40 CrNiSi 22-10	As cast		450		230	8			950	0.30 0.50	2.00	0.040	0.030	1.00 2.50	9.00 11.00	21.00 23.00	0.50								
GX 40 CrNiSiNb 24-24	As cast		400		220	4			1050	0.25 0.50	2.00	0.040	0.030	1.00 2.50	23.00 25.00	23.00 25.00	0.50	1.20 1.80							
GX 40 CrNiSi 25-12	As cast		450		220	6			1050	0.30 0.50	2.00	0.040	0.030	1.00 2.50	11.00 14.00	24.00 27.00	0.50								
GX 40 CrNiSi 25-20	As cast		450		220	6			1100	0.30 0.50	2.00	0.040	0.030	1.00 2.50	19.00 22.00	24.00 27.00	0.50								
GX 40 CrNiSi 27-4	As cast		400		250	3		400 Max	1100	0.30 0.50	1.50	0.040	0.030	1.00 2.50	3.00 6.00	25.00 28.00	0.50								
GX 40 NiCrCo 20-20-20	As cast		400		320	6			1150	0.35 0.60	2.00	0.040	0.030	1.00	18.00 22.00	19.00 22.00	2.50 3.00		18.00 22.00	2.0 3.0				
GX 10 NiCrNb 31-20	As cast		440		170	20			1000	0.05 0.12	1.20	0.040	0.030	1.20	30.00 34.00	19.00 23.00	0.50	0.80 1.50							
GX 40 NiCrSi 35-17	As cast		420		220	6			980	0.30 0.50	2.00	0.040	0.030	1.00 2.50	34.00 36.00	16.00 18.00	0.50								
GX 40 NiCrSi 35-26	As cast		440		220	6			1050	0.30 0.50	2.00	0.040	0.030	1.00 2.50	33.00 36.00	24.00 27.00	0.50								
GX 40 NiCrSiNb 35-26	As cast		440		220	4			1050	0.30 0.50	2.00	0.040	0.030	1.00 2.50	33.00 36.00	24.00 27.00	0.50	0.80 1.80							
GX 40 NiCrSi 38-19	As cast		420		220	6			1050	0.30 0.50	2.00	0.040	0.030	1.00 2.50	36.00 39.00	18.00 21.00	0.50								
GX 40 NiCrSiNb 38-19	As cast		420		220	4			1000	0.30 0.50	2.00	0.040	0.030	1.00 2.50	36.00 39.00	18.00 21.00	0.50	1.20 1.80							
GX 45 NiCrWSi 48-28-5	As cast		400		220	3			1200	0.35 0.55	1.50	0.040	0.030	1.00 2.50	47.00 50.00	27.00 30.00				4.00 6.00					
GX 10 NiCrNb 50-50	As cast		540		230	8			1050	0.10	0.50	0.020	0.020	0.50	bal.	47.00 52.00	0.50	1.4 1.7			0.16	0.20		
GX 50 NiCr 52-19	As cast		440		220	5			1100	0.40 0.60	1.50	0.040	0.030	0.50 2.00	50.00 55.00	16.00 21.00	0.50								
GX 50 NiCr 65-15	As cast		400		200	3			1100	0.35 0.65	1.30	0.040	0.030	2.00	64.00 69.00	13.00 19.00								
GX 45 NiCrCoW 35-25-15-5	As cast		480		270	5			1200	0.44 0.48	2.00	0.040	0.030	1.00 2.00	33.00 37.00	24.00 26.00			14.0 16.0				4.0 6.0	
GX 30 CoCr 50-28	As cast		[A]		[A]	[A]		[A]	1200	0.50	1.00	0.040	0.030	1.00	1.00	25.00 30.00	0.50		48.0 52.0					20.0

[A] Properties as agreed upon by manufacturer and purchaser
[B] Maximum hardness in annealed condition – castings may also be supplied in the “as cast” condition, in which case hardness limits will not apply

[C] Maximum use temperature depends upon the actual use conditions and these values are being given only to aid the user; these are given for oxidising environments, the actual alloy composition will also affect performance

ISO 12725 NICKEL AND NICKEL ALLOY CASTINGS

This International Standard specifies requirements for nickel and nickel alloy castings. The grades covered represent types of alloys suitable for a broad range of application in a wide variety of corrosive and high temperature environments.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given) [B]															
Grade and UNS	Heat Treatment[A]	Tensile Strength		Yield Strength		Elong %	Red A %	Other Tests Hardness (HBN)	C	Co	Cr	Cu	Fe	Mn	Mo	Ni	P	S	Si	W	Nb	V	Nb+Ta
		ksi	MPa	ksi	MPa																			
C-Ni99, HC	As cast		345 545		125	10			1.00			1.25	3.0	1.50		95.0	0.030	0.030	2.00				
C-NiCu30Si	As cast		450 650		205	25			0.35			26.0 33.0	3.5	1.50		bal.	0.030	0.030	2.00		0.5		
C-NiCu30	As cast		450		170	25			0.35			26.0 33.0	3.5	1.50		bal.	0.030	0.030	1.25		0.5		
C-NiCu30Si3	As cast		690 890		415	10			0.30			27.0 33.0	3.5	1.50		bal.	0.030	0.030	2.7 3.7				
C-NiCu30Nb2Si2	As cast		450		225	25			0.30			26.0 33.0	.5	1.50		bal.	0.030	0.030	1.0 2.0		1.0 3.0		
C-NiMo31	WQ		525 725		275	6			0.03		1.0		3.0	1.00	30.0 33.0	bal.	0.030	0.030	1.00				
C-NiMo30Fe5	WQ		525 725		275	20			0.05		1.0		4.0 6.0	1.00	26.0 33.0	bal.	0.030	0.030	1.00			0.20 0.60	
-NiCr22Fe20Mo7Cu2	WQ		550 750		220	30			0.02	5.0	21.5 23.5	1.5 2.5	18.0 21.0	1.00	6.0 8.0	bal.	0.025	0.030	1.00	1.50			0.5
C-NiCr22Mo9Nb4	WQ		485 685		275	25			0.06		20.0 23.0		5.0	1.00	8.0 10.0	bal.	0.030	0.030	1.00		3.2 4.5		
C-NiCr16Mo16	WQ		495 695		275	20			0.02		15.0 17.5		2.0	1.00	15.0 17.5	bal.	0.030	0.030	0.80	1.00			
C-NiMo17Cr16Fe6W4	WQ		495 695		275	4			0.06		15.5 17.5		4.5 7.5	1.00	16.0 18.0	bal.	0.030	0.030	1.00	3.8 5.3		0.20 0.40	
C-NiCr21Mo14Fe4W3	WQ		550		280	30			0.02		20.0 22.5		2.0 6.0	1.00	12.5 14.5	bal.	0.025	0.025	0.80	2.5 3.5		0.35	
C-NiCr18Mo18	WQ		495 695		275	25			0.03		17.0 20.0		3.0	1.00	17.0 20.0	bal.	0.030	0.030	1.00				
C-NiCr15Fe	WQ		485 685		195	30			0.40		14.0 17.0		11.0	1.50		bal.	0.030	0.030	3.00				
C-NiFe30Cr20Mo3CuNb	AC		450 650		170	25			0.05		19.5 23.5	1.5 3.0	28.0 32.0	1.00	2.5 3.5	bal.	0.030	0.030	0.75 1.20		0.70 1.00		
C-NiSi9Cu3	AC							300	0.12		1.0	2.4 4.0		1.50		bal.	0.030	0.030	8.5 10.0				

[A] See original specification for full details
[B] Single values are maximum limits, except for nickel for which single values are minimum.

ISO 19960

CAST STEELS AND ALLOYS WITH SPECIAL PHYSICAL PROPERTIES

The cast steel and alloy grades covered by this international standard are used in applications which require low linear thermal expansion, or low ferromagnetic responses, or low galling properties.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)																	
Grade and UNS	Heat Treatment	Tensile Strength		Yield Strength		Elong %	Red A %	Charpy J. min	C	Si	Mn	P	S	Cr	Mo	Ni	N	Co	Cu	Nb	V	Al	Fe	Bi	Sn
		ksi	MPa	ksi	MPa																					
GX12CrNi18-11	ST		440 590		195	20		80	0.15	1.50	2.00	0.045	0.030	16.5 18.5	0.75	10.0 12.0			0.50						
GX2CrNiN18-13	ST		440 640		210	30		115	0.030	1.50	2.00	0.035	0.020	16.5 18.5	1.00	12.0 14.0	0.10 0.20		0.50						
GX2CrNiMoN18-14	ST		490 690		240	30		80	0.030	1.50	2.00	0.035	0.020	16.5 18.5	2.50 3.00	13.0 15.0	0.15 0.25		0.50						
GX2CrNiN19-11	ST		440		180	30			0.030	1.50	2.00	0.035	0.020	18.0 20.0	1.00	10.0 12.0	0.10 0.20		0.50						
GX3CrNiMnSi17-9-8	ST		580		290	24			0.05	3.5 4.5	7.0 9.0	0.045	0.030	16.0 18.0	1.00	8.0 9.0	0.08 0.18		0.50						
GX4CrNiMnN22-12-5	ST		580		290	24			0.06	1.00	4.0 6.0	0.040	0.030	20.5 23.5	1.50 3.00	11.5 13.5	0.20 0.40		0.50	0.10 0.30	0.10 0.30				
GX2CrNiMnMoNNb21-16-5-3	ST		570 800		315	20		65	0.030	1.00	4.0 6.0	0.025	0.010	20.0 21.5	3.0 3.5	15.0 17.0	0.20 0.35		0.50	0.25					
GX3NiCo32	ST + T		425		250	15			0.05	.50	0.60	0.030	0.020	0.25	1.00	30.5 33.5		4.0 6.5	0.50			0.10			
GX3NiCo29-17	ST + T								0.05	.50	0.50	0.030	0.020	0.25	1.00	28.0 30.0		16.0 18.0	0.50						
GX3Ni36	ST + T		260		175	20			0.05	.50	0.50	0.030	0.020	0.25	1.00	35.0 37.0			0.50						
GX3NiS36	ST + T		260		175	20			0.05	.50	0.50	0.030	0.10 0.20	0.25	1.00	35.0 37.0			0.50						
G-NiCr13SnBiMo	As cast								0.05	.50	1.50	0.030	0.030	11.0 14.0	2.00 3.50	Bal.			0.50				2.0	3.0 5.0	3.0 5.0

MIL-C-24707/3

CASTINGS, FERROUS, CORROSION-RESISTANT, AUSTENITIC, CHROMIUM-NICKEL

This specification covers austenitic chromium-nickel alloy castings for corrosion-resistant and low magnetic permeability applications.

PREVIOUS SPECIFICATION MIL specification (class)	REPLACEMENT SPECIFICATION MIL-C-24707/3 ASTM specification (grade)
MIL-S-17509 (I)	A 744 (CF-8)
MIL-S-17509 (II)	A 744 (CF-8C)
MIL-S-17509 (III)	A 744 (CF-8M)
MIL-S-867 (I)	A 744 (CF-8)
MIL-S-867 (II)	A 744 (CF-8C)
MIL-S-867 (III)	A 744 (CF-8M)

Additional notes for specification are as follows; see original military specification booklet for further information, including Quality Assurance Provisions. Two different levels may be specified; level I has no magnetic restrictions and level II has low relative magnetic permeability. For all grades, supplementary requirements SZ1 (intergranular corrosion test) and SZ2 (tension test) of ASTM A 744 shall be mandatory. When type II is specified, the relative magnetic permeability of the castings shall not exceed 1.3 for first article and 1.6 for quality conformance tests; unless otherwise specified, the field strength shall be 0.5 oersteds for first article testing. Heat treat casting per ASTM A 744 except the minimum temperature shall be 1950 F. After all cleaning and machining, the casting shall be passivated in accordance with QQ-P-35.

MIL-C-24707/6 CASTINGS, FERROUS, CHROMIUM STEEL, FOR PRESSURE-CONTAINING PARTS SUITABLE FOR HIGH-TEMPERATURE SERVICE

This specification covers 12% chromium steel castings for high temperatures and for impact at low temperatures.

PREVIOUS SPECIFICATION MIL specification (class)	REPLACEMENT SPECIFICATION MIL-C-24707/6 ASTM specification (grade)
MIL-S-16993 (1)	A 217 (CA-15)
MIL-S-16993 (2)	A 487 (CA-15M, class A)

Additional notes for specification are as follows; see original military specification booklet for further information, including Quality Assurance Provisions. ASTM A 757 grade E3N castings are intended for use where either CA-15 or CA-15M is used; grade E3N has better weldability, corrosion and erosion resistance, low temperature properties such as notch toughness, and improved soundness and casting characteristics. CA-15M castings shall be normalized and tempered only with a tempering temperature not less than 1100 F; a liquid quench shall not be used without the permission of the Command or agency concerned.

SUMMARY OF MATERIAL SPECIFICATIONS FOR CENTRIFUGALLY CAST STEELS

Below is a list of centrifugally cast steel specifications, with summary details on the following pages. Note that the values given in the summary of the specifications are stated with either U.S. Conventional Units (USCS) or Metric (SI) units, and are to be regarded separately. Units given in brackets are SI units. The values stated in each system are not exact equivalents (soft conversion); therefore, each system must be used independently of the other. Combining values from the two systems, by using conversion equations (hard conversion), may result in nonconformance with the specification. Also note that the values in the table are given in a minimum over maximum format. This means that if the value is a minimum it will be listed in the upper portion of the specification's table row and in the lower portion of the row if it is a maximum value. Finally, note that tables and their footnotes may be split across two or more pages.

ASTM A 426 – 08	Centrifugally Cast Ferritic Alloy Steel Pipe for High-Temperature Service
ASTM A 451 – 06	Centrifugally Cast Austenitic Steel Pipe for High-Temperature Service
ASTM A 608 – 06	Centrifugally Cast Iron-Chromium-Nickel High-Alloy Tubing for Pressure Application at High Temperatures
ASTM A 660 – 05	Centrifugally Cast Carbon Steel Pipe for High Temperature Service
ASTM A 872 – 07	Centrifugally Cast Ferritic/Austenitic Stainless Steel Pipe for Corrosive Environments
ISO 13583-2	Centrifugally Cast Tube

ASTM A 426 – 08 CENTRIFUGALLY CAST FERRITIC ALLOY STEEL PIPE FOR HIGH-TEMPERATURE SERVICE

This specification covers centrifugally cast alloy steel pipe intended for use in high-temperature, high-pressure service.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)													
Grade and UNS	Heat Treatment[A]	Tensile Strength ksi	Tensile Strength MPa	Yield Strength ksi	Yield Strength MPa	Elong % [C]	Red A %	Other Tests[B] Hardness (HBN)	C	Mn	P	S	Si	Cr	Mo	Ni	Cb	N	V	Al	Ti	Zr
CP1	NT, QT	65	450	35	240	24	35			0.30			0.10		0.44							
J12521								201	0.25	0.80	0.040	0.045	0.50		0.65							
CP2	NT, QT	60	415	30	205	22	35		0.10	0.30			0.10	0.50	0.44							
J11547								201	0.20	0.61	0.040	0.045	0.50	0.81	0.65							
CP5	NT, QT	90	620	60	415	18	35			0.30				4.00	0.45							
J42045								225	0.20	0.70	0.040	0.045	0.75	6.50	0.65							
CP5b	NT, QT	60	415	30	205	22	35			0.30			1.00	4.00	0.45							
J51545								225	0.15	0.60	0.040	0.045	2.00	6.00	0.65							
CP9	NT, QT	90	620	60	415	18	35			0.30			0.25	8.0	0.90							
J82090								225	0.20	0.65	0.040	0.045	1.00	10.0	1.20							
CP91	NT, QT	85	585	60	415	18	45		0.08	0.30			0.20	8.0	0.85		0.060	0.030	0.18			
84090		110	760					225	0.12	0.60	0.030	0.010	0.50	9.5	1.05	0.40	0.10	0.070	0.25	0.02	0.01	0.01
CP11	NT, QT	70	485	40	275	20	35		0.05	0.30				1.00	0.44							
J12072								201	0.20	0.80	0.040	0.045	0.60	1.50	0.65							
CP12	NT, QT	60	415	30	205	22	35		0.05	0.30				0.80	0.44							
J11562								201	0.15	0.61	0.040	0.045	0.50	1.25	0.65							
CP15	NT, QT	60	415	30	205	22	35			0.30			0.15		0.44							
J11522								201	0.15	0.60	0.040	0.045	1.65		0.65							
CP21	NT, QT	60	415	30	205	22	35		0.05	0.30				2.65	0.80							
J31545								201	0.15	0.60	0.040	0.045	0.50	3.35	1.06							
CP22	NT, QT	70	485	40	275	20	35		0.05	0.30				2.00	0.90							
J21890								201	0.15	0.70	0.040	0.045	0.60	2.75	1.20							
CPCA15	NT, QT	90	620	65	450	18	30							11.5								
J91150/71								225	0.15	1.00	0.040	0.040	1.50	14.0	0.50 Max							

[A] Minimum tempering temperature given
[B] Hydrostatic test – see original specification for further details
[C] Elongation in 2 in. (50mm) using a standard round specimen, in either transverse or longitudinal direction.

ASTM A 451 – 93 CENTRIFUGALLY CAST AUSTENITIC STEEL PIPE FOR HIGH-TEMPERATURE SERVICE

This specification covers austenitic alloy steel pipe for use in high-temperature, corrosive, or nuclear pressure service.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)										
Grade And UNS	Heat Treatment[B]	Tensile Strength ksi	Tensile Strength MPa	Yield Strength ksi	Yield Strength MPa	Elong %	Red A %	Other Tests Hydrostatic Test[C]	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Ta	N
CPF3 J92500	ST	70	485	30	205	35			0.03	1.50	0.040	0.040	2.00	8.0 12.0	17.0 21.0				
CPF3A[A] J92500	ST	77	535	35	240	35			0.03	1.50	0.040	0.040	2.00	8.0 12.0	17.0 21.0				
CPF3M J92800	ST	70	485	30	205	30			0.03	1.50	0.040	0.040	1.50	9.0 13.0	17.0 21.0	2.0 3.0			
CPF8 J92600	ST	70	485	30	205	35			0.08	1.50	0.040	0.040	2.00	8.0 11.0	18.0 21.0				
CPF8A[A] J92600	ST	77	535	35	240	35			0.08	1.50	0.040	0.040	2.00	8.0 11.0	18.0 21.0				
CPF8M J92900	ST	70	485	30	205	30.0			0.08	1.50	0.040	0.040	1.50	9.0 12.0	18.0 21.0	2.0 3.0			
CPF10MC[E]	ST	70	485	30	205	20.0			0.10	1.50	0.040	0.040	1.50	13.0 16.0	15.0 18.0	1.75 2.25	10xC Min 1.2 Max		
CPH10 J93402	ST	70	485	30	205	30.0			0.10[F]	1.50	0.040	0.040	2.00	12.0 15.0	22.0 26.0				
CPF8C[E] J92710	ST	70	485	30	205	30.0			0.08	1.50	0.040	0.040	2.00	9.0 12.0	28.0 21.0		8xC Min 1.0 Max		
CPF8C (Ta max)[D]	ST	70	485	30	205	30.0			0.08	1.50	0.040	0.040	2.00	9.0 12.0	18.0 21.0		8xC Min 1.0 Max	0.10	
CPH8 J93400	ST	65	448	28	195	30.0			0.08	1.50	0.040	0.040	1.5	12.0 15.0	22.0 26.0				
CPK20 J94202	ST	65	448	28	195	30.0			0.20	1.50	0.040	0.040	1.75	19.0 22.0	23.0 27.0				
CPH20 J93402	ST	70	485	30	205	30.0			0.20[F]	1.50	0.040	0.040	2.00	12.0 15.0	22.0 26.0				
CPE 20N	ST	80	550	40	275	30.0			0.20	1.50	0.040	0.040	1.50	8.0 11.0	23.0 26.0				0.08 0.20

[A] The properties shown are obtained by adjusting the composition within the limits shown in the table to obtain a ferrite-austentite ratio that will result in the higher ultimate yield strengths indicated – a lowering of impact values may develop in these materials when exposed to service temperature above 800 F

[B] The pipe shall receive a solution treatment, ST, at the temperature shown with holding time 2 h/in of thickness [50.8 mm] for CPF10MC, CPF8C, and CPF8C (Ta max), and 1 h/in of thickness for all others, followed by quenching

[C] Hydrostatic test – see original specification for further details

[D] No designation as yet assigned by ASTM or SFSA

[E] Grades CPF10MC and CPF8C have a columbium plus tantalum content maximum of 1.35%

[F] By agreement between the manufacturer and the purchaser, the carbon content of Grade CPH20 may be restricted to 0.10% maximum – when so agreed, the grade designation shall be CPH10

ASTM A 608 – 06

CENTRIFUGALLY CAST IRON-CHROMIUM-NICKEL HIGH-ALLOY TUBING FOR PRESSURE APPLICATION AT HIGH TEMPERATURES

This specification covers iron-chromium-nickel, high-alloy tubes made by the centrifugal casting process intended for use under pressure at high temperatures.

GRADE & HEAT TREATMENT		CHEMICAL COMPOSITION, % (maximum percent unless range given)							
Grade and UNS	**Heat Treatment**	**C**	**Mn**	**P**	**S**	**Si**	**Ni**	**Cr**	**Mo**
HC 30 J92613	As cast	0.25 0.35	0.5 1.0	0.04	0.04	0.50 2.00	4.0	26 30	0.50
HD 50 J92615	As cast	0.45 0.55	1.50	0.04	0.04	0.50 2.00	4 7	26 30	0.50
HE 35 J93413	As cast	0.30 0.40	1.50	0.04	0.04	0.50 2.00	8 11	26 30	0.50
HF 30 J92803	As cast	0.25 0.35	1.50	0.04	0.04	0.50 2.00	9 12	19 23	0.50
HH 30 J93513	As cast	0.25 0.35	1.50	0.04	0.04	0.50 2.00	11 14	24 28	0.50
HH 33[A] J93633	As cast	0.28 0.38	1.50	0.04	0.04	0.50 2.00	12 14	24 26	0.50
HI 35 J94613	As cast	0.30 0.40	1.50	0.04	0.04	0.50 2.00	14 18	26 30	0.50
HK 30 J94203	As cast	0.25 0.35	1.50	0.04	0.04	0.50 2.00	19 22	23 27	0.50
HK 40 J94204	As cast	0.35 0.45	1.50	0.04	0.04	0.50 2.00	19 22	23 27	0.50
HL 30 N08613	As cast	0.25 0.35	1.50	0.04	0.04	0.50 2.00	18 22	28 32	0.50
HL 40 N08614	As cast	0.35 0.45	1.50	0.04	0.04	0.50 2.00	18 22	28 32	0.50
HN 40 J94214	As cast	0.35 0.45	1.50	0.04	0.04	0.50 2.00	23 27	19 23	0.50
HT 50 N08050	As cast	0.40 0.60	1.50	0.04	0.04	0.50 2.00	33 37	15 19	0.50
HU 50 N08005	As cast	0.40 0.60	1.50	0.04	0.04	0.50 2.00	37 41	17 21	0.50
HW 50 N08006	As cast	0.40 0.60	1.50	0.04	0.04	0.50 2.00	58 62	10 14	0.50
HX 50 N06050	As cast	0.40 0.60	1.50	0.04	0.04	0.50 2.00	64 68	15 19	0.50

[A] Manufacturing control should ensure that this composition contain a minimal amount of ferrite

ASTM A 660 – 05 CENTRIFUGALLY CAST CARBON STEEL PIPE FOR HIGH TEMPERATURE SERVICE

This specification covers carbon steel pipe made by the centrifugal casting process intended for use in high-temperature, high-pressure service. Pipe ordered under this specification shall be suitable for fusion welding, bending, and other forming operations.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)				
Grade and UNS	Heat Treatment[A]	Tensile Strength ksi	Tensile Strength MPa	Yield Strength ksi	Yield Strength MPa	Elong %	Red A %	Other Tests[B]	C	Mn	P	S	Si
WCA J02504		60	414	30	207	24	35		0.25[C]	0.70[C]	0.035	0.035	0.60
WCB J03003		70	483	36	248	22	35		0.30	1.00	0.035	0.035	0.60
WCC J02505		70	483	40	276	22	35		0.25[D]	1.20[D]	0.035	0.035	0.60

[A] Heat treatment per design and chemical composition
[B] Hydrostatic and flattening tests – see original specification for further details
[C] For each reduction of 0.01% below the specified maximum carbon content, an increase of 0.04% manganese above the specified maximum will be permitted to a maximum of 1.10%
[D] For each reduction of 0.01% below the specified maximum carbon content, an increase of 0.04% manganese above the specified maximum will be permitted to a maximum of 1.40%

ASTM A 872 – 07 CENTRIFUGALLY CAST FERRITIC/AUSTENITIC STAINLESS STEEL PIPE FOR CORROSIVE ENVIRONMENTS

This specification covers centrifugally cast ferritic/austenitic steel pipe intended for general corrosive service. These steels are susceptible to embrittlement if used for prolonged periods at elevated temperatures.

GRADE & HEAT TREATMENT		MECHANICAL PROPERTIES (minimum unless range given)							CHEMICAL COMPOSITION, % (maximum percent unless range given)										
Grade and UNS	Heat Treatment	Tensile Strength ksi	Tensile Strength MPa	Yield Strength ksi	Yield Strength MPa	Elong %	Red A %	Other Tests Hardness (HBN / HRC)	C	Mn	P	S	Si	Ni	Cr	Mo	N	Cu	Co
J93183	WQ 1920-2100F [1050-1150C]	90	620	65	450	25		290 / 30.5	0.030	2.0	0.040	0.030	2.0	4.00 6.00	20.0 23.0	2.00 4.00	0.08 0.25	0.08 0.25	0.50 1.50
J93550	WQ 1920-2100F [1050-1150C]	90	620	65	450	20		297 / 31.5	0.030	2.0	0.040	0.030	2.0	5.00 8.00	23.0 26.0	2.00 4.00	1.00	1.00	0.50 1.50
J94300	WQ 1900 minimum	110	760	70	480	20			0.04	0.50 1.50	0.04	0.04	1.10	4.5 6.0	24.5 26.5	2.5 4.0	0.18 0.26	1.3 3.0	

ISO 13583-2 CENTRIFUGALLY CAST TUBE

GRADE	MECHANICAL PROPERTIES (minimum unless range given)					CHEMICAL COMPOSITION, % (maximum percent unless range given)														
Grade and UNS	Tensile	Yield	Elong %	100 hr. rupture		C	Si	Mn	P	S	Cr	Ni	Mo	Nb	W	Co	Ti	N	C+N	Fe
	Mpa	Mpa		°C	MPa															
GX30CrNiSi19-9	450	230	15	800	47	0.25 0.35	1.30 1.80	0.50 1.50	0.03	0.03	18.0 20.0	18.0 20.0	0.5							
GX40CrNiSi25-12	450	230	10	900	34	0.35 0.45	1.00 2.00	0.50 1.50	0.03	0.03	24.0 26.0	24.0 26.0	0.5							
GX42CrNiSi25-20	450	220	8	900	40	0.38 0.45	1.00 2.00	0.50 1.50	0.03	0.03	24.0 26.0	24.0 26.0	0.5							
GX30CrNiSiNb24-24	450	220	10	900	48	0.25 0.35	0.70 2.00	0.50 1.50	0.03	0.03	23.0 25.0	23.0 25.0	0.5	1.20 1.80						
GX12NiCrSi32-21	440	170	20	800	70	0.08 0.15	0.50 1.50	0.50 1.50	0.03	0.03	19.0 22.0	32.0 33.0	0.5	0.60 1.30						
GX40NiCrSi38-18	420	220	6	900	34	0.35 0.45	1.30 2.00	0.50 1.50	0.03	0.03	17.0 19.0	36.0 39.0	0.5							
GX12NiCrSiNb35-25	440	175	20	800	70	0.08 0.15	0.50 1.50	0.50 1.50	0.03	0.03	24.0 27.0	34.0 37.0	0.5	0.60 1.30						
GX42NiCrSiNb35-25	450	220	8	950	40	0.38 0.45	0.50 1.50	0.50 1.50	0.03	0.03	24.0 27.0	34.0 37.0	0.5	0.60 1.25						
GX43NiCrSiNb35-25	450	220	8	950	40	0.38 0.48	1.50 2.50	0.50 1.50	0.03	0.03	24.0 27.0	34.0 37.0	0.5	0.60 1.80						
GX42NiCrSi35-25	450	220	8	950	42	0.38 0.48	1.00 2.00	0.50 1.50	0.03	0.03	24.0 27.0	34.0 37.0	0.5	0.60 1.80			0.06 Min. [A]			
GX42NiCrWSi35-25-5	450	220	4	950	35	0.38 0.48	1.00 2.00	0.50 1.50	0.03	0.03	24.0 27.0	34.0 37.0	0.5		4.00 6.00					
GX42NiCrSiNbTi 45-35	450	250	5	1050	21	0.38 0.48	1.00 2.00	0.50 1.50	0.03	0.03	33.0 36.0	44.0 47.0	0.5	0.50 1.50			0.06 Min. [A]			
GX45NiCrCoW35-25-15-5	450	250	5	950	40	0.40 0.50	1.00 2.00	0.50 1.50	0.03	0.03	24.0 26.0	33.0 37.0	0.5		4.00 6.00	14.0 16.0				
GX48NiCrWSi48-28-5	400	220	5	1050	20	0.40 0.55	1.00 1.75	0.50 1.50	0.03	0.03	27.0 29.0	47.0 49.0	0.5		4.00 6.00					
GX48NiCrWCo48-28-5-3	400	220	5	1050	20	0.40 0.55	1.00 1.75	0.50 1.50	0.03	0.03	27.0 29.0	47.0 49.0	0.5		4.00 6.00	2.50 3.50				
GX8NiCrNb50-50	550	250	8	900	40	0.1	0.5	0.50	0.02	0.02	47.0 52.0	Bal.	0.5	1.40 1.70				0.16	0.20	1.0

[A] Other micro alloying elements can be substituted for titanium. The total micro alloying elements shall be 0.06% min.

SUMMARY OF STANDARD TEST METHODS FOR STEEL CASTINGS

Overview

Testing is required to ensure that the product will perform safely and economically in service. Excessive testing and overly stringent requirements increase the cost of the product without increasing value. On the other hand, insufficient testing or overly lax requirements are meaningless. Therefore, it becomes the task of the customer to decide what tests and requirements are necessary for his or her application.

Mechanical properties and chemical compositional limits are generally the subject of ASTM material specifications. These must be controlled and tested in products ordered to those specifications. Consult the latest revisions of the ASTM Standards referenced in this document for more information.

Mechanical Testing

Background

Mechanical testing is generally carried out in accordance with methods described in ASTM A 370, "Standard Test Methods and Definitions for Mechanical Testing of Steel Products". These methods cover procedures and definitions for the mechanical testing of wrought and cast steel products. The various mechanical tests herein described are used to determine properties required in the product specifications. Variations in testing methods are to be avoided and standard methods of testing are to be followed to obtain reproducible and comparable results. The test methods most often used in steel castings include tension testing, hardness testing, and impact testing.

The mechanical properties are obtained from test bars and represent the quality of the steel from which the castings have been poured. The properties are not identical with the properties of the castings, which are affected by solidification rates and cooling rates during heat treating, which in turn are influenced by casting thickness, size, and shape.

Tension Testing

The tension test is the most uniformly applied test used to verify the mechanical performance of the material. The test results include tensile strength, yield strength, elongation and reduction in area. The strength measurements are useful in determining the load bearing capabilities of the material. Ductility measurements give an indication of the ability of the material to undergo deformation. The tension test is used to verify that the mechanical performance of the material is consistent. Evaluating performance in service environments may require information of other material properties such as fracture toughness, fatigue, creep-rupture, etc.

Hardness Testing

Hardness testing is used as a quick estimation of strength and/or wear resistance. It is particularly useful in the control of heat treatment for carbon and low to medium alloy steels. The most commonly used method for determining hardness in steel castings is the Brinell Test. The Rockwell test uses a much smaller probe and when used on cast steels is subject to variations. Converting numbers must be done with care because the conversions from Brinell to Rockwell is not exact and varies somewhat depending on the actual alloy tested. Stainless cast steels, excluding martensitic grades, are treated for corrosion resistance, not to develop strength and the hardness does not relate to heat treatment.

Impact Testing

Impact testing gives the amount of energy absorbed by a material. A sample of the material is hit with a hammer that has a known energy. The difference in energy the hammer has after striking the material is the impact strength of the material. This provides a useful measure of toughness or resistance to sudden failure. For low temperature service this test becomes increasingly important because most steels become less tough as the

temperature decreases. Impact testing is an ASTM requirement in specifications for material used in low temperature service. The Charpy V-notch is the most commonly applied method.

Nondestructive Examination

Background

Nondestructive examination testing is done to verify the mechanical integrity or soundness of the steel casting. It can be separated in to surface examination methods which include visual, liquid penetrant, and magnetic particle and subsurface or internal examination methods which include radiography and ultrasonics. Not only must a test method be chosen, but also an acceptance criterion must be applied. Acceptance criteria should be related to the service requirements because overly stringent criteria add directly to the cost. For critical service both surface and internal examination may be required to assure the attainment of the level of soundness specified.

Visual Examination

Equipment Required	Enables Detection of	Advantages	Limitations	Remarks
Surface comparator Pocket rule Straight Edge Workmanship standards	Surface flaws – cracks, porosity, slag inclusions, adhering sand, scale, etc.	Low cost Can be applied while work is in process, permitting correction of faults	Applicable to surface defects only Provides no permanent record	Should always be the primary method of inspection, no matter what other techniques are required

ASTM A 802/A 802M – 95	Standard Practice for Steel Castings, Surface Acceptance Standards, Visual Examination
SCRATA Comparators	Steel Casting Research and Trade Association (SCRATA) Comparator Plates - for establishing mutually agreeable acceptance criteria for a specific part
ISO DIS 1197(a)	Visual examination of surface quality of steel castings
MSS SP-55-1996	Quality Standard for Steel Castings for Valves, Flanges and Fittings, and Other Piping Components (Visual Method for Evaluation of Surface Irregularities)

Liquid Penetrant Examination (PT)

Equipment Required	Enables Detection of	Advantages	Limitations	Remarks
Commercial kits, containing fluorescent or dye penetrants and developers Application equipment for the developer A source of ultraviolet light – if fluorescent method is used	Surface discontinuities not readily visible to the unaided eye	Applicable to magnetic, nonmagnetic materials Easy to use Low cost	Only surface discontinuities are detectable	

ASTM A 903/A 903M – 91	Steel Castings, Surface Acceptance Standards, Magnetic Particle and Liquid Penetrant Inspection
ASTM E 165 – 95	Standard Test Method for Liquid Penetrant Examination
ASTM E 433 – 71	Standard Reference Photographs for Liquid Penetrant Examination
ISO 3452	Non-destructive testing – Penetrant inspection – General principles

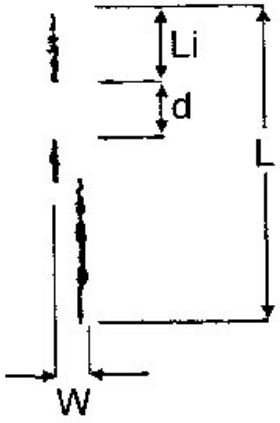
ISO 4987	Steel castings – Penetrant inspection
MSS SP-93-1987(92)	Quality Standard for Steel Castings and Forgings for Valves, Flanges and Fittings, and Other Piping Components (Liquid Penetrant Examination Method)

Magnetic Particle Examination (MT)

Equipment Required	Enables Detection of	Advantages	Limitations	Remarks
Special commercial equipment Magnetic powders – dry or wet form; may be fluorescent for viewing under ultraviolet light	Excellent for detecting surface and subsurface discontinuities to approximately ¼" below the surface – especially cracks	Permits controlled sensitivity Relatively low cost method	Applicable to ferromagnetic materials only Requires skill in interpretation of indications and recognition of irrelevant patterns Difficult to use on rough surfaces	Elongated discontinuities parallel to the magnetic field may not give pattern; for this reason the filed should be applied from two directions at or near right angles to each other

ASTM A 903/A 903M – 91	Steel Castings, Surface Acceptance Standards, Magnetic Particle and Liquid Penetrant Inspection
ASTM E 709 – 95	Standard Guide for Magnetic Particle Examination
ASTM E 125 – 63	Standard Reference Photographs for Magnetic Particle Indications on Ferrous Castings
ASTM E 1444 – 94a	Standard Practice for Magnetic Particle Examination
ISO 4986	Steel castings – Magnetic particle inspection
MSS SP-53-1995	Quality Standard for Steel Castings and Forgings for Valves, Flanges and Fittings, and Other Piping Components (Magnetic Particle Examination Method)

All the surface examinations require severity levels to be set for acceptance. Methods of establishing severity levels by assigning numerical values to discontinuity attributes are illustrated in Figure 1 for the length of single linear discontinuities and arrays of aligned linear or nonlinear discontinuities. For nonlinear indications, acceptance criteria are typically expressed by limiting the "major" dimension of the indication, the length and width, or the area of the indication. Note, Figure 1 is an example and is not part of any acceptance standard unless agreed upon by the producer and buyer of steel castings.



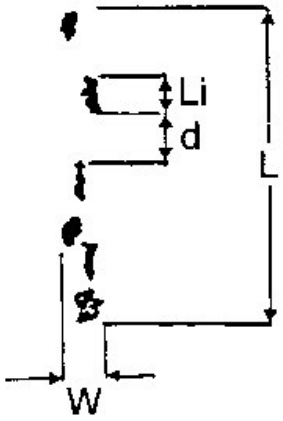
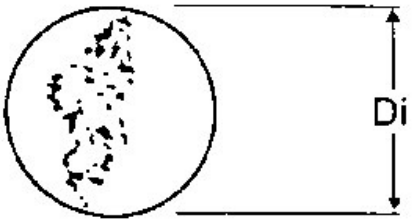
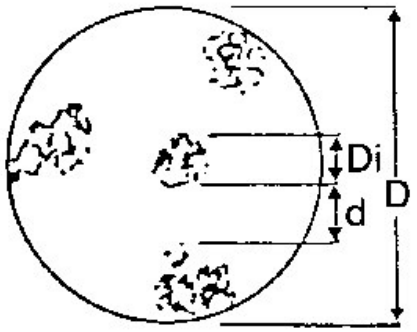


Figure 1: Length measurement of linear discontinuities; linear arrays of linear and non-linear discontinuities





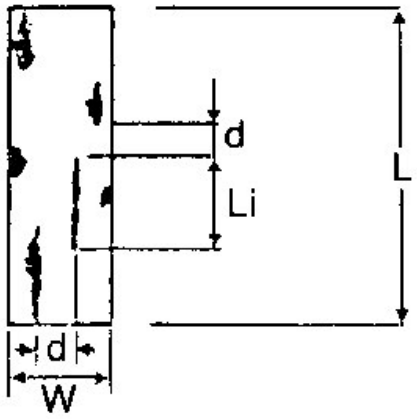


Figure 2: Area measurement; diameter or length, and width measurement of discontinuity arrays

Li, Wi, Di = Length, width, diameter of individual discontinuities, or clusters
L, W, D = Length, width, diameter of discontinuity arrays
d = Distance between discontinuities, or discontinuity clusters
Linear discontinuity = Li ≥ 3Wi
Linear array = L ≥ 5W
Distance between discontinuities within an array = d < Li_{max}, that is, d < Di_{max}
Li_{max}, Di_{max} = Largest length, or diameter of discontinuity, or cluster within an array

The ASME Code has methods and acceptance criteria in Section III and Section VIII. In Section VIII (non-nuclear) para. 9-103(a) and 9-230(a) no linear discontinuities are allowed. This is a classic example of overly strict requirements because it requires all discontinuities to be eliminated. In Section III (nuclear) para. NB-2545.3 and NB-2546.3 allow indications of 1/16". The nuclear section is actually easier to comply with because it does allow for some small indications without rework. The code contains high standards of quality, but these need not be used for all castings for all applications. Rather, the service conditions should be used to help choose appropriate levels of acceptance.

Radiographic Examination (RT)

Equipment Required	Enables Detection of	Advantages	Limitations	Remarks
Commercial x-ray or gamma units, made especially for inspecting welds, castings, and forgings Film and processing facilities	Internal macroscopic flaws – cracks, porosity, blow holes, non-metallic inclusions, shrinkage, etc.	When the indications are recorded on film, gives a permanent record	Requires skill in choosing angles of exposure, operating equipment, and interpreting indications Requires safety precautions Cracks difficult to detect	Radiographic inspection is required by many codes and specifications Useful in qualification of processes Because of cost, its use should be limited to those areas where other methods will not provide the assurance required

ASTM E 94 – 93	Standard Guide for Radiographic Testing
ASTM E 142 – 92	Standard Method for Controlling Quality of Radiographic Testing
ASTM E 446 – 93	Standard Reference Radiographs for Steel Castings up to 2 in. in Thickness (3 Sets; X-rays, Iridium, Cobalt)
ASTM E 186 – 93	Standard Reference Radiographs for Heavy-walled (2 to 4-1/2 in.) Steel Castings (3 Sets; X-ray, Gamma Rays, Betatron)
ASTM E 280 – 93	Standard Reference Radiographs for Heavy-walled (4-1/2 to 12 in.) Steel Castings (2 Sets; X-ray, Betatron)
ASTM E192 – 95	Standard Radiographs of Investment Steel Castings for Aerospace Applications
ISO 4993	Steel castings – Radiographic inspection
ISO 5579	Non-destructive testing – Radiographic examination of metallic materials by X- and gamma rays – Basic rules
MSS SP-54-1995	Quality Standard for Steel Castings for Valves, Flanges and Fittings, and Other Piping Components (Radiographic Examination Method)

Ultrasonic Testing (UT)

Equipment Required	Enables Detection of	Advantages	Limitations	Remarks
Special commercial equipment, either of the pulse-echo or transmission type	Sub-surface discontinuities, including those too small to be detected by other methods Especially for detecting subsurface, planar discontinuities	Very sensitive Permits probing of joints inaccessible to radiography	Requires high degree of skill in interpreting pulse-echo patterns Permanent record is not readily obtained	

ASTM A 609/A 609M - 91	Standard Practice for Castings, Carbon, Low-alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof
ISO DIS 4992(a)	Steel castings – Ultrasonic inspection
MSS SP-94-1992	Quality Standard for Ferritic and Martensitic Steel Castings for Valves, Flanges and Fittings, and Other Piping Components (Ultrasonic Examination Method)

SPECIAL STANDARD PRACTICES

Ferrite Content

ASTM A 800/A 800M — STEEL CASTINGS, AUSTENITIC ALLOY, ESTIMATING FERRITE CONTENT THEREOF

This practice covers procedures and definitions for estimating ferrite content in certain grades of austenitic iron-chromium-nickel alloy castings that have compositions balanced to create the formation of ferrite as a second phase in amounts controlled to be within specified limits. Methods are described for estimating ferrite content by chemicals, magnetic, and metallographic means.

The tensile and impact properties, the weldability, and the corrosion resistance of iron-chromium-nickel alloy castings may be influenced beneficially or detrimentally by the ratio of the amount of ferrite to the amount of austenite in the microstructure. The ferrite content may be limited by purchase order requirements or by the design construction codes governing the equipment in which the castings will be used. The quantity of ferrite in the structure is fundamentally a function of the chemical composition of the alloy and its thermal history. Because of segregation, the chemical composition, and, therefore, the ferrite content, may differ from point to point on a casting. Determination of the ferrite content by any of the procedures described in the following practice ASTM A 800/A 800M is subject to varying degrees of imprecision which must be recognized in setting realistic limits on the range of ferritic content specified. Sources of error include the following:

1. In Determinations from Chemical Composition – Deviations from the actual quantity of each element present because of chemical analysis variance, although possibly minor in each case, can result in substantial differences in the ratio of total ferrite-promoting to total austenite-promoting elements. Therefore, the precision of the ferrite content estimated from chemical composition depends on the accuracy of the chemical analysis procedure.

2. In Determinations from Magnetic Response – Phases other than ferrite and austenite may be formed at certain temperatures and persist at room temperature. These may so alter the magnetic response of the alloy that the indicated ferrite content is quite different from that of the same chemical composition that has undergone different thermal treatment. Also, because the magnets or probes of the various measuring instruments are small, different degrees of surface roughness or surface curvature will vary the magnetic linkage with the material being measured.

3. In Determinations from Metallographic Examinations – Metallographic point count estimates of ferrite percentage may vary with the etching technique used for identification of the ferrite phase and with the number of grid points chosen for the examination, as explained in Test Method E 562.

ISO WD 13520(c) — ESTIMATION OF FERRITE CONTENT IN AUSTENITIC STAINLESS STEEL CASTINGS

See original specification for details.

Welding

ASTM A 488/A 488M	STEEL CASTINGS, WELDING, QUALIFICATIONS OF PROCEDURES AND PERSONNEL This practice established the qualifications of procedures, welders, and operators for the fabrication and repair of steel castings by electric arc welding.
ISO WD 11970(c)	WELD QUALIFICATION PROCEDURES FOR STEEL CASTINGS

CODE AND SPECIFICATION AGENCIES

American Society for Testing and Materials
(ASTM)
100 Barr Harbor Drive
West Conshohocken, PA 19428
(610) 832-9500
[www.astm.org]

American National Standards Institute
(ANSI) - US International Standards Organization (ISO) member
11 W 42nd Street, 13th floor
New York, NY 10036
(212) 642-4900
[www.ansi.org]

American Society of Mechanical Engineers
(ASME) - Boiler and Pressure Vessel Code Committee
PO Box 2900
Fairfield, NJ 07007
(800) 843-2763
[www.asme.org]

American Petroleum Institute
(API)
275 7th Avenue, floor 9
New York, NY 10001
(212) 366-4040
[www.api.org]

Manufacturers Standardization Society of the Valve and Fitting Industry, Inc. (MSS)
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(703) 281-6613
[www.mss-hq.com]

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(SAE)
400 Commonwealth Drive
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[www.sae.org]

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[www.eagle.org]

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[www.lr.org]

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1440 South Creek Drive
Houston, TX 77084
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[www.nace.org]

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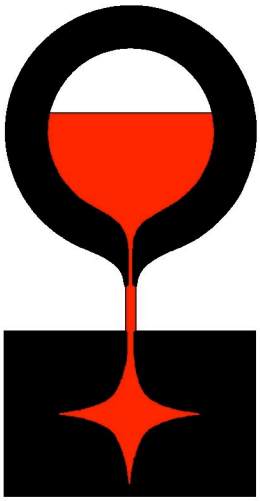

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