



Standard Specification for Hot Isostatically-Pressed Alloy Steel Flanges, Fittings, Valves, and Parts for High Temperature Service¹

This standard is issued under the fixed designation A 989; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers hot isostatically-pressed, powder metal, alloy steel piping components for use in pressure systems. Included are flanges, fittings, valves, and similar parts made to specified dimensions or to dimensional standards, such as in ASME Specification B16.5.

1.2 Several grades of alloy steels are included in this specification.

1.3 Supplementary requirements are provided for use when additional testing or inspection is desired. These shall apply only when specified individually by the purchaser in the order.

1.4 This specification is expressed in both inch-pound units and in SI units. Unless the order specifies the applicable "M" specification designation (SI units), however, the material shall be furnished to inch-pound units.

1.5 The values stated in either inch-pound units or SI units are to be regarded separately as the standard. Within the text, the SI units are shown in parentheses. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.6 The following safety hazards caveat pertains only to test methods portions, 8.1, 8.2, and 9.5-9.7 of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

A 275/A 275M Test Method for Magnetic Particle Examination of Steel Forgings²

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products³

A 751 Test Methods, Practices, and Terminology for

Chemical Analysis of Steel Products³

E 165 Practice for Liquid Penetrant Inspection Examination⁴

E 340 Test Method for Macroetching Metals and Alloys⁵

E 606 Practice for Strain-Controlled Fatigue Testing⁵

2.2 MSS Standard:

SP 25 Standard Marking System for Valves, Fittings, Flanges, and Unions⁶

2.3 ASME Specifications and Boiler and Pressure Vessel Codes:

B16.5 Dimensional Standards for Steel Pipe Flanges and Flanged Fittings⁷

2.4 ASME Section IX Welding Qualifications:

SFA-5.5 Specification for Low-Alloy Steel Covered Arc-Welding Electrodes⁷

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *can, n*—the container used to encapsulate the powder during the pressure consolidation process that is removed partially or fully from the final part.

3.1.2 *compact, n*—the consolidated powder from one can that may be used to make one or more parts.

3.1.3 *consolidation, n*—the bonding of adjacent powder particles in a compact under pressure by heating to a temperature below the melting point of the powder.

3.1.4 *fill stem, n*—the part of the compact used to fill the can that usually is not integral to the part produced.

3.1.5 *hot isostatic-pressing, n*—a process for simultaneously heating and forming a compact in which the powder is contained in a sealed formable enclosure usually made from metal and the so-contained powder is subjected to equal pressure from all directions at a temperature high enough to permit plastic deformation and consolidation of the powder particles to take place.

3.1.6 *lot, n*—a number of parts produced from a single powder blend following the same manufacturing conditions.

3.1.7 *part, n*—a single item coming from a compact, either

¹ This specification is under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.22 on Steel Forgings and Wrought Fittings for Piping Applications and Bolting Materials for Piping and Special Purpose Applications.
Current edition approved Mar. 10, 1998. Published September 1998.

² Annual Book of ASTM Standards, Vol 01.05.

³ Annual Book of ASTM Standards, Vol 01.01.

⁴ Annual Book of ASTM Standards, Vol 03.03.

⁵ Annual Book of ASTM Standards, Vol 03.01.

⁶ Available from Manufacturers Standardization Society of the Valve and Fittings Industry, 1815 N. Fort Myer Drive, Arlington, VA 22209.

⁷ Available from American Society of Mechanical Engineers, 345 E. 47th Street, New York, NY 10017.

prior to or after machining.

3.1.8 *powder blend, n*—a homogeneous mixture of powder from one or more heats of the same grade.

3.1.9 *rough part, n*—the part prior to final machining.

4. Ordering Information

4.1 It is the responsibility of the purchaser to specify in the purchase order all requirements that are necessary for material ordered under this specification. Such requirements may include, but are not limited to, the following:

- 4.1.1 Quantity (weight or number of parts).
- 4.1.2 Name of material or UNS number.
- 4.1.3 ASTM designation and year of issue.
- 4.1.4 Dimensions (tolerances and surface finishes).
- 4.1.5 Microstructure examination, if required (5.1.4).
- 4.1.6 Inspection (14.1).
- 4.1.7 Whether rough part or finished machined (8.2.2).
- 4.1.8 Supplementary requirements, if any.
- 4.1.9 Additional requirements (see 7.2.1 and 16.1).
- 4.1.10 Requirement, if any, that the manufacturer shall submit drawings for approval showing the shape of the rough part before machining and the exact location of test specimen material (see 9.3.1).

5. Materials and Manufacture

5.1 Manufacturing Practice:

5.1.1 Compacts shall be manufactured by placing a single powder blend into a can, evacuating the can, and sealing it. The can material shall be selected to ensure that it has no deleterious effect on the final product. The entire assembly shall be heated at a temperature and placed under sufficient pressure for a sufficient period of time to ensure that the final consolidated part meets the density requirements of 8.1.2.1. One or more parts shall be machined from a single compact.

5.1.2 The powder shall be prealloyed and made by a melting method capable of producing the specified chemical composition, such as but not limited to air or vacuum induction melting, followed by gas atomization.

5.1.3 When powder from more than one heat is used to make a blend, the heats shall be mixed thoroughly to ensure homogeneity.

5.1.4 The compact shall be sectioned and the microstructure examined to check for porosity and other internal imperfections and shall meet the requirements of 8.1.3. The sample shall be taken from the fill stem or from a location in a part as agreed upon by the manufacturer and purchaser.

5.1.5 Unless otherwise specified in the purchase order, the manufacturer shall remove the can material from the surfaces of the consolidated compacts by chemical or mechanical methods, such as by pickling or machining. This may be done before or after heat treatment at the option of the manufacturer (see Note 1).

NOTE 1—Often, it is advantageous to leave the can material in place until after heat treatment or further thermal processing of the consolidated compact.

6. Chemical Composition

6.1 The steel both as a blend and as a part shall conform to the requirements for chemical composition prescribed in Table 1. Test Methods, Practices, and Terminology of A 751 shall apply.

6.1.1 Each blend of powder shall be analyzed by the manufacturer to determine the percentage of elements prescribed in Table 1. This analysis shall be made using a representative sample of the powder. The blend shall conform to the chemical composition requirements prescribed in Table 1.

6.1.2 When required by the purchaser, the chemical composition of a sample from one part from each lot of parts shall be determined by the manufacturer. The composition of the sample shall conform to the chemical composition requirements prescribed in Table 1.

6.2 Addition of lead, selenium, or other elements for the purpose of rendering the material free-machining shall not be permitted.

6.3 The steel shall not contain an unspecified element, for the ordered grade, to the extent that the steel conforms to the requirements of another grade for which that element is a specified element having a required minimum content.

TABLE 1 Chemical Requirements

UNS Designation	Grade	Composition, %										
		Carbon	Manganese	Phosphorus, max	Sulfur, max	Silicon	Nickel	Chromium	Molybdenum	Columbium plus Tantalum	Tantalum, max	Titanium
Alloy Steels												
K90941	9 % chromium	0.15 max	0.30–0.60	0.030	0.030	0.50–1.00	...	8.0–10.0	0.90–1.10	...	...	...
K91560	9 % chromium, 1 % molybdenum, 0.2 % vanadium plus columbium and nitrogen	0.08–0.12	0.30–0.60	0.020	0.010	0.20–0.50	0.40 max	8.0–9.5	0.85–1.05	Other Elements Cb 0.06–0.10 N 0.03–0.07 Al 0.04 max V 0.18–0.25		
K31545	chromium-molybdenum	0.05–0.15	0.30–0.60	0.040	0.040	0.50 max	...	2.7–3.3	0.80–1.06	...	...	...
K21590 Class 1	chromium-molybdenum	0.05–0.15	0.30–0.60	0.040	0.040	0.50 max	...	2.00–2.50	0.87–1.13	...	...	...
K21590 Class 3	chromium-molybdenum	0.05–0.15	0.30–0.60	0.040	0.040	0.50 max	...	2.00–2.50	0.87–1.13	...	...	...

7. Heat Treatment

7.1 After hot isostatic pressing, the compacts may be annealed prior to heat treating in accordance with the requirements of Table 2. At the option of the producer, the anneal may be a separate operation following powder consolidation or may be a part of the consolidation process.

7.2 The alloy steels shall be heat treated in accordance with the requirements of 7.1 and Table 2.

7.2.1 *Liquid Quenching*—When agreed to by the purchaser, liquid quenching followed by tempering shall be permitted provided the temperatures in Table 2 for each grade are utilized.

7.2.1.1 *Marking*—Parts that are liquid quenched and tempered shall be marked “QT”.

7.3 See Supplementary Requirement S10 if a particular heat treatment method is specified by the purchaser.

7.4 *Time of Heat Treatment*—Heat treatment of the hot isostatically-pressed parts shall be performed before or after machining.

8. Structural Integrity Requirements

8.1 Microporosity:

8.1.1 The parts shall be free of microporosity as demonstrated by measurement of density as provided in 8.1.2 or by microstructural examination as provided in 8.1.3.

8.1.2 Density Measurement:

8.1.2.1 The density measurement shall be used for acceptance of material but not for rejection of material. The measured density for each material shall exceed 99 % of the density typical of that grade when wrought and in the same heat treated condition as the sample. Material that fails to meet this acceptance criterion may, at the option of the producer, be tested for microporosity in accordance with the microstructural examination as provided in 8.1.3.

8.1.2.2 Density shall be determined for one sample from each production lot by measuring the difference in weight of the sample when weighed in air and when weighed in water and multiplying this difference by the density of water (Archimede’s principle). The equipment used shall be capable of determining density within $\pm 0.004 \text{ lb/in.}^3$ (0.10 g/cm^3).

8.1.2.3 At the option of the producer, the density shall be compared to the room temperature density typical of wrought alloy steels or to the density of a wrought reference sample of the same grade heat treated in accordance with the requirements of Table 2 (see Note 2). The typical density for alloy

steel in the annealed condition at room temperature is 0.28 lb/in.^3 (7.8 g/cm^3).

NOTE 2—The actual density of alloy steel varies slightly with composition and heat treatment. For this reason, small differences in the measured density from the typical density for a given grade of steel may be the result of differences in alloy content, heat treatment, or microporosity. When density values are measured that are less than the density typical of a given grade of steel, it is appropriate to examine the sample for microporosity by the more specific metallographic examination procedures.

8.1.3 Microstructural Examination:

8.1.3.1 The microstructure when examined at $20\text{-}50\times$, $100\text{-}200\times$, and $1000\text{-}2000\times$ shall be reasonably uniform and shall be free of voids, laps, cracks, and porosity.

8.1.3.2 One sample from each production lot shall be examined. The sample shall be taken after hot isostatic pressing or after final heat treatment. The microstructure shall meet the requirements of 8.1.3.1.

8.1.3.3 If the sample fails to meet the requirements for acceptance, each part in the lot may be retested and those that pass may be accepted.

8.2 *Hydrostatic Tests*—After they have been machined, pressure-containing parts shall be tested to the hydrostatic shell test pressures prescribed in ASME B16.5 for the applicable steel rating for which the part is designed and shall show no leaks. Parts ordered under these specifications for working pressures other than those listed in the ASME B16.5 ratings shall be tested to such pressures as may be agreed upon between the manufacturer and purchaser.

8.2.1 No hydrostatic test is required for welding neck or other flanges.

8.2.2 The compact manufacturer is not required to perform pressure tests on rough parts that are to be finish machined by others. The fabricator of the finished part is not required to pressure test parts that are designed to be pressure containing only after assembly by welding into a larger structure. The manufacturer of the compacts, however, shall be responsible as required in 15.1 for the satisfactory performance of the parts under the final test required in 8.2.

9. Mechanical Properties

9.1 The material shall conform to the requirements for mechanical properties prescribed in Table 3 at room temperature.

9.2 Mechanical test specimens shall be obtained from production parts or from the fill stems. Mechanical test specimens

TABLE 2 Heat Treating Requirements

UNS No.	Heat Treat Type	Austenitizing/Solutioning Temperature, °F (°C) ^A	Cooling Media	Quenching, Cool to Below °F (°C)	Tempering Temperature, min° F (°C)
Alloy Steels					
K90941	anneal	1750 [955]	furnace cool	<i>B</i>	<i>B</i>
K91560	normalize and temper	1750 [955]	air cool	<i>B</i>	1250 [675]
	normalize and temper	1900-2000 [1040-1095]	air cool	<i>B</i>	1350 [730]
K31545	anneal	1750 [955]	furnace cool	<i>B</i>	<i>B</i>
K21590 Class 1,3	anneal	1650 [900]	furnace cool	<i>B</i>	<i>B</i>
	normalize and temper	1650 [900]	air cool	<i>B</i>	1250 [675]

^A Minimum unless temperature range is listed.

^B Not applicable.