Designation: A 989/A 989M – 07

Standard Specification for Hot Isostatically-Pressed Alloy Steel Flanges, Fittings, Valves, and Parts for High Temperature Service[1]

This standard is issued under the fixed designation A 989/A 989M; 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 metallurgy, 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:* [2]

A 275/A 275M Practice for Magnetic Particle Examination of Steel Forgings

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

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

B 311 Test Method for Density Determination for Powder Metallurgy (P/M) Materials Containing Less Than Two Percent Porosity

E 165 Test Method for Liquid Penetrant Examination

E 340 Test Method for Macroetching Metals and Alloys

E 606 Practice for Strain-Controlled Fatigue Testing

2.2 *MSS Standard:*

SP 25 Standard Marking System for Valves, Fittings, Flanges, and Unions[3]

2.3 *ASME Specifications and Boiler and Pressure Vessel Codes:*

B16.5 Dimensional Standards for Steel Pipe Flanges and Flanged Fittings [4]

2.4 *ASME Section IX Welding Qualifications:*

SFA-5.5 Specification for Low-Alloy Steel Covered Arc-Welding Electrodes[4]

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 is not usually 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

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.22 on Steel Forgings and Wrought Fittings for Piping Applications and Bolting Materials for Piping and Special Purpose Applications.

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

[3] Available from Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), 127 Park St., NE, Vienna, VA 22180-4602, http://www.mss-hq.com.

[4] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

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

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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 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 part (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 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 removal shall 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 A 751 shall apply.

6.1.1 A representative sample of each blend of powder shall be analyzed by the manufacturer to determine the percentage of elements prescribed in Table 1. 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 unspecified elements for the purpose of improving the machinability of the compact 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

TABLE 1 Chemical Requirements

UNS Designation	Grade	Composition, %[A]										
		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	. . .	. . .	. . .

[A] Maximum, unless otherwise specified.

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requirements of another grade for which that element is a specified element having a required minimum content.

7. Heat Treatment

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

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

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 production lot shall exceed 99 % of the density typical of that grade when wrought and in the same heat treated condition as the sample. A production lot that fails to meet this acceptance criterion is permitted, at the option of the producer, to 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 ±0.004 lb/in.^{3} (0.10 g/cm^3). Alternatively, at the option of the producer, it is permitted to use Test Method B 311 to determine the density.

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 20-50×, 100-200×, and 1000-2000× 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, at the option of the producer, 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, it is permitted to retest each part in the lot. Each part that passes the requirements of 8.1.3.1 shall 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. [check terminology]

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

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	[B]	[B]
	normalize and temper	1750 [955]	air cool	[B]	1250 [675]
K91560	normalize and temper	1900-2000 [1040-1095]	air cool	[B]	1350 [730]
K31545	anneal	1750 [955]	furnace cool	[B]	[B]
K21590 Class 1,3	anneal	1650 [900]	furnace cool	[B]	[B]
	normalize and temper	1650 [900]	air cool	[B]	1250 [675]

[A] Minimum unless temperature range is listed.
[B] Not applicable.

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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 shall be taken from material that has received the same heat treatment as the parts that they represent. If repair welding is required (see Section 15), the test specimens prior to testing shall accompany the repaired parts if a post weld heat treatment is done.

9.3 For normalized and tempered parts, or quenched and tempered parts, the central axis of the test specimen shall correspond to the ¼ *T* plane or deeper position where *T* is the maximum heat treated thickness of the represented part. In addition, for quenched and tempered parts, the midlength of the test specimen shall be at least *T* from any second heat treated surface. When the section thickness does not permit this positioning, the test specimen shall be positioned as near as possible to the prescribed location, as agreed to by the purchaser and the supplier.

9.3.1 Alternatively, with prior approval of the purchaser, it is permitted to take the test specimen for the steel parts at a depth (*t*) corresponding to the distance from the area of significant stress to the nearest heat treated surface and at least twice this distance (2*t*) from any second surface. The test depth, however, shall not be nearer to one treated surface than ¾ in. (19 mm) and to the second treated surface than 1½ in. (38 mm). This method of test specimen location would normally apply to complex parts, or parts with thick cross-sectional areas where ¼ *T* and *T* testing (see 9.3) is not practical. Sketches showing the exact test locations shall be approved by the purchaser when this method is used.

9.4 For annealed alloy steels the test specimen may be taken from any convenient location.

9.5 *Tension Test*:

9.5.1 One tension test shall be made for each production lot in each heat treatment charge.

9.5.1.1 When the heat treating cycles are the same and the furnaces (either batch or continuous type) are controlled within ±25 °F [±14 °C] and equipped with recording pyrometers so that complete records of heat treatment are available, then only one tension test from each production lot of each type of part, and section size is required instead of one test from each production lot in each heat-treatment charge. The term "type," as used here, designates a characteristic shape of a part, such as flange, elbow, tee, and so forth.

9.5.1.2 The tension test specimen shall be made from material accompanying the parts in final heat treatment.

9.5.2 Testing shall be performed in accordance with Test Methods and Definitions A 370 using the largest feasible of the round specimens. The gage length for measuring elongation shall be four times the diameter of the test section.

9.6 *Hardness Tests*:

9.6.1 When two or more parts are produced, a minimum of two pieces per batch or continuous run as defined in 9.6.2 shall be hardness tested in accordance with Test Methods and Definitions A 370 to ensure that the parts are within the hardness limits given for each grade in Table 3. When only one part is produced, it shall be hardness tested as required. The purchaser is permitted to verify that the requirement has been met by testing at any location on any part, provided such testing does not render the part useless.

9.6.2 When the reduced number of tension tests permitted by 9.5.1.1 is applied, additional hardness tests shall be made on parts or samples as defined in 9.2 distributed throughout the charge. At least eight samples shall be checked from each batch load and a least one check/h shall be made from a continuous run. When the furnace batch charge is less than eight parts, each part shall be checked. If any hardness test result falls outside the prescribed limits, the entire lot of parts shall be reheat treated and the requirements of 9.5.1 shall apply.

9.7 *Fatigue Tests*—When specified in the order, the fatigue strength of alloy steel, except UNS K91560, components intended for service above 800 °F [425 °C] and for UNS K91560 components intended for service above 1000 °F [540 °C] shall be tested in accordance with the requirements of Supplementary Requirement S11.

10. Product Analysis

10.1 The purchaser is permitted to make a product analysis on parts supplied to this specification. Samples for analysis shall be taken from midway between the center and surface of solid parts, midway between the inner and outer surfaces of hollow parts, midway between the center and surface of full-size prolongations, or from broken mechanical test specimens. The chemical composition thus determined shall conform to Table 1 with the tolerances as stated in Table 4 or Table 5.

TABLE 3 Tensile and Hardness Requirements

UNS Designation	Tensile Strength, min, ksi [MPa]	Yield Strength, min, ksi [MPa][A]	Elongation in 2 in. [50 mm] or 4*D*, min, %	Reduction of Area, min, %	Brinell Hardness Number
		Alloy Steels			
K90941	85 [585]	55 [380]	20.0	40.0	179–217
K91560	85 [585]	60 [415]	20.0	40.0	248 max
K31545	75 [515]	45 [310]	20.0	30.0	156–207
K21590 Class 1	60 [415]	30 [205]	20.0	35.0	170 max
K21590 Class 3	75 [515]	45 [310]	20.0	30.0	156–207

[A] Determined by the 0.2 % offset method. For ferritic steels only, the 0.5 % extension-under-load method also may be used.

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TABLE 4 Product Analysis Tolerances for Alloy Steels with a Maximum Chromium Limit 4 % or More[A]

Elements	Limit or Maximum of Specified Range, %	Tolerance Over the Maximum Limit or Under the Minimum Limit
Carbon	0.030, incl	0.005
	over 0.030 to 0.20 incl	0.01
Manganese	to 1.00, incl	0.03
	over 1.00 to 3.00, incl	0.04
Phosphorus	to 0.040, incl	0.005
Sulfur	to 0.030, incl	0.005
Silicon	to 1.00, incl	0.05
Chromium	over 4.00 to 10.00, incl	0.10
	over 10.00 to 15.00, incl	0.15
Nickel	to 1.00, incl	0.03
	over 1.00 to 5.00, incl	0.07
Molybdenum	to 0.20 incl	0.01
	over 0.20 to 0.60, incl	0.03
	over 0.60 to 2.00, incl	0.05
Titanium	all ranges	0.05
Columbium + tantalum	all ranges	0.05
Tantalum	to 0.10, incl	0.02
Cobalt	0.05 to 0.20, incl	0.01[B]
Nitrogen	to 0.19 incl	0.01
Columbium	0.05 to 0.20, incl	0.01
Aluminum	to 0.05 incl	0.01
Vanadium	to 0.10 incl	0.01
	over 0.10 to 0.25 incl	0.02
Cerium	0.03 to 0.08	–0.005 +0.01
Tungsten	to 1.00, incl	0.04
Copper	to 1.00, incl	0.03

[A] This table does not apply to heat analysis.
[B] Product analysis limits for cobalt under 0.05 % have not been established and the producer should be consulted for those limits.

TABLE 5 Product Analysis Tolerances for Alloy Steels with Maximum Chromium Limit Less than 4 %

Element[B]	Limit or Maximum of Specified Ranges, %	Tolerance Over Maximum Limit or Under Minimum Limit for Size Ranges Shown, %[A]			
		100 $in.^2$ (6.45×10^4 mm^2) or less	Over 100 to 200 $in.^2$ (1.290×10^5 mm^2), incl	Over 200 to 400 $in.^2$ (2.581×10^5 mm^2), incl	Over 400 $in.^2$
Manganese	to 0.90 incl	0.03	0.04	0.05	0.06
	over 0.90 to 1.00 incl	0.04	0.05	0.06	0.07
Phosphorus	to 0.045 incl	0.005	0.010	0.010	0.010
Sulfur	to 0.045 incl	0.005	0.010	0.010	0.010
Silicon	to 0.40 incl	0.02	0.02	0.03	0.04
	over 0.40 to 1.00 incl	0.05	0.06	0.06	0.07
Nickel	to 0.50	0.03	0.03	0.03	0.03
Chromium	to 0.90 incl	0.03	0.04	0.04	0.05
	over 0.90 to 2.10 incl	0.05	0.06	0.06	0.07
	over 2.10 to 3.99 incl	0.10	0.10	0.12	0.14
Molybdenum	to 0.20 incl	0.01	0.01	0.02	0.03
	over 0.20 to 0.40 incl	0.02	0.03	0.03	0.04
	over 0.40 to 1.15 incl	0.03	0.04	0.05	0.06
Copper	to 1.00 incl	0.03	0.03	0.03	0.03
	over 1.00 to 2.00 incl	0.05	0.05	0.05	0.05
Titanium	to 0.10	0.01	0.01	0.01	0.01
Vanadium	to 0.10 incl	0.01	0.01	0.01	0.01
	0.11 to 0.25 incl	0.02	0.02	0.02	0.02
	0.26 to 0.50 incl	0.03	0.03	0.03	0.03

[A] Cross-sectional area.
[B] Product analysis for carbon, boron, columbium, and calcium shall conform to Table 1.

11. Reheat Treatment

11.1 If the results of the mechanical tests do not conform to the requirements specified, the manufacturer is permitted to reheat treat the parts and repeat the tests specified in Section 9, but not more than twice.

12. Workmanship, Finish and Appearance

12.1 The parts shall be free of scale, machining burrs, and other injurious imperfections as defined herein. The parts shall have a workmanlike finish and machined surfaces, other than surfaces having special requirements, shall have a surface finish not to exceed 250 AA (arithmetic average) roughness height.

12.2 At the discretion of the purchaser, finished parts shall be subject to rejection if surface imperfections acceptable under 12.4 are not scattered but appear over a large area in excess of what is considered to be a workmanlike finish.

12.3 *Depth of Imperfections*—Linear imperfections shall be explored for depth. When the depth encroaches on the minimum wall thickness of the finished parts, such imperfections shall be considered defects.

12.4 *Machining or Grinding Imperfections Not Classified as Defects*—Surface imperfections not classified as defects shall be treated as follows:

12.4.1 Seams, laps, tears, or slivers not deeper than 5 % of the nominal wall thickness or 1⁄16 in. [1.6 mm], whichever is less, need not be removed. If these imperfections are removed, they shall be removed by machining or grinding.

12.4.2 Mechanical marks or abrasions and pits shall be acceptable without grinding or machining provided the depth does not exceed the limitations in 12.4.1. Imperfections that are deeper than 1⁄16 in. (1.6 mm), but that do not encroach on the minimum wall thickness of the part shall be removed by grinding to sound metal.

12.4.3 When imperfections have been removed by grinding or machining, the outside dimension at the point of grinding or machining may be reduced by the amount removed. Should it be impracticable to secure a direct measurement, the wall thickness at the point of grinding, or at an imperfection not required to be removed, shall be determined by deducting the amount removed by grinding from the nominal finished wall thickness of the part, and the remainder shall not be less than the minimum specified or required wall thickness.

13. Repair by Welding

13.1 Weld repairs shall be permitted (see Supplementary Requirement S7) only with prior approval of the purchaser and with the following limitations and requirements:

13.1.1 The welding procedure and welders shall be qualified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code.

13.1.2 The weld metal shall be deposited using the electrodes specified in Table 6. The electrodes shall be purchased in accordance with ASME Specification SFA-5.5. The submerged arc process with neutral flux, the gas metal-arc welding and gas tungsten-arc welding processes are permitted.

13.1.3 Defects shall be completely removed prior to welding by chipping or grinding to sound metal as verified by

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TABLE 6 Repair Welding Requirements

UNS Designation	Electrodes[A]	Preheat and Interpass Temperature Range, °F [°C]	Minimum Post-Weld Heat Treatment Temperature °F [°C]
	Alloy Steels		
K90941	E 505-15 or 16	400-700 [205-370]	1250 [675]
K91650	9 % Cr, 1 % Mo, VCbN	400-700 [205-370]	1300 [705]
K31545	E 9018-B 3	300-600 [150-315]	1250 [675]
K21590 Class 1	E 9018-B 3	300-600 [150-315]	1250 [675]
K21590 Class 3	E 9018-B 3	300-600 [150-315]	1250 [675]

[A] Electrodes shall comply with ASME SFA 5.5.

magnetic particle inspection in accordance with Test Method A 275/A 275M for the alloy steels in this specification, or by liquid penetrant inspection in accordance with Test Method E 165 for all grades.

13.1.4 After repair welding, the welded area shall be ground smooth to the original contour and shall be free of defects as verified by magnetic-particle or liquid-penetrant inspection, as applicable.

13.1.5 The preheat, interpass temperature, and post-weld heat treatment, requirements given in Table 6 shall be met.

13.1.6 Repair by welding shall not exceed 10 % of the surface area of the part. Repair by welding shall not exceed 33⅓ % of the wall thickness of the finished part or ⅜ in. (9.5 mm), whichever is less.

14. Inspection

14.1 The manufacturer shall afford the purchaser's inspector all reasonable facilities necessary to satisfy the inspector that the material is being furnished in accordance with the purchase order. Inspection by the purchaser shall not interfere unnecessarily with the manufacturer's operations. All tests and inspections shall be made at the place of manufacture unless otherwise agreed upon.

15. Rejection

15.1 Each part that develops defects during shop working operations or in service shall be rejected and the manufacturer notified.

15.2 Samples representing material rejected by the purchaser shall be preserved until disposition of the claim has been agreed upon between the manufacturer and the purchaser.

16. Certification

16.1 Test reports are required and shall include certification that all requirements of this specification have been met. The specification designations included on test reports shall include year of issue and revision letter, if any. The manufacturer shall provide the results of all tests required by this specification and the purchase order.

17. Product Marking

17.1 Identification marks consisting of the manufacturer's symbol or name (see Note 3), the blend number, designation of service rating, the specification number, the designation showing the grade of material, and the size shall be legibly stamped on each part or the parts may be marked in accordance with Standard SP 25 of the Manufacturers Standardization Society of the Valve and Fittings Industry, and in such position so as not to injure the usefulness of the part. The specification number marked on the part need not include specification year of issue and revision letter.

NOTE 3—For purposes of identification marking, the manufacturer is considered the organization that certifies the piping component was manufactured, sampled, and tested in accordance with this specification and the results have been determined to meet the requirements of this specification.

17.1.1 Quenched and tempered alloy steel parts shall be marked with the letters "QT" following the specification designation.

17.1.2 Hot isostatically-pressed parts repaired by welding shall be marked with the letter "W" following the specification designation.

17.1.3 When test reports are required, the markings shall consist of the manufacturer's symbol or name, the grade symbol, and such other markings as necessary to identify the part with the test report (17.1.1 and 17.1.2 shall apply).

17.1.4 Hot isostatically-pressed parts meeting all requirements for more than one class or grade are permitted at the option of the producer to be marked with more than one class or grade designation.

17.2 *Bar Coding*—In addition to the requirements in 17.1, bar coding is acceptable as a supplemental identification method. The purchaser may specify in the order that a specific bar coding system be used. The bar coding system, if applied at the discretion of the supplier, should be consistent with one of the published industry standards for bar coding. If used on small parts, the bar code may be applied to the box or a substantially applied tag.

18. Keywords

18.1 alloy steel; chromium-alloy steel; chromium-molybdenum steel; gas-atomized powder; hot isostatically-pressed alloy steel parts; piping applications; pipe fittings, steel; pressure containing parts; steel flanges; steel valves; temperature service applications, elevated; temperature service applications, high

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SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the contract or order.

S1. Macroetch Test

S1.1 A sample part shall be sectioned and etched to show internal imperfections. The test shall be conducted according to Test Method E 340. Details of the test shall be agreed upon between the manufacturer and the purchaser.

S2. Product Analysis

S2.1 A product analysis in accordance with Section 10 shall be made from one randomly selected part representing each size and type (See 9.5.1.1) of part on the order. If the analysis fails to comply, each part in that lot, at the option of the manufacturer, shall be checked and accepted if the analysis for the part complies with the requirements, or the lot shall be rejected. All results shall be reported to the purchaser.

S3. Tension Tests

S3.1 In addition to the requirements of Section 9, one tension specimen shall be obtained from a representative part from each production lot at a location agreed upon between the manufacturer and the purchaser. The results of the test shall comply with Table 3 and shall be reported to the purchaser.

S4. Magnetic Particle Examination

S4.1 All accessible surfaces of a finished alloy steel part shall be examined by a magnetic-particle method. The method shall be in accordance with Test Method A 275/A 275M. Acceptance limits shall be agreed upon between the manufacturer and purchaser.

S5. Liquid Penetrant Examination

S5.1 All accessible surfaces shall be examined by a liquid penetrant method in accordance with Test Method E 165. Acceptance limits shall be agreed upon between the manufacturer and the purchaser.

S6. Hydrostatic Testing

S6.1 A hydrostatic test at a pressure agreed upon between the manufacturer and the purchaser shall be applied by the manufacturer.

S7. Repair Welding

S7.1 No repair welding shall be permitted without prior approval of the purchaser. If permitted, the restrictions of Section 15 shall apply.

S8. Heat Treatment Details

S8.1 The manufacturer shall furnish a detailed test report containing the information required in 16.1 and shall include all pertinent details of the heat treating cycle given the parts.

S9. Hardness Test

S9.1 Each part shall be hardness tested and shall meet the requirements of Table 3.

S10. Alternate Heat Treatment (Grade K91560)

S10.1 Grade K91560 shall be normalized in accordance with Section 7 and tempered at a temperature, to be specified by the purchaser, less than 1350 °F [730 °C]. It shall be the purchaser's responsibility to subsequently temper at 1350 °F [730 °C] min to conform to the requirements of the specification. All mechanical tests shall be made on material heat treated in accordance with Section 7. The certification shall reference this supplementary requirement indicating the tempering temperature applied. The notation "S10" shall be included with the required marking of the part.

S11. Fatigue Acceptance Test

S11.1 For alloy steel, except UNS K91560, components intended for service above 800 °F [425°C], and for UNS K91560 components intended for service above 1000 °F [540 °C] a uniaxial fatigue test shall be performed.

S11.2 The fatigue test shall be performed in air at 1100 °F [595 °C] at an axial strain range of 1.0 % with a one hour hold period at the maximum positive strain point in each cycle. Test specimen location and orientation shall be in accordance with the general guidance of Test Methods and Definitions A 370 and the applicable product specifications. Testing shall be conducted in accordance with Practice E 606. The test shall exceed 200 cycles without fracture or a 20 % drop in the load range.

S11.3 Failure to meet this requirement shall be cause for rejection of all parts from that powder blend.

S11.4 Test frequency shall be the same as for tension tests (see 9.5). Retesting is permitted. Two additional specimens produced from the same powder blend shall be tested and both specimens must pass the cyclic life requirement. Further retests are not permitted.

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SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this specification since the last issue, A 989/A 989M – 05, that may impact the use of this specification. (Approved September 1, 2007)

(*1*) Corrected Type for K21590 in Table 3.

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