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MSS SP-94-1999

Quality Standard for Ferritic and Martensitic Steel Castings for Valves, Flanges, and Fittings and Other Piping Components

Ultrasonic Examination Method

Standard Practice

Developed and Approved by the
Manufacturers Standardization Society of the
Valve and Fittings, Industry, Inc.
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U.S. customary units in this SP are the standard; metric units are for reference only.

Substantive changes in this 1998 edition are "flagged" by parallel bars as shown on the margins of this paragraph. The specific detail of the change may be determined by comparing the material flagged with that in the previous edition.

Non-toleranced Dimensions in this Standard Practice are nominal, and, unless otherwise specified, shall be considered "for reference only".

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FOREWORD

The MSS SP-94 Standard for Ferritic and Martensitic Steel Castings for Valves, Flanges and Fittings and other Piping Components, Ultrasonic Examination Method, was first adopted in 1983. It was developed to provide industry with a uniform method of applying the Ultrasonic Examination procedure and interpretation of the results.

The standard was reaffirmed in 1987 with essentially no changes.

The third edition issued in 1992 was revised to include a surface finish requirement for the calibration blocks. This was necessary as the previously referenced surface comparator of the Alloy Casting Institute was no longer available.

The 1999 edition includes minor revisions and was formatted to conform to current MSS practices.

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ULTRASONIC EXAMINATION METHOD

1. SCOPE

1.1 This standard practice provides methods and acceptance standards for ultrasonic examination of ferritic and martensitic steel castings for valves, flanges, fittings, and other piping components. It is applicable to examination of repairs as well as to the initial examination of castings.

1.2 The methods of Section 8 describe uniform procedures which will provide satisfactory and consistent results upon which the acceptance standards of Section 11 may be used.

1.3 It is recognized that ultrasonic examination and radiographic examination are not directly comparable. This standard practice is intended to provide a casting of functionally equivalent quality to those accepted by the method of MSS SP-54.

2. DEFINITIONS

For definitions of terms relating to ultrasonic testing see ASTM E 1316.

3. BASIS FOR USE

Critical sections of pressure containing castings shall be examined ultrasonically. These sections will be selected by the purchaser of the castings on the basis of previous experience. They may be considered critical in any one of three senses:

a) Casting solidification
b) Stress concentration
c) Ability to contain pressure

4. EQUIPMENT

4.1 Electronic Apparatus

4.1.1 An ultrasonic, pulsed, reflection type of instrument which shall be capable of generating, receiving, and amplifying frequencies of at least 1MHz to 5MHz.

4.1.2 The ultrasonic equipment shall provide linear presentation (within ± 5 percent) for at least 75 percent of the screen height (sweep line to top of screen). Linearity shall be determined in accordance with ASTM E 317 or equivalent electronic means.

4.1.3 The electronic apparatus shall contain a single attenuator or calibrated gain control which shall be accurate over its useful range to ± 10 percent of the nominal attenuation or gain ratio to allow measurement of signals beyond the linear range of the instrument.

4.2 Search Units

4.2.1 Longitudinal Wave internally grounded search units having 1/2 to 1-1/8 inch (13mm to 29mm) diameter or 1 inch (25mm) square piezoelectric elements shall be used. Based on the signal to noise ratio of the response pattern of the casting, a frequency in the range of 1MHz to 5MHz shall be used. The background noise shall not exceed 25 percent of the distance amplitude correction (DAC) curve. Transducers shall be utilized at their rated frequencies.

4.2.2 Dual element 5MHz search units are recommended for sections 1 inch (25mm) and under in thickness.

4.2.3 Angle beam search units shall produce a shear wave beam in steel in the range of 40° to 75° inclusive, measured to the perpendicular of the entry surface of the casting being examined and have a frequency of 1MHz to 5MHz.

4.2.4 Other frequencies and sizes of search units may be used for evaluating and pinpointing indications.

4.3 Reference Blocks

4.3.1 Reference blocks shall be used to establish test sensitivity.

4.3.2 Reference blocks shall be made from cast steels that give an acoustic response similar to the castings being examined.

4.3.3 For single and dual element longitudinal wave transducers the design of reference blocks

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shall be in accordance with Figure 1 and the basic set shall consist of the blocks listed in Table 1. When section thicknesses over 10 inches (250mm) are to be inspected, an additional block of the maximum test thickness shall be made to supplement the basic set.

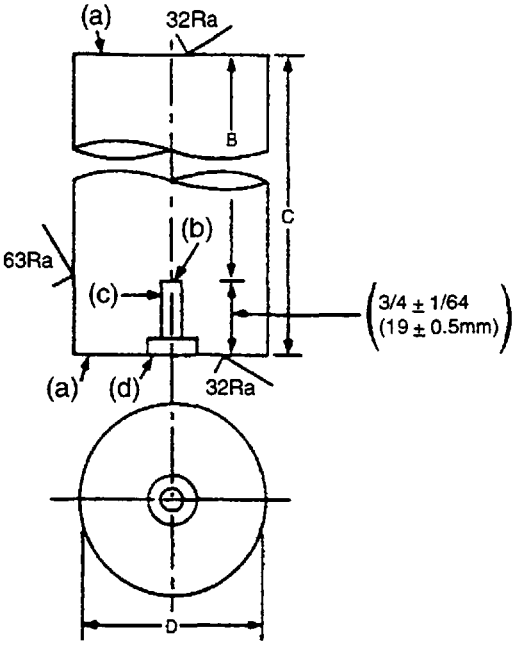

FIGURE 1—ULTRASONIC STANDARD REFERENCE BLOCK

(a) Opposite ends of reference block shall be flat and parallel within 0.001 in. (0.03mm)
(b) Bottom of flat-bottom hole shall be flat within 0.002 in. (0.05mm) and finished diameter shall be 0.250 ± 0.002 in. (6.35 ± 0.05mm)
(c) Hole shall be straight and perpendicular to entry surface within 0 deg. 30 min. and located within 1/32 in. (1mm) of longitudinal axis.
(d) Counter bore shall be 1/2 in. (13mm) diameter by 1/8 in. (3mm) deep.

TABLE 1—DIMENSIONS AND IDENTIFICATION OF REFERENCE BLOCK IN THE BASIC SET

Hole Diameter in. (mm)	Metal Distance (B), in. (mm)	Over-All Length (C), in. (mm)	Width or Diameter (D), min. in. (mm)	Block Identification Number
1/4 (6)	1/8 (3)	7/8 (22)	2 (50)	16-00125
1/4 (6)	1/4 (6.5)	1 (25)	2 (50)	16-0025
1/4 (6)	1/2 (13)	1 1/4 (32)	2 (50)	16-0050
1/4 (6)	3/4 (19)	1 1/2 (38)	2 (50)	16-0075
1/4 (6)	1 (25)	1 3/4 (44)	2 (50)	16-0100
1/4 (6)	2 (50)	2 3/4 (70)	2 (50)	16-0200
1/4 (6)	3 (75)	3 3/4 (95)	2 (50)	16-0300
1/4 (6)	6 (150)	6 3/4 (171)	3 (75)	16-0600
1/4 (6)	10 (250)	10 3/4 (273)	4 (100)	16-1000
1/4 (6)	B	B + 3/4	5 (125)	16-B00

General Note: See 4.3.3 for additional supplemental blocks for testing thickness greater than 10 inches (250mm).

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4.3.4 For angle beam transducers a set of blocks, as shown in Figure 2 and Table 2, with a cast surface equivalent to or smoother than 900 microinches (22.9 micrometers) and of a thickness comparable to the sections being examined with side-drilled holes at 1/4 t, 1/2 t, and 3/4 t (where t = thickness of the block) shall be used to establish a DAC curve. A basic set shall consist of those blocks listed in Table 2.

4.3.5 Each reference block shall be permanently identified along the side of the block indicating the material and the block identification.

4.4 Couplant

A suitable couplant having good wetting characteristics shall be used between the search unit and examination surface.

5. PERSONNEL REQUIREMENTS

5.1 The manufacturer shall be responsible for assigning qualified personnel to perform ultrasonic examinations in conformance with the requirements of this standard practice.

5.2 Personnel performing ultrasonic examinations in accordance with this specification shall be familiar with the following:

a) Ultrasonic terminology
b) Instrument
c) Effect of transducer material, size, frequency, and mode on test results.
d) Effect of material structure (grain size, cleanliness, etc.) on test results.
e) Effect of test distance on test results.
f) Effect of nonlinearity on test results.
g) Effect of thickness and orientation of discontinuities on test results.
h) Effect of surface roughness and geometry on test results.

5.3 A qualification record of personnel considered suitable by the manufacturer to perform examinations in accordance with this standard practice shall be available upon request. ASNT recommended Practice No. SNT-TC-1A-1996 provides a procedure for qualifying personnel.

6. CASTING CONDITIONS

6.1 Castings shall receive at least an austenitizing heat treatment before being ultrasonically examined.

6.2 Test surfaces of castings shall be free of material such as scale, weld spatter, etc. that will interfere with the ultrasonic examination. Test surfaces may be as cast, blasted, ground, or machined.

6.3 The ultrasonic examination shall be conducted prior to any machining that might prevent an effective examination of the casting.

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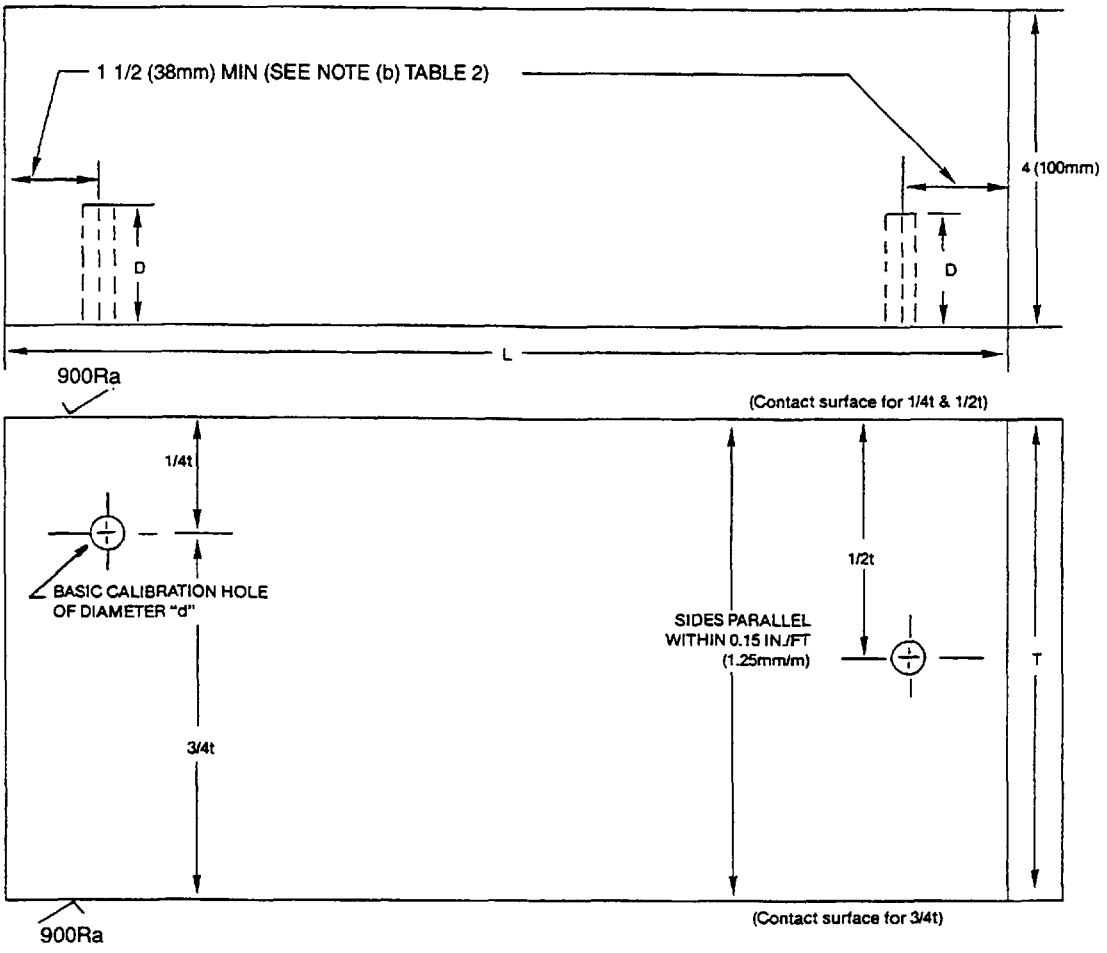

L = Length of block determined by the angle of search unit and the vee-path used
T = Thickness of basic calibration block (see Table 2)
D = Depth of side-drilled hole (see Table 2)
d = Diameter of side-drilled hole (see Table 2)
t = Nominal production material thickness

FIGURE 2—BASIC CALIBRATION BLOCK FOR ANGLE BEAM EXAMINATION

TABLE 2—DIMENSIONS OF CALIBRATION BLOCKS FOR ANGLE BEAM EXAMINATION

Nominal Production Material Thickness (t), in. (mm)	Basic Calibration Block Thickness (T), in. (mm)	Hole Diameter (d), in ± 0.002 (mm. ± 0.05)	Minimum Depth (D), in. (mm)
Up to 1 (25) incl.	1 (25) or t	0.094 (2.38)	1 1/2 (38)
Over 1 thru 2 (25 thru 50)	2 (50) or t	0.125 (3.18)	1 1/2 (38)
Over 2 thru 4 (50 thru 100)	4 (100) or t	0.188 (4.76)	1 1/2 (38)
Over 4 thru 6 (100 thru 150)	6 (150) or t	0.250 (6.35)	1 1/2 (38)
Over 6 thru 8 (150 thru 200)	8 (200) or t	0.312 (7.94)	1 1/2 (38)
Over 8 thru 10 (200 thru 250)	10 (250) or t	0.375 (9.53)	1 1/2 (38)
Over 10 (250)	t	See Note 1	1 1/2 (38)

(a) For each increase in thickness of 2 in. (50mm), or a fraction thereof, the hole diameter shall increase 1/16 in. (1.5mm)

(b) For block sizes over 3 in. (75mm) in thickness (T), the distance from the hole to the end of the block shall be 1/2 T min. to prevent coincident reflections from the hole and the corner. Block fabrication with a 2 in. (50mm) minimum dimension need not be modified if the corner and hole indications can be easily resolved.

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7. TEST CONDITIONS

7.1 To assure complete coverage of the specified casting section each pass of the search unit shall overlap by at least 10 percent of the width of the transducer.

7.2 The rate of scanning shall be appropriate for the surface condition but shall not exceed 6 in/s. (150 mm/s).

8. PROCEDURE

8.1 Longitudinal Wave Examination

8.1.1 Adjust the instrument controls to position the first back reflection for the thickness to be tested at least one half of the distance across the cathode ray tube.

8.1.2 Using the set of reference blocks spanning the thickness of casting being inspected, mark the flat-bottom hole indication height for each of the applicable blocks on the cathode ray tube shield. Draw a curve through these marks on the screen or on a suitable graph paper. The maximum signal amplitude for the test blocks used shall peak at approximately 75 percent of screen height above the sweep by use of the attenuator. This curve shall be referred to as the 100 percent distance amplitude correction (DAC) curve.

8.1.3 Place the transducer on a surface of the casting to be examined where the walls are parallel and adjust the gain until the back reflection signal height reaches the DAC curve. Increase the sensitivity by 22 decibels for single element transducers or 18 decibels for 5MHz dual element transducers.

8.1.4 Do not change those instrument controls and the test frequency set during calibration, except the attenuator or calibrated gain control, during acceptance examination of a given thickness of the casting. make a periodic calibration during the inspection by checking the amplitude of response from the 1/4 inch (mm) diameter flat-bottom hole in the test block.

The attenuator or calibrated gain control may be used to change the signal amplitude during examination to permit small amplitude signals to be more readily detected. Signal evaluation is made by returning the attenuator or calibrated gain control to its original setting.

8.1.5 Recheck areas showing 50 percent or greater loss of back reflection to determine whether loss of back reflection is due to poor contact, insufficient couplant, casting geometry, etc. or due to discontinuity orientation. If due to the orientation of a discontinuity, re-examination, including the methods of 8.2, shall be conducted.

8.2 Angle Beam Examination

8.2.1 Construct a distance amplitude correction (DAC) curve by utilizing the responses from the side-drilled holes in the basic calibration block for angle beam examination as shown in Figure 2 and Table 2.

8.2.1.1 The amplitudes of the 1/4 t and 1/2 t side-drilled holes shall be resolved and marked from the same surface. The side-drilled hole used for the 1/4 t amplitude may be used to establish the 3/4 t amplitude from the opposite surface or a separate hole may be used.

8.1.2 The 1/4 t, 1/2 t, and 3/4 t amplitudes shall be connected to establish the applicable DAC curve.

8.2.2 Do not change instrument controls or the test frequency set during calibration, except the attenuator, or calibrated gain control, during acceptance examination of a given thickness of casting.

The attenuator or gain control may be used to change the signal amplitude during examination to permit small amplitude signals to be more readily detected. Signal evaluation is made by returning the attenuator or calibrated gain control to its original setting.

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9. DATA REPORTING

9.1 The manufacturer's report of final ultrasonic examination shall contain the following data and shall be furnished to the purchaser:

9.1.1 The examination frequency, type of instrument, types of search units employed, couplant, examination operator, manufacturer's identifying numbers, purchaser's order number and date and authorized signature.

9.1.2 A sketch showing the physical outline of the casting including dimensions of all areas not inspected due to geometric configuration; with the location and sizes of all recordable indications accepted.

10. EVALUATION OF INDICATIONS

10.1 Sections With Effectively Parallel Walls (no loss of back wall reflection due to geometry)

10.1.1 Indications shall be evaluated according to the following criteria:

10.1.1.1 An indication shall be considered as recordable if it has an amplitude equal to or greater than the DAC curve.

10.1.1.2 An indication shall be considered as recordable if the back wall echo/discontinuity echo ration is less than 5 to 1 (14db's). The ratio shall be obtained by bringing the back wall echo and then the discontinuity echo to the DAC and noting the decibel difference.

10.1.1.3 An indication shall be considered as recordable if the back wall echo is reduced by at least 50% (6 db's).

10.1.1.4 Recordable indications shall be marked on the casting surface along with the depth below the test surface and evaluated in accordance with Section 12.

10.2 Section With Non-Parallel Walls

10.2.1 Indications shall be evaluated according to the following criteria:

10.2.1.1 An indication shall be considered as recordable if it has an amplitude equal to or greater than the DAC curve.

10.2.1.2 If back wall echo is discernible, an indication shall be considered as recordable if the remaining back wall echo is reduced by at least 50% (6 db's).

10.2.1.3 Recordable indications shall be marked on the casting surface along with the depth below the test surface and evaluated in accordance with Section 11.

11. ACCEPTANCE STANDARDS

11.1 For section thicknesses up to 2 inches (50mm) the maximum allowable area of recordable indication shall be 0.8 square inches (sq.com.) and the longest allowable dimension of the indication shall be 1.5 inches (38mm).

11.2 For section thicknesses 2 to 4 inches (50 to 100mm) the maximum allowable area of recordable indications shall be 1.5 square inches (10 sq.cm.) and the longest allowable dimension of the indication shall be 2.2 inches (55mm).

11.3 For section thicknesses greater than 4 inches (100mm) the maximum allowable area of recordable indications shall be 5 square inches (32 sq.cm.) and the longest allowable dimension of the indication shall be 3.9 inches (98mm).

11.4 The acceptance criteria as defined in 11.1 above also apply for the volume of casting within one inch (25mm) of the surface regardless of the overall thickness.

11.5 Two or more recordable indications in the same plane shall be considered as one indication if the distance separating the indications is less than the longest dimension of the larger indication.

11.6 Recordable indication which have a change in depth equal to or greater than one half the wall thickness or one inch (25mm), whichever is less, are unacceptable.

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| ANNEX A |
REFERENCED STANDARDS AND APPLICABLE DATES

This Annex is an integral part of this Standard Practice which is placed after the main text for convenience.

Standard Name or Designation

ASNT

SNT-TC-1A-1992	Recommended Practice for Personnel Qualifications and Certification in Nondestructive Testing

ASTM	SPECIFICATIONS FOR:
E 1316-1991	Terminology Relating to Ultrasonic Examinations
E 317-1985	Practice for Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Systems

MSS

SP-54-1995	Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components - Radiographic Examination Method

Publications of the following organizations appear on the above lists:

ASNT	American Society for Nondestructive Testing 1711 Arlingate Plaza Columbus, OH 43228
ASTM	American Society for Testing and Materials 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959
MSS	Manufacturers Standardization Society of the Valve and Fittings Industry 127 Park Street, N.E., Vienna, VA 22180

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List of MSS Standard Practices
(Price List Available Upon Request)

Number	
SP-6-1996	Standard Finishes for Contact Faces of Pipe Flanges and Connecting-End Flanges of Valves and Fittings
SP-9-1997	Spot Facing for Bronze, Iron and Steel Flanges
SP-25-1998	Standard Marking System For Valves, Fittings, Flanges and Unions
SP-42-1999	(R 95) Class 150 Corrosion Resistant Gate, Glove, Angle and Check Valves with Flanged and Butt Weld Ends
SP-43-1991	(R 96) Wrought Stainless Steel Butt-Welding Fittings
SP-44-1996	Steel Pipeline Flanges
SP-45-1998	Bypass and Drain Connections
SP-51-1991	(R 95) Class 150LW Corrosion Resistant Cast Flanges and Flanged Fittings
SP-53-1995	Quality Standard for Steel Castings and Forgings for Valves, Flanges and Fittings and Other Piping Components - Magnetic Particle Examination Method
SP-54-1995	Quality Standard for Steel Castings for Valves, Flanges, and Fittings and Other Piping Components - Radiographic Examination Method
SP-55-1996	Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components - Visual Method for Eval. of Surface Irregularities
SP-58-1993	Pipe Hangers and Supports - Materials, Design and Manufacture
SP-60-1999	Connecting Flange Joint Between Tapping Sleeves and Tapping Valves
SP-61-1992	Pressure Testing of Steel Valves
SP-65-1999	High Pressure Chemical Industry Flanges and Threaded Stubs for Use with Lens Gaskets
SP-67-1995	Butterfly Valves
SP-68-1997	High Pressure Butterfly Valves with Offset Design
SP-69-1996	Pipe Hangers and Supports - Selection and Application
SP-70-1998	Cast Iron Gate Valves, Flanged and Threaded Ends
SP-71-1997	Gray Iron Swing Check Valves, Flanged and Threaded Ends
SP-72-1992	Ball Valves with Flanged or Butt-Welding Ends for General Service
SP-73-1991	(R 96) Brazing Joints for Wrought and Cast Copper Alloy Solder Joint Pressure Fittings
SP-75-1998	Specification for High Test Wrought Butt Welding Fittings
SP-77-1995	Guidelines for Pipe Support Contractual Relationships
SP-78-1998	(R 92) Cast Iron Plug Valves, Flanged and Threaded Ends
SP-79-1992	Socket-Welding Reducer Inserts
SP-80-1997	Bronze Gate, Globe, Angle and Check Valves
SP-81-1995	Stainless Steel, Bonnetless, Flanged, Knife Gate Valves
SP-82-1992	Valve Pressure Testing Methods
SP-83-1995	Class 3000 Steel Pipe Unions, Socket-Welding and Threaded
SP-85-1994	Cast Iron Globe & Angle Valves, Flanged and Threaded Ends
SP-86-1997	Guidelines for Metric Data in Standards for Valves, Flanges, Fittings and Actuators
SP-87-1991	(R 96) Factory-Made Butt-Welding Fittings for Class 1 Nuclear Piping Applications
SP-88-1993	Diaphragm Type Valves
SP-89-1998	Pipe Hangers and Supports - Fabrication and Installation Practices
SP-90-1986	(R 91) Guidelines on Terminology for Pipe Hangers and Supports
SP-91-1992	(R 96) Guidelines for Manual Operation of Valves
SP-92-1987	(R 92) MSS Valve User Guide
SP-93-1987	(R 92) Quality Standard for Steel Castings and Forgings for Valves, Flanges, and Fittings and Other Piping Components - Liquid Penetrant Examination Method
SP-94-1999	Quality Std for Ferritic and Martensitic Steel Castings for Valves, Flanges, and Fittings and Other Piping Components - Ultrasonic Examination Method
SP-95-1986	(R 91) Swage (d) Nipples and Bull Plugs
SP-96-1996	Guidelines on Terminology for Valves and Fittings
SP-97-1995	Integrally Reinforced Forged Branch Outlet Fittings - Socket Welding, Threaded and Buttwelding Ends
SP-98-1996	Protective Coatings for the Interior of Valves, Hydrants, and Fittings
SP-99-1994	Instrument Valves
SP-100-1997	Qualification Requirements for Elastomer Diaphragms for Nuclear Service Diaphragm Type Valves
SP-101-1989	Part-Turn Valve Actuator Attachment - Flange and Driving Component Dimensions and Performance Characteristics
SP-102-1989	Multi-Turn Valve Actuator Attachment - Flange and Driving Component Dimensions and Performance Characteristics
SP-103-1995	Wrought Copper and Copper Alloy Insert Fittings for Polybutylene Systems
SP-104-1995	Wrought Copper Solder Joint Pressure Fittings
SP-105-1996	Instrument Valves for Code Applications
SP-106-1990	(R 96) Cast Copper Alloy Flanges and Flanged Fittings, Class 125, 150 and 300
SP-107-1991	Transition Union Fittings for Joining Metal and Plastic Products
SP-108-1996	Resilient-Seated Cast Iron-Eccentric Plug Valves
SP-109-1996	Welded Fabricated Copper Solder Joint Pressure Fittings
SP-110-1996	Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
SP-111-1996	Gray-Iron and Ductile-Iron Tapping Sleeves
SP-112-1993	Quality Standard for Evaluation of Cast Surface Finishes - Visual and Tactile Method. This SP must be sold with a 10-surface, three-dimensional Cast Surface Comparator, which is a necessary part of the Standard. Additional Comparators may be sold separately at $19.00 each. Same quantity discounts apply on total order.
SP-113-1994	Connecting Joint between Tapping Machines and Tapping Valves
SP-114-1995	Corrosion Resistant Pipe Fittings Threaded and Socket Welding, Class 150 and 1000
SP-115-1999	Excess Flow Valves for Natural Gas Service
SP-116-1996	Service Line Valves and Fittings for Drinking Water Systems
SP-117-1996	Bellows Seals for Globe and Gate Valves
SP-118-1996	Compact Steel Globe & Check Valves - Flanged, Flangeless, Threaded & Welding Ends (Chemical & Petroleum Refinery Service)
SP-119-1996	Belled End Socket Welding Fittings, Stainless Steel and Copper Nickel
SP-120-1997	Flexible Graphite Packing System for Rising Stem Steel Valves (Design Requirements)
SP-121-1997	Qualification Testing Methods for Stem Packing for Rising Stem Steel Valves
SP-122-1997	Plastic Industrial Ball Valves
SP-123-1998	Non-Ferrous Threaded and Solder-Joint Unions for Use With Copper Water Tube

(R-YEAR) Indicates year standard reaffirmed without substantive changes

A large number of former MSS Practices have been approved by the ANSI or ANSI Standards, published by others. In order to maintain a single source of authoritative information, the MSS withdraws its Standard Practices in such cases.

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