

## **Chapter Commerce 41 Appendix**

Commerce 41 Appendix is repealed and recreated to read:

### **(EXCERPTS FROM BOILER, PRESSURE VESSEL AND PIPING CODES AND STANDARDS)**

Excerpts from the following boiler, pressure vessel and piping codes and standards are reproduced here strictly for reference: ASME Sections I, IV and VIII and ANSI/ASME B31.1 (2007 Edition). This information has been included to provide a general idea as to the requirements of these codes and standards. Users of this information must be cautioned that these excerpts do not provide complete guidelines for inspection, installation, operation and manufacturing.

Only portions of each code and standard thought to be frequently used by persons not having direct access to the complete documents have been included. It must be noted that these codes and standards change on a periodic basis as indicated in s. Comm 41.10. Those who are bound by the rules of ch. Comm 41 must avail themselves of the applicable code section or standards listed in s. Comm 41.10.

**EXCERPTS FROM: ASME BOILER AND PRESSURE VESSEL CODE**  
**SECTION I - POWER BOILERS**  
**2007 EDITION**  
**INTRODUCTION**

This Code covers rules for construction of power boilers<sup>1</sup>, electric boilers<sup>2</sup>, miniature boilers<sup>3</sup>, and high-temperature water boilers<sup>4</sup> to be used in stationary service and includes those power boilers used in locomotive, portable, and traction service. Reference to a paragraph includes all the subparagraphs and subdivisions under that paragraph.

<sup>1</sup> Power boiler - a boiler in which steam or other vapor is generated at a pressure of more than 15 psi (100 kPa) for use external to itself.

<sup>2</sup> Electric boiler - a power boiler or a high-temperature water boiler in which the source of heat is electricity.

<sup>3</sup> Miniature boiler - a power boiler or a high-temperature water boiler in which the limits specified in PMB-2 are not exceeded.

<sup>4</sup> High-temperature water boiler - a water boiler intended for operation at pressures in excess of 160 psi (1.1 MPa) and/or temperatures in excess of 250°F (120°C).

The Code does not contain rules to cover all details of design and construction. Where complete details are not given, it is intended that the manufacturer, subject to the acceptance of the Authorized Inspector, shall provide details of design and construction which will be as safe as otherwise provided by the rules in the Code.

The scope of jurisdiction of Section I applies to the boiler proper and to the boiler external piping.

Superheaters, economizers, and other pressure parts connected directly to the boiler without intervening valves shall be considered as parts of the boiler proper, and their construction shall conform to Section I rules.

Boiler external piping shall be considered as that piping which begins where the boiler proper or separately fired superheater terminates at:

- (a) the first circumferential joint for welding end connections; or
- (b) the face of the first flange in bolted

flanged connections; or

(c) the first threaded joint in that type of connection; and which extends up to and including the valve or valves required by this Code.

ASME Code Certification (including Data Forms and Code Symbol Stamping), and/or inspection by the Authorized Inspector, when required by this Code, is required for the boiler proper and the boiler external piping.

Construction rules for materials, design, fabrication, installation, and testing of the boiler external piping are contained in ASME B31.1, Power Piping. Piping beyond the valve or valves required by Section I is not within the scope of Section I, and it is not the intent that the Code Symbol Stamp be applied to such piping or any other piping.

The material for forced-circulation boilers, boilers with no fixed steam and water line, and high-temperature water boilers shall conform to the requirements of the Code. All other requirements shall also be met except where they relate to special features of construction made necessary in boilers of these types, and to accessories that are manifestly not needed or used in connection with such boilers, such as water gages and water columns.

Reheaters receiving steam which has passed through part of a turbine or other prime mover and separately fired steam superheaters which are not integral with the boiler are considered fired pressure vessels and their construction shall comply with Code requirements for superheaters, including safety devices. Piping between the reheater connections and the turbine or other prime mover is not within the scope of

the Code.

A pressure vessel in which steam is generated by the application of heat resulting from the combustion of fuel (solid, liquid, or gaseous) shall be classed as a fired steam boiler.

Unfired pressure vessels in which steam is generated shall be classed as unfired steam boilers with the following exceptions:

- (a) vessels known as evaporators or heat exchangers;
- (b) vessels in which steam is generated by the use of heat resulting from operation of a processing system containing a number of pressure vessels such as used in the manufacture of chemical and petroleum products.

Unfired steam boilers shall be constructed under the provisions of Section I or Section VIII.

Expansion tanks required in connection with high-temperature water boilers shall be constructed to the requirements of Section I or Section VIII.

A pressure vessel in which an organic fluid is vaporized by the application of heat resulting from the combustion of fuel (solid, liquid, or gaseous) shall be constructed under the provisions of Section I. Vessels in which vapor is generated incidental to the operation of a processing system, containing a number of pressure vessels such as used in chemical and petroleum manufacture, are not covered by the rules of Section I.

## **PART PG GENERAL REQUIREMENTS FOR ALL METHODS OF CONSTRUCTION GENERAL**

### **PG-1 SCOPE**

The requirements of Part PG apply to power boilers and high pressure, high-temperature water boilers and to parts and appurtenances thereto and shall be used in

conjunction with the specific requirements in the applicable Parts of this Section that pertain to the methods of construction used.

### **PG-2 SERVICE LIMITATIONS**

**PG-2.1** The rules of this Section are applicable to the following services:

- (a) boilers in which steam or other vapor is generated at a pressure of more than 15 psig (100 kPa) for use external to itself
- (b) high-temperature water boilers intended for operation at pressures exceeding 160 psig (1.1 MPa) and/or temperatures exceeding 250°F (120°C)

**PG-2.2** For services below those specified in PG-2.1 it is intended that rules of Section IV apply; however, boilers for such services may be constructed and stamped in accordance with this Section provided all applicable requirements are met.

**PG-2.3** Coil-type hot water boilers where the water can flash into steam when released directly to the atmosphere through a manually operated nozzle may be exempted from the rules of this Section provided the following conditions are met:

- (a) There is no drum, header, or other steam space.
- (b) No steam is generated within the coil.
- (c) Tubing outside diameter does not exceed 1 in. (25 mm).
- (d) Pipe size does not exceed NPS  $\frac{3}{4}$  (DN 20).
- (e) Nominal water capacity does not exceed 6 gal (23 L).
- (f) Water temperature does not exceed 350°F (175°C).
- (g) Adequate safety relief valves and controls are provided.

### **PG-3 REFERENCED STANDARDS**

Specific editions of standards referenced in this Section are shown in A-360.

### **PG-4 UNITS**

Either U.S. Customary, SI, or any local customary units may be used to demonstrate compliance with all requirements of this edition (e.g., materials, design, fabrication, examination, inspection, testing, certification, and overpressure protection).

In general, it is expected that a single system of units shall be used for all aspects of design except where unfeasible or impractical. When components are manufactured at different locations where local customary units are different than those used for the general design, the local units may be used for the design and documentation of that component. Similarly, for proprietary components or those uniquely associated with a system of units different than that used for the general design, the alternate units may be used for the design and documentation of that component.

For any single equation, all variables shall be expressed in a single system of units. When separate equations are provided for U.S. Customary and SI units, those equations must be executed using variables in the units associated with the specific equation. Data expressed in other units shall be converted to U.S. Customary or SI units for use in these equations. The result obtained from execution of these equations may be converted to other units.

Production, measurement and test equipment, drawings, welding procedure specifications, welding procedure and performance qualifications, and other fabrication documents may be in U.S. Customary, SI, or local customary units in accordance with the fabricator's practice. When values shown in calculations and analysis, fabrication documents or measurement and test equipment are in different units, any conversions necessary for verification of Code compliance, and to ensure that dimensional consistency is

maintained, shall be in accordance with the following:

(a) Conversion factors shall be accurate to at least four significant figures.

(b) The results of conversions of units shall be expressed to a minimum of three significant figures.

Conversion of units, using the precision specified above shall be performed to ensure that dimensional consistency is maintained. Conversion factors between U.S. Customary and SI units may be found in A-390 of Nonmandatory Appendix A, *Guidance for the Use of U.S. Customary and SI Units in the ASME Boiler and Pressure Vessel Code*. Whenever local customary units are used, the Manufacturer shall provide the source of the conversion factors which shall be subject to verification and acceptance by the Authorized Inspector or Certified Individual.

Material that has been manufactured and certified to either the U.S. Customary or SI material specification (e.g., SA-516M) may be used regardless of the unit system used in design. Standard fittings (e.g., flanges, elbows, etc.) that have been certified to either U.S. Customary or SI units may be used regardless of the units system used in design.

All entries on a Manufacturer's Data Report and data for Code-required nameplate marking shall be in units consistent with the fabrication drawings for the component using U.S. Customary, SI, or local customary units. It is acceptable to show alternate units parenthetically. Users of this Code are cautioned that the receiving jurisdiction should be contacted to ensure the units are acceptable.

## **MATERIALS**

### **PG-5 GENERAL**

**PG-5.1** Material subject to stress due to pressure shall conform to one of the specifications given in Section II and shall be limited to those that are listed in the

Tables of Section II, Part D, except as otherwise permitted in PG-8.2, PG-8.3, PG-10, and PG-11. Materials shall not be used at temperatures above those for which stress values are limited, for Section I construction, in the Tables of Section II, Part D. Specific additional requirements described in PG-5 through PG-13 shall be met as applicable.

**PG-5.2** Material covered by specifications in Section II is not restricted as to the method of production unless so stated in the specification, and as long as the product complies with the requirements of the specification.

**PG-5.3** If, in the development of the art of boiler construction, it is desired to use materials other than those herein described, data should be submitted to the Boiler and Pressure Vessel Committee in accordance with the requirements of Appendix 5 of Section II, Part D. Material not completely identified with any approved Code specifications may be used in the construction of boilers under the conditions outlined in PG-10.

#### **PG-5.4 Size Limits and Tolerances**

**PG-5.4.1** Materials outside the limits of size or thickness given in the title or scope clause of any specification in Section II may be used if the material is in compliance with the other requirements of the specification, and no similar limitation is given in the rules for construction.

**PG-5.4.2** Pipe having a tolerance of  $\pm 1\%$  on either the O.D. or the I.D., rather than the tolerance specified in the material specification, may be used, provided the material complies with all other requirements of the specifications. When used under external pressure, such pipe shall be limited to a maximum of 24 in. (600 mm) in diameter. The pipe shall include the designation 1% O.D. or 1% I.D., as appropriate, in any required documentation and marking of the material.

**PG-5.5** The use of austenitic alloy steel is permitted for boiler pressure parts that are steam touched in normal operation. Except as specifically provided in PG-9.1.1, PG-12, and PEB-5.3, the use of such austenitic alloys for boiler pressure parts that are water wetted in normal service is prohibited.<sup>1</sup>

---

<sup>1</sup> Austenitic alloys are susceptible to intergranular corrosion and stress corrosion cracking when used in boiler applications in water wetted service. Factors that affect the sensitivity to these metallurgical phenomena are applied or residual stress and water chemistry. Susceptibility to attack is usually enhanced by using the material in a stressed condition with a concentration of corrosive agents (e.g., chlorides, caustic, or reduced sulfur species). For successful operation in water environments, residual and applied stresses must be minimized and careful attention must be paid to continuous control of water chemistry.

#### **PG-6 PLATE**

**PG-6.1** Steel plates for any part of a boiler subject to pressure, whether or not exposed to the fire or products of combustion, shall be of pressure vessel quality in accordance with one of the following specifications:

SA-202 Pressure Vessel Plates, Alloy Steel, Chromium-Manganese-Silicon

SA-204 Pressure Vessel Plates, Alloy Steel, Molybdenum

SA-240 (Type 405 only) Pressure Vessel Plates, Alloy Steel (Ferritic Stainless), Chromium

SA-285 Pressure Vessel Plates, Carbon Steel, Low-and Intermediate-Tensile Strength

SA-299 Pressure Vessel Plates, Carbon Steel, Manganese-Silicon

SA-302 Pressure Vessel Plates, Alloy Steel, Manganese-Molybdenum and Manganese-Molybdenum-Nickel

SA-387 Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum

SA-515 Pressure Vessel Plates, Carbon Steel, for Intermediate-and Higher-Temperature Service

#### **PG-55 SUPPORTS AND ATTACHMENT LUGS**

**PG-55.1** Lugs or hangers when used to support a boiler of any type shall be properly fitted to the surfaces to which they are attached.

**PG-55.2** Lugs, hangers, or brackets may be attached by fusion welding provided the welding meets the requirements of Part PW, including stress relieving but omitting radiographic examination and provided they are attached by full penetration welds, combination groove and fillet welds, or by fillet welds along the entire periphery or contact edges. Some acceptable forms of welds for lugs, hangers, or brackets are shown in Fig. PW-16.2. The materials for lugs, hangers, or brackets are not limited to those listed in Tables 1A and 1B of Section II, Part D, but shall be of weldable quality. The allowable load on the fillet welds shall equal the product of the weld area based on minimum leg dimension, the allowable stress value in tension of the material being welded, and the factor 0.55. When using welded pipe, the stress values given in Table 1A of Section II, Part D, may be increased to that of the basic material by eliminating the stated weld efficiencies.

## **BOILER EXTERNAL PIPING AND BOILER PROPER CONNECTIONS**

### **PG-58 OUTLETS AND EXTERNAL PIPING**

**PG-58.1 General.** The rules of this subparagraph apply to the boiler external piping as defined in the Preamble [Introduction].

**PG-58.2 Boiler External Piping Connections to Boilers.** All boiler external piping connected to a boiler for any purpose shall be attached to one of the types of joints listed in PG-59.1.1.1, PG-59.1.1.2, and PG-59.1.1.3.

**PG-58.3 Boiler External Piping.** The following defines the Code Jurisdictional

Limits of the boiler external piping systems, including general requirements, valves, and inspection. The limits are also shown in Figs. PG-58.3.1 and PG-58.3.2. The materials, design, fabrication, installation, and testing shall be in accordance with ASME B31.1, Power Piping.

**PG-58.3.1** The steam piping connected to the boiler drum or to the superheater outlet header shall extend up to and including the first stop valve in each connection, except as required by PG-58.3.2. In the case of a single boiler and prime mover installation, the stop valve required herein may be omitted provided the prime mover throttle valve is equipped with an indicator to show whether the valve is open or closed and is designed to withstand the required hydrostatic pressure test of the boiler.

For an isolable or separately fired superheater which discharges steam directly to a process stream, the stop valve required by this paragraph and the safety valve(s) required by PG-68 may be omitted provided the following conditions are satisfied:

(a) The boiler is a drum-type boiler in a single-boiler installation.

(b) The steam discharge passes through the process stream to the atmosphere with no intervening valves.

(c) The system shall be designed so that the process stream through which the steam discharge passes cannot be obstructed in such a way as to cause the pressure in the superheater to exceed that permitted by PG-67.2, with maximum steam flow from the boiler to the superheater. Flow and pressure calculations demonstrating that the superheater will not be overpressurized under any steam flow conditions shall be documented and made available to the Inspector. These calculations shall be certified by a Professional Engineer experienced in the mechanical design of power plants.

(d) There is no valve on the discharge side of the superheater.

(e) Section I jurisdiction shall include the pressure parts between the superheater inlet and the outlet at:

(1) the first circumferential joint for welding end connections; or

(2) the face of the first flange in bolted flange connections; or

(3) the first threaded joint in that type of connection.

**PG-58.3.2** When two or more boilers are connected to a common steam header, or when a single boiler is connected to a header having another steam source (e.g., a turbine extraction line), the connection from each boiler having a manhole opening shall be fitted with two stop valves having an ample free-blow drain between them. The boiler external piping includes all piping from the boiler proper up to and including the second stop valve and the free-blow drain valve.

**PG-58.3.3** The feedwater piping for all boilers, except high-temperature water boilers and forced-flow steam generators complying with PG-58.3.5, shall extend through the required stop valve and up to and including the check valve except as required by PG-58.3.4. On a single boiler-turbine unit installation the boiler feed shutoff valve may be located upstream from the boiler feed check valve.

If a feedwater heater or heaters meeting the requirements of Part PFH are installed between the required stop valve and the boiler, and are fitted with isolation and bypass valves, provisions must be made to prevent the feedwater pressure from exceeding the maximum allowable working pressure of the piping or feedwater heater, whichever is less. Control and interlock systems are permitted in order to prevent overpressure.

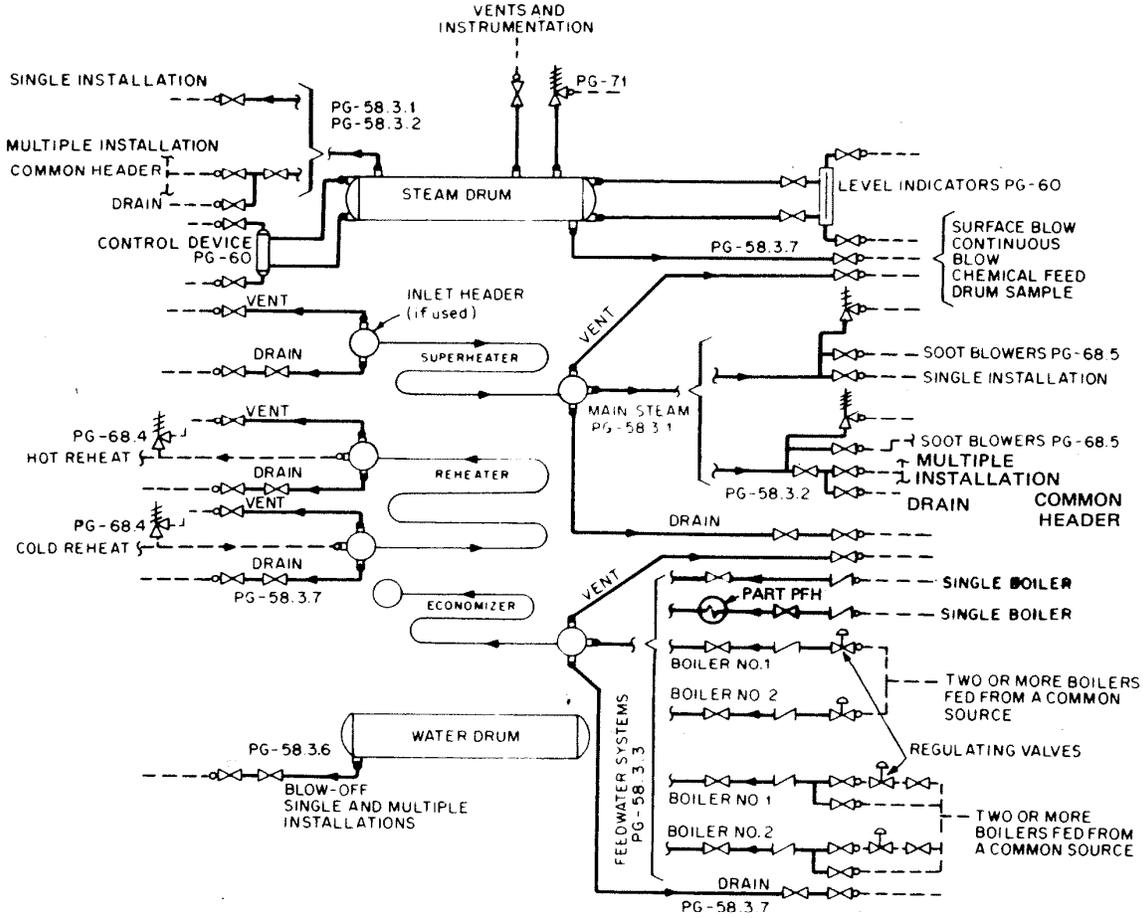
**PG-58.3.4** When two or more boilers are fed from a common source, the piping shall be up to and including a globe or regulating

valve located between the check valve required in PG-58.3.3 and the source of supply. If the regulating valve is equipped with an isolation valve and a bypass valve, the piping shall be up to and including both the isolation valve downstream from the regulating valve and the shutoff valve in the bypass.

**PG-58.3.5** The feedwater piping for a forced-flow steam generator with no fixed steam and waterline may terminate up to and including the stop valve near the boiler and omitting the check valve near the boiler, provided that a check valve having a pressure rating no less than the boiler inlet design pressure is installed at the discharge of the boiler feed pump or elsewhere in the feedline between the feed pump and the feed stop valve. If the feedwater heater(s) is fitted with isolation and bypass valves, the applicable requirements of PG-58.3.3 must be met.

**PG-58.3.6** The blowoff piping for all boilers, except forced-flow steam generators with no fixed steam and waterline, high-temperature water boilers, and those used for traction and/or portable purposes, when the maximum allowable working pressure exceeds 100 psi (700 kPa) shall extend through and including the second valve. The blowoff piping for all traction and/or portable boilers and for forced circulation and electric boilers having a normal water content not exceeding 100 gal (380 L) are required to extend through only one valve.

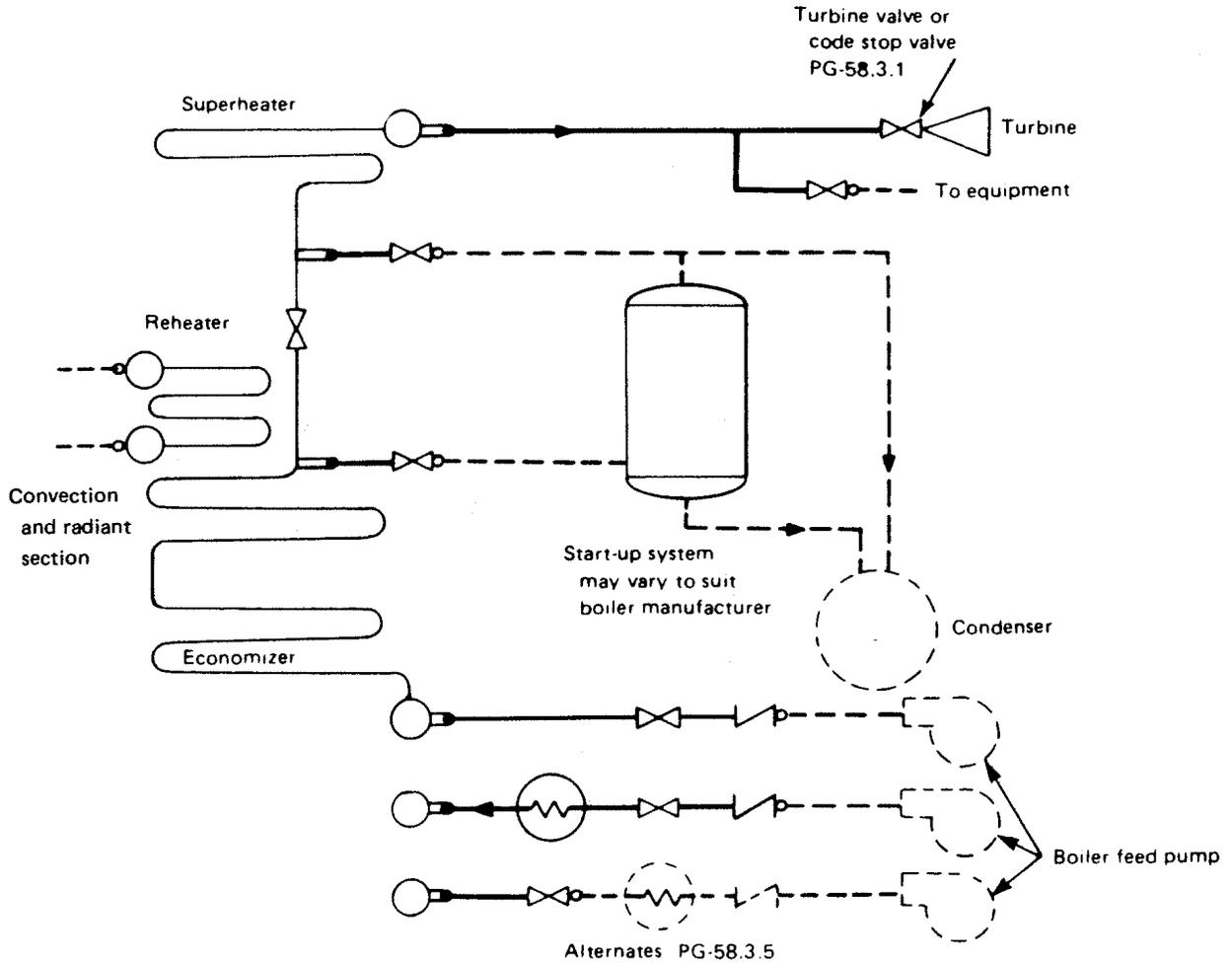
FIG. PG-58.3.1 CODE JURISDICTIONAL LIMITS FOR PIPING — DRUM-TYPE BOILERS



**ADMINISTRATIVE JURISDICTION & TECHNICAL RESPONSIBILITY**

- Boiler Proper — The ASME Boiler and Pressure Vessel Code (ASME BPVC) has total administrative jurisdiction and technical responsibility (refer to Section I Preamble).
- — Boiler External Piping and Joint — The ASME BPVC has total administrative jurisdiction (mandatory certification by Code Symbol stamping, ASME Data Forms, and Authorized Inspection) of Boiler External Piping and Joint. The ASME Section Committee B31.1 has been assigned technical responsibility.
- — Non-Boiler External Piping and Joint — Not Section I jurisdiction (see applicable ASME B31 Code).

FIG. PG-58.3.2 CODE JURISDICTIONAL LIMITS FOR PIPING — FORCED-FLOW STEAM GENERATOR WITH NO FIXED STEAM OR WATERLINE



**ADMINISTRATIVE JURISDICTION & TECHNICAL RESPONSIBILITY**

- Boiler Proper — The ASME Boiler and Pressure Vessel Code (ASME BPVC) has total administrative jurisdiction and technical responsibility (refer to Section I Preamble).
- Boiler External Piping and Joint — The ASME BPVC has total administrative jurisdiction (mandatory certification by Code Symbol stamping, ASME Data Forms, and Authorized Inspection) of Boiler External Piping and Joint. The ASME Section Committee B31.1 has been assigned technical responsibility.
- - - - Non-Boiler External Piping and Joint — Not Section I jurisdiction (see applicable ASME B31 Code).

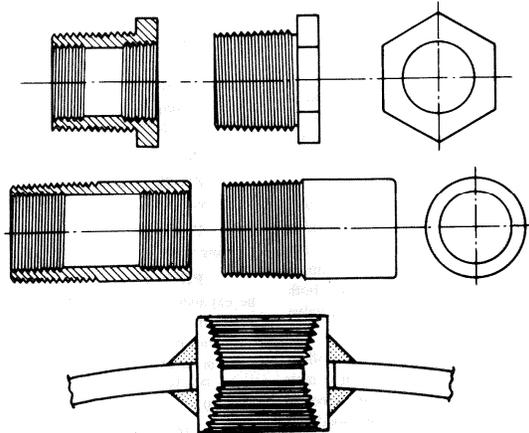
**PG-58.3.7** The miscellaneous piping shall include the piping for such items as drains, vents, surface-blowoff, steam and water piping for water columns, gage glasses and pressure gages. When a drain is not intended for blowoff purposes (when the boiler is under pressure) a single valve is acceptable, otherwise two valves in series are required except as permitted by PG-58.3.6.

**PG-58.3.8** Boiler external piping for high-temperature water boilers shall extend from the connections to the boiler up to and including the first stop valve and shall be classified as miscellaneous piping.

**PG-58.3.9** Welded piping in PG-58.3.1, PG-58.3.2, PG-58.3.3, PG-58.3.4, PG-58.3.5, PG-58.3.6, PG-58.3.7, and PG-58.3.8 is also subject to the requirements of PG-104 for proper Code certification.

## PG-59 APPLICATION REQUIREMENTS FOR THE BOILER PROPER

FIG. PG-59.1 TYPICAL BOILER BUSHINGS



### PG-59.1 Common to Steam, Feedwater, Blowoff, and Drain Systems

**PG-59.1.1** Outlets of a boiler to which piping is to be attached for any purpose, and which piping comes within the Code requirements, shall meet the requirements of PG-39 and shall be:

**PG-59.1.1.1** A tapped opening.

**PG-59.1.1.2** Bolted flanged joints including those of the Van Stone type.

**PG-59.1.1.3** Welding ends of the butt or socket welding type.

**PG-59.1.1.4** Piping within the boiler proper may be expanded into grooved holes, seal welded if desired. Blowoff piping of firetube boilers shall be attached by threading into a tapped opening with a threaded fitting or valve at the other end if exposed to products of combustion, or by PG-59.1.1.1 or PG-59.1.1.2 if not so exposed (see PFT-49).

**PG-59.1.2 Steam Mains.** Provisions shall be made for the expansion and contraction of steam mains connected to boilers, by providing substantial anchorage at suitable points, so that there shall be no undue strain transmitted to the boiler. Steam reservoirs shall be used on steam mains when heavy pulsations of the steam currents cause vibration of the boiler shell plates.

**PG-59.1.3** Figure PG-59.1 illustrates a typical form of connection for use on boiler shells for passing through piping such as feed, surface blowoff connections, etc., and which permits the pipes' being threaded in solid from both sides in addition to the reinforcing of the opening of the shell. The pipes shall be attached as provided in PG-59.1.1.

In these and other types of boilers where both internal and external pipes making a continuous passage are employed, the boiler bushing or its equivalent shall be used.

**PG-59.2 Requirements for Feedwater Connections.** The feedwater shall be introduced into a boiler in such a manner that the water will not be discharged directly against surfaces exposed to gases of high temperature or to direct radiation from the fire. For pressures of 400 psi (3 MPa) or over, the feedwater inlet through the drum shall be fitted with shields, sleeves, or other suitable means to reduce the effects of temperature differentials in the shell or head.

Feedwater, other than condensate returns as provided for in PG-59.3.6, shall not be introduced through the blowoff.

### **PG-59.3 Requirements for Blowoffs**

**PG-59.3.1** A blowoff as required herein is defined as a pipe connection provided with valves located in the external piping through which the water in the boiler may be blown out under pressure, excepting drains such as are used on water columns, gage glasses, or piping to feedwater regulators, etc., used for the purpose of determining the operating condition of such equipment. Piping connections used primarily for continuous operation, such as deconcentrators on continuous blowdown systems, are not classed as blowoffs but the pipe connections and all fittings up to and including the first shutoff valve shall be equal at least to the pressure requirements for the lowest set pressure of any safety valve on the boiler drum and with the corresponding saturated-steam temperature.

**PG-59.3.2** A surface blowoff connection shall not exceed NPS 2½ (DN 65), and the internal pipe and the terminal connection for the external pipe, when used, shall form a continuous passage, but with clearance between their ends and arranged so that the removal of either will not disturb the other. A properly designed steel bushing, similar to or the equivalent of those shown in Fig. PG-59.1, or a flanged connection shall be used.

**PG-59.3.3** Each boiler except forced-flow steam generators with no fixed steam and waterline and high-temperature water boilers shall have a bottom blowoff outlet in direct connection with the lowest water space practicable for external piping conforming to PG-58.3.6.

**PG-59.3.4** All waterwalls and water screens that do not drain back into the boiler, and all integral economizers, shall be equipped with outlet connections for a blowoff or drain line and conform to the requirements of PG-58.3.6 or PG-58.3.7.

**PG-59.3.5** Except as permitted for miniature boilers in Part PMB and for boilers with 100 ft<sup>2</sup> (9.3 m<sup>2</sup>) of heating surface or less, the minimum size of blowoff connections shall be NPS 1 (DN 25) and the maximum size shall be NPS 2½ (DN 65). Boilers with 100 ft<sup>2</sup> (9.3 m<sup>2</sup>) or less but more than 20 ft<sup>2</sup> (1.9 m<sup>2</sup>) of heating surface may have a minimum size blowoff connection of NPS ¾ (DN 20). Boilers with 20 ft<sup>2</sup> (1.9 m<sup>2</sup>) or less of heating surface may have a minimum size blowoff connection of NPS ½ (DN 15).

**PG-59.3.6** Condensate return connections of the same size or larger than the size herein specified may be used, and the blowoff may be connected to them. In such case the blowoff shall be so located that the connection may be completely drained.

**PG-59.3.7** A bottom blowoff pipe when exposed to direct furnace heat shall be protected by firebrick or other heat resisting material that is so arranged that the pipe may be inspected.

**PG-59.3.8** An opening in the boiler setting for a blowoff pipe shall be arranged to provide free expansion and contraction.

### **PG-59.4 Requirements for Drains**

**PG-59.4.1** Ample drain connections shall be provided where required to permit complete drainage of all piping, superheaters, waterwalls, water screens, economizers, and all other boiler components in which water may collect. Piping shall conform to the requirements of PG-58.3.6 or PG-58.3.7.

**PG-59.4.1.1** Each superheater shall be equipped with at least one drain connection so located as to most effectively provide for the proper operation of the apparatus.

**PG-59.4.1.2** Each high-temperature water boiler shall have a bottom drain connection of at least NPS 1 (DN 25) in direct connection with the lowest water space practical for external piping conforming to PG-58.3.8.

**PG-59.5 Requirements for Valves and Fittings.** The following requirements apply to the use of valves and fittings in the boiler proper.

**PG-59.5.1 Steam Stop Valves**

**PG-59.5.1.1** If a shutoff valve is used between the boiler and its superheater, the safety valve capacity on the boiler shall comply with the requirements of PG-67.2 and PG-70, except as provided for in PG-59.5.1.2, no credit being taken for the safety valve on the superheater, and the superheater must be equipped with safety valve capacity as required by PG-68. A stop valve is not required at the inlet or the outlet of a reheater or separately fired superheater.

**PG-59.5.1.2** When stop valves are installed in the water-steam flow path between any two sections of a forced-flow steam generator with no fixed steam and waterline, the safety valves shall satisfy the requirements of PG-67.4.4.

## DESIGN AND APPLICATION

### PG-60 REQUIREMENTS FOR MISCELLANEOUS PIPE, VALVES, AND FITTINGS

Piping referred to in this paragraph shall be designed in accordance with the applicable requirements of ASME B31.1.

**PG-60.1 Water Level Indicators.** All boilers having a fixed water level (steam and water interface) shall have at least one gage glass (a transparent device that permits visual determination of the water level). Boilers not having a fixed water level, such as forced-flow steam generators and high-temperature water boilers of the forced circulation type, are not required to have a gage glass. The lowest visible water level in a gage glass shall be at least 2 in. (50 mm) above the lowest permissible water level, as determined by the boiler Manufacturer. Electrode-type electric boilers are required

to have only one gage glass, regardless of MAWP.

Gage glasses having multiple tubular sections shall have a minimum of 1 in. (25 mm) overlap of the sections in which the water level may be visible. Segmented gage glasses, such as ported or end-connected strip gages, shall be equipped to provide obvious visual discrimination between water and vapor in the individual sections.

**PG-60.1.1** Boilers having a maximum allowable working pressure exceeding 400 psi (3 MPa) shall have two gage glasses. Instead of one of the two required gage glasses, two independent remote water level indicators (two discrete systems that continuously measure, transmit, and display water level) may be provided.

**PG-60.1.1.1** When the water level in at least one gage glass is not readily visible to the operator in the area where control actions are initiated, either a fiber optic cable (with no electrical modification of the optical signal) or mirrors shall be provided to transfer the optical image of the water level to the control area. Alternatively, any combination of two of the following shall be provided:

- (a) an independent remote water level indicator
- (b) an independent continuous transmission and display of an image of the water level in a gage glass

**PG-60.1.1.2** When two independent remote water level indicators are in reliable operation (continuously indicating water level), the one required gage glass may be shut off, but shall be maintained in the serviceable condition.

**PG-60.1.1.3** The display of a remote water level indicator shall have a clearly marked minimum water level reference at least 2 in. (50 mm) above the lowest permissible water level, as determined by the Manufacturer.

**PG-60.1.1.4** Independent remote level indicators that contain sensing devices that include a magnetically coupled float inside a nonmagnetic cylindrical pressure chamber to utilize through-the-wall sensing of float position shall be restricted to the requirements of PG- 12.2.<sup>19</sup> The design and construction of such devices shall include provisions for ease of cleaning and maintenance. Attachment of any control devices for use other than indicating water level is prohibited.

---

<sup>19</sup> Such float-type devices are calibrated for a specific range of pressures and temperatures, and restrictions specified by the remote indicator manufacturer shall be satisfied.

**PG-60.1.6** Each gage glass or austenitic stainless steel or nickel-based alloy water level-sensing device shall be fitted with a drain cock or valve having an unrestricted drain opening of not less than ¼ in. (6 mm) diameter to facilitate cleaning. When the boiler MAWP exceeds 100 psi (700 kPa), the gage glass shall be furnished with a connection to install a valved drain to a point of safe discharge.

Each gage glass or austenitic stainless steel or nickel-based alloy water level-sensing device shall be equipped with a top and a bottom shutoff valve of such through-flow construction as to prevent stoppage by deposits of sediments. If the bottom valve is more than 7 ft (2 m) above the floor or platform from which it is operated, the operating mechanism shall indicate by its position whether the valve is open or closed. The pressure-temperature rating of valves, fittings, and piping shall be at least equal to the boiler MAWP and the corresponding saturated-steam temperature.

Straight-run globe valves shall not be used on such connections. Automatic shutoff valves as referenced here, are valves intended to automatically restrict flow in the event of a gage glass failure without human

intervention, and shall conform to the requirements given in A-18.

**PG-60.1.7** As used in this section, “automated isolation valve” shall be taken to mean a device that is actuated electrically, pneumatically, or hydraulically to temporarily isolate a gage glass. It is required that the closing and opening sequences of such a device be manually initiated by the operator.

Automated isolation valves may be used, provided

(a) all piping and fittings between the sight glass and the boiler, or sight glass and water column, are designed for internal inspection and cleaning, or are designed to

allow passage internally of a rotary cleaning tool. The valves shall be of such through-flow construction as to prevent stoppage by deposits of sediment.

(b) the valves are equipped with opened and closed indicators that can readily be seen from the valve operating floor or platform. The design of the valves shall be such as to prevent indicating a false opened or closed condition.

(c) a means of manually opening and closing the valves from the valve operating floor or platform is provided.

(d) automated isolation valves are designed to fail-safe in the as-is condition.

## **PG-60.2 Water Columns**

**PG-60.2.1** A water column shall be so mounted that it will be correctly positioned, relative to the normal water level under operating conditions.

**PG-60.2.3** Each water column shall be furnished with a connection of at least NPS ¾ (DN 20) to install a valved drain to a safe point of discharge.

**PG-60.2.4** The design and material of a water column shall comply with the requirements of PG-8.2, PG-8.3, and PG-42.

## **PG-60.3 Connections**

**PG-60.3.1** Gage glasses that are required by PG-60.1 shall be connected directly to

the shell or drum of the boiler or to an intervening water column. When two gage glasses are required, both may be connected to a single water column.

**PG-60.3.2** The lower edge of the steam connection between a water column, gage glass, or austenitic stainless steel or nickel-based alloy water level-sensing device in the boiler shall not be below the highest visible water level in the gage glass. There shall be no sag or offset in the piping that will permit the accumulation of water.

**PG-60.3.3** The upper edge of the water connection between a water column, gage glass, or austenitic stainless steel or nickel-based alloy water level-sensing device and the boiler shall not be above the lowest visible water level in the gage glass. No part of this pipe connection shall be above the point of connection at the water column.

**PG-60.3.4** Connections from the boiler to the water column shall be at least NPS 1 (DN 25). Connections for gage glasses connected directly to the boiler or to an intervening water column shall be at least NPS ½ (DN 15). Connections from the boiler to the remote level indicator shall be at least NPS ¾ (DN 20) to and including the isolation valve and from there to the remote level indicator at least ½ in. (13 mm) O.D. tubing.

**PG-60.3.5** When the boiler MAWP exceeds 400 psi (3 MPa), lower connections to drums for water columns and remote level indicators shall be provided with shields, sleeves, or other suitable means to reduce the effect of temperature differentials in the shells or heads.

**PG-60.3.6** The steam and water connections to a water column, gage glass, or austenitic stainless steel or nickel-based alloy water level-sensing device shall be readily accessible for internal inspection and cleaning. Some acceptable methods of meeting this requirement are by providing a cross or fitting with a back outlet at each

right-angle turn to permit inspection and cleaning in both directions, or by using pipe bends or fittings of a type that does not leave an internal shoulder or pocket in the pipe connection and with a radius of curvature that will permit the passage of a rotary cleaner. Screwed plug closures using threaded connections as allowed by PG-39.5.3 are acceptable means of access for this inspection and cleaning. When the boiler MAWP exceeds 400 psig (3 MPa), socket-welded plugs may be used for this purpose in lieu of screwed plugs. If the water connection to the water column has a rising bend or pocket that cannot be drained by means of the water-column drain, an additional drain shall be placed on this connection so that it may be blown off to clear any sediment from the pipe.

**PG-60.3.7** Shutoff valves, including automated valves as described in PG-60.1.7, if provided in the pipe connections between a boiler and a water column or between a boiler and the shutoff valves required for the gage glass, or austenitic stainless steel or nickel-based alloy water level-sensing device (PG-60.1.6), shall be of such through-flow construction as to prevent stoppage by deposits of sediment and shall indicate whether they are in open or closed position of the operating mechanism.

Some examples of acceptable valves are

- (a) outside-screw-and-yoke type gate valve
- (b) lever-lifting-type gate valve with permanently fastened lever
- (c) stopcock with the plug held in place by a guard or gland
- (d) ball valve

Such valves shall be locked or sealed open except under the following additional conditions:

(1) The boiler MAWP shall not exceed 250 psig (1.7 MPa).

(2) The boiler shall not be hand fired or fired with solid fuel not in suspension.

(3) Interlocks between the valve and the burner control system shall stop fuel supply and prevent firing whenever the valve between the drum and the water column is not in the fully open position.

(4) The minimum valve size shall be NPS 1 (DN 25).

**PG-60.3.7.1** Automated isolation valves (as described in PG-60.1.7) need not be locked or sealed open as noted above.

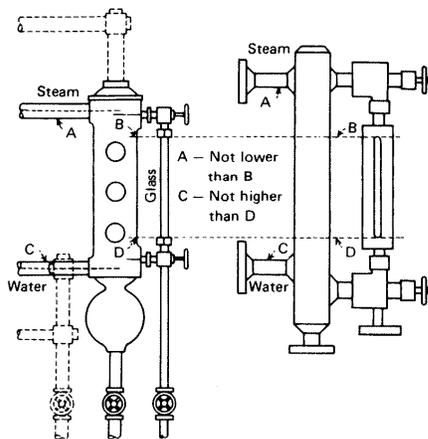
**PG-60.3.8** Except for control devices such as damper regulators and feedwater regulators, drains, steam pressure gages, or apparatus of such form as does not permit the

escape of an appreciable amount of steam or water there-from, no outlet connections shall be placed on the piping connecting a water column or gage glass to a boiler. No outlet connections shall be placed on the piping connecting a remote level indicator to the boiler or to a water column for any function other than water level indication.

**PG-60.3.9** An acceptable arrangement is shown in Fig. PG-60.

**PG-60.4 Gage Cocks.** Not required.

FIG. PG-60 TYPICAL ARRANGEMENT OF STEAM AND WATER CONNECTIONS FOR A WATER COLUMN



**PG-60.5 Water Fronts.** Each boiler fitted with a water jacketed boiler-furnace mouth protector, or similar appliance having valves on the pipes connecting them to the boiler shall have these valves locked or

sealed open. Such valves, when used, shall be of the straightway type.

### **PG-60.6 Pressure Gages**

**PG-60.6.1** Each boiler shall have a pressure gage so located that it is easily readable. The pressure gage shall be installed so that it shall at all times indicate the pressure in the boiler. Each steam boiler shall have the pressure gage connected to the steam space or to the water column or its steam connection. A valve or cock shall be placed in the gage connection adjacent to the gage. An additional valve or cock may be located near the boiler providing it is locked or sealed in the open position. No other shutoff valves shall be located between the gage and the boiler. The pipe connection shall be of ample size and arranged so that it may be cleared by blowing out. For a steam boiler the gage or connection shall contain a siphon or equivalent device that will develop and maintain a water seal that will prevent steam from entering the gage tube. Pressure gage connections shall be suitable for the maximum allowable working pressure and temperature, but if the temperature exceeds 406°F (208°C), brass or copper pipe or tubing shall not be used. The connections to the boiler, except the siphon, if used, shall not be less than NPS ¼ (DN 8) but where steel or wrought iron pipe or tubing is used, they shall not be less than ½ in. (13 mm) inside diameter. The minimum size of a siphon, if used, shall be ¼ in. (6 mm) inside diameter. The dial of the pressure gage shall be graduated to approximately double the pressure at which the safety valve is set, but in no case to less than 1½ times this pressure.

**PG-60.6.2** Each forced-flow steam generator with no fixed steam and waterline shall be equipped with pressure gages or other pressure measuring devices located as specified in PG-60.6.2.1 through PG-60.6.2.3.

**PG-60.6.2.1** at the boiler or superheater outlet (following the last section, which involves absorption of heat)

**PG-60.6.2.2** at the boiler or economizer inlet (preceding any section that involves absorption of heat), and

**PG-60.6.2.3** upstream of any shutoff valve that may be used between any two sections of the heat absorbing surface

**PG-60.6.3** Each boiler shall be provided with a valve connection at least NPS ¼ (DN 8) for the exclusive purpose of attaching a test gage when the boiler is in service, so that the accuracy of the boiler pressure gage can be ascertained.

**PG-60.6.4** Each high-temperature water boiler shall have a temperature gage so located and connected that it shall be easily readable. The temperature gage shall be installed so that it at all times indicates the temperature in degrees Fahrenheit (Celsius) of the water in the boiler, at or near the outlet connection.

#### **PG-61 FEEDWATER SUPPLY**

**PG-61.1** Except as provided for in PG-61.2 and PG-61.4, boilers having more than 500 ft<sup>2</sup> (47 m<sup>2</sup>) of water-heating surface shall have at least two means of feeding water. Except as provided for in PG-61.3, PG-61.4, and PG-61.5, each source of feeding shall be capable of supplying water to the boiler at a pressure of 3% higher than the highest setting of any safety valve on the boiler. For boilers that are fired with solid fuel not in suspension, and for boilers whose setting or heat source can continue to supply sufficient heat to cause damage to the boiler if the feed supply is interrupted, one such means of feeding shall not be susceptible to the same interruption as the other, and each shall provide sufficient water to prevent damage to the boiler.

**PG-61.2** Except as provided for in PG-61.1, a boiler fired by gaseous, liquid, or solid fuel in suspension, or heated by combustion turbine engine exhaust, may be

equipped with a single means of feeding water, provided means are furnished for the shutting off of its heat input prior to the water level reaching the lowest permissible level established by PG-60.

**PG-61.3** For boilers having a water-heating surface of more than 100 ft<sup>2</sup> (9.3 m<sup>2</sup>), the feed water connection to the boiler shall be not less than NPS ¾ (DN 20).

For boilers having a water-heating surface of 100 ft<sup>2</sup> (9.3 m<sup>2</sup>) or less, the feed water connection to the boiler shall be not less than NPS ½ (DN 15).

Boilers with 20 ft<sup>2</sup> (1.9 m<sup>2</sup>) or less of water heating surface may have the feed water delivered through the blowoff opening.

**PG-61.4** High-temperature water boilers shall be provided with means of adding water to the boiler or system while under pressure.

**PG-61.5** A forced-flow steam generator with no fixed steam and waterline shall be provided with a source of feeding capable of supplying water to the boiler at a pressure not less than the expected maximum sustained pressure at the boiler inlet, as determined by the boiler Manufacturer, corresponding to operation at maximum designed steaming capacity with maximum allowable working pressure at the superheater outlet.

### **SAFETY VALVES AND SAFETY RELIEF VALVES<sup>20</sup>**

---

<sup>20</sup> *Safety Valve:* An automatic pressure relieving device actuated by the static pressure upstream of the valve and characterized by full-opening pop action. It is used for gas or vapor service.

*Relief Valve:* An automatic pressure relieving device actuated by the static pressure upstream of the valve which opens further with the increase in pressure over the opening pressure. It is used primarily for liquid service.

*Safety Relief Valve:* An automatic pressure-actuated relieving device suitable for use either as a safety valve or relief valve, depending on application.

Unless otherwise defined, the definitions relating to pressure relief devices in Appendix I of ASME PTC 25-1994, Pressure Relief Devices, shall apply

## **PG-67 BOILER SAFETY VALVE REQUIREMENTS**

**PG-67.1** Each boiler shall have at least one safety valve or safety relief valve and if it has more than 500 ft<sup>2</sup> (47 m<sup>2</sup>) of bare tube water-heating surface, or if an electric boiler has a power input more than 1,100 kW, it shall have two or more safety valves or safety relief valves. For a boiler with combined bare tube and extended water-heating surface exceeding 500 ft<sup>2</sup> (47 m<sup>2</sup>), two or more safety valves or safety relief valves are required only if the design steam generating capacity of the boiler exceeds 4,000 lb/hr (1 800 kg/hr). Organic fluid vaporizer generators require special consideration as given in Part PVG.

**PG-67.2** The safety valve or safety relief valve capacity for each boiler (except as noted in PG-67.4) shall be such that the safety valve, or valves will discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than 6% above the highest pressure at which any valve is set and in no case to more than 6% above the maximum allowable working pressure.

**PG-67.2.1** The minimum required relieving capacity of the safety valves or safety relief valves for all types of boilers shall be not less than the maximum designed steaming capacity at the MAWP of the boiler, as determined by the Manufacturer and shall be based on the capacity of all the fuel burning equipment as limited by other boiler functions

**PG-67.2.2** The minimum required relieving capacity for a waste heat boiler shall be determined by the Manufacturer. When auxiliary firing is to be used in combination with waste heat recovery, the maximum output as determined by the boiler Manufacturer shall include the effect of such firing in the total required capacity. When auxiliary firing is to be used in place of waste heat recovery, the minimum required

relieving capacity shall be based on auxiliary firing or waste heat recovery, whichever is higher.

**PG-67.2.3** The minimum required relieving capacity for electric boilers shall be in accordance with PEB-15.

**PG-67.2.4** The minimum required relieving capacity in lb/hr (kg/hr) for a high-temperature water boiler shall be determined by dividing the maximum output in Btu/hr (W) at the boiler nozzle, produced by the highest heating value fuel for which the boiler is designed, by 1,000 (1.6).

**PG-67.2.5** The minimum required relieving capacity for organic fluid vaporizers shall be in accordance with PVG-12.

**PG-67.2.6** Any economizer that may be shut off from the boiler, thereby permitting the economizer to become a fired pressure vessel, shall have one or more

safety relief valves with a total discharge capacity, in lb/hr (kg/hr), calculated from the maximum expected heat absorption in Btu/hr (W), as determined by the Manufacturer, divided by 1,000 (1.6). This absorption shall be stated in the stamping (PG-106.4).

**PG-67.3** One or more safety valves on the boiler proper shall be set at or below the maximum allowable working pressure (except as noted in PG-67.4). If additional valves are used the highest pressure setting shall not exceed the maximum allowable working pressure by more than 3%. The complete range of pressure settings of all the saturated-steam safety valves on a boiler shall not exceed 10% of the highest pressure to which any valve is set. Pressure setting of safety relief valves on high-temperature water boilers<sup>21</sup> may exceed this 10% range.

---

<sup>21</sup> Safety relief valves in hot water service are more susceptible to damage and subsequent leakage, than safety valves relieving steam. It is recommended that the maximum allowable working pressure of the boiler and the safety relief valve setting for high-temperature water boilers be selected substantially higher than the desired

operating pressure so as to minimize the times the safety relief valve must lift.

**PG-67.4** For a forced-flow steam generator with no fixed steam and waterline (Fig. PG-67.4), equipped with automatic controls and protective interlocks responsive to steam pressure, safety valves may be provided in accordance with the above paragraphs or the following protection against overpressure shall be provided:

**PG-67.4.1** One or more power-actuated pressure relieving valves<sup>22</sup> shall be provided in direct communication with the boiler when the boiler is under pressure and shall receive a control impulse to open when the maximum allowable working pressure at the superheater outlet, as shown in the master stamping (PG-106.3), is exceeded. The total combined relieving capacity of the power-actuated relieving valves shall be not less than 10% of the maximum design steaming capacity of the boiler under any operating condition as determined by the Manufacturer. The valve or valves shall be located in the pressure part system where they will relieve the overpressure.

---

<sup>22</sup> The power-actuated pressure relieving valve is one whose movements to open or close are fully controlled by a source of power (electricity, air, steam, or hydraulic). The valve may discharge to atmosphere or to a container at lower pressure. The discharge capacity may be affected by the downstream conditions, and such effects shall be taken into account. If the power-actuated pressure relieving valves are also positioned in response to other control signals, the control impulse to prevent overpressure shall be responsive only to pressure and shall override any other control function.

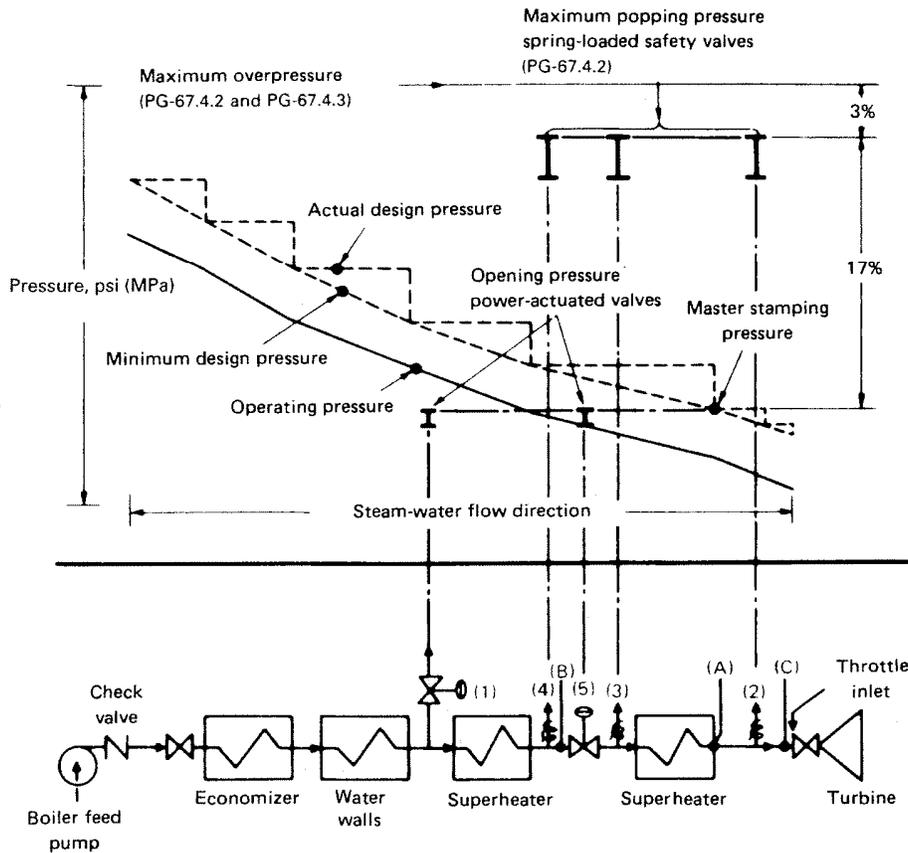
An isolating stop valve of the outside-screw-and-yoke or ball type may be installed between the power-actuated pressure relieving valve and the boiler to permit repairs provided an alternate power-actuated pressure relieving valve of the same capacity is so installed as to be in direct communication with the boiler in accordance with the requirements of this paragraph.

The isolating stop valve port area shall at least equal the area of the inlet of the power-actuated pressure relieving valve. If the isolating stop valve is of the ball type, the valve shall include a means to clearly identify whether the valve is in the open or closed position. If the isolating stop valve is power actuated (air, motor, hydraulic, etc.), a manual override mechanism shall be provided.

Power-actuated pressure relieving valves discharging to intermediate pressure and incorporated into bypass and/or startup circuits by the boiler Manufacturer need not be capacity certified. Instead, they shall be marked by the valve manufacturer with a capacity rating at a set of specified inlet pressure and temperature conditions. Power-actuated pressure relieving valves discharging directly to atmosphere shall be capacity certified. This capacity certification shall be conducted in accordance with the provisions of PG-69.3. The valves shall be marked in accordance with the provisions of PG-69.4.

**PG-67.4.2** Spring-loaded safety valves shall be provided, having a total combined relieving capacity, including that of the power-actuated pressure relieving capacity installed under PG-67.4.1, of not less than 100% of the maximum designed steaming capacity of the boiler, as determined by the Manufacturer, except the alternate provisions of PG-67.4.3 are satisfied. In this total, no credit in excess of 30% of the total required relieving capacity shall be allowed for the power-actuated pressure relieving valves actually installed. Any or all of the spring-loaded safety valves may be set above the maximum allowable

FIG. PG-67.4 REQUIREMENTS FOR PRESSURE RELIEF FORCED-FLOW STEAM GENERATOR



**Pressure**

- (A) = master stamping (PG-106.3)
- (B) = component design at inlet to stop valve (5) (PG-67.4.4.1)
- (C) = turbine throttle inlet (ANSI/ASME B31.1, paragraph 122.1.2, A.4)

**Pressure Relief Valves**

- (1) = power actuated (PG-67.4.1)
- (2), (3), and (4) = spring loaded safety (PG-67.4.2)
- (5) = superheater stop (PG-67.4.4)

**Relief Valve Flow Capacity (minimum, based on rated capacity of boiler)**

- (1) = 10 – 30% (PG-67.4.1)
- (2) = minimum of one valve (PG-68.1)
- (2) + (3) when downstream to stop valve (5) = that required for independently fired superheaters (PG-68.3)
- (2) + (3) + (4) = 100% – (1) (PG-67.4.2)

**Relief Valve Opening Pressure (maximum)**

- (1) = (A), and (B) when there is stop valve (5) (PG-67.4.1)
- (2), (3), and (4) = (A) + 17% (PG-67.4.2)
- (5) = (A) (PG-67.4.1)

**Alternate Requirements for Safety Valves**

**Relief Valve Flow Capacity (minimum, based on rated capacity of boiler)**

- (1) = 10 – 30% (PG-67.4.1)
- (2) = one valve minimum (PG-68.1)
- (2) + (3) when downstream to stop valve (5) = that required for independently fired superheaters (PG-68.3)
- (4) = 10% total with minimum of 2 valves when there is a stop valve (5) (PG-67.5.3.3)
- (2) + (4) = 10% with minimum of 2 valves when there is no stop valve (5) (PG-67.4.3.3)

**Relief Valve Opening Pressure (maximum)**

- (1) = (A), and (B) when there is stop valve (5) (PG-67.4.1)
- (2), (3), and (4) = (A) + 20% (PG-67.4.3.3)
- (5) = (A) (PG-67.4.1)

**Automatic Pressure Controls (PG-67.4.3)**

- (a) at (C) for normal operation under load (PG-67.4.3.2.1)
- (b) at (A) + 10% to override control (a) (PG-67.4.3.2.2)
- (c) at (A) + 20% to shut off flow of fuel and feedwater (PG-67.4.3.2.3)
- (d) safety valves at (4) to shut off flow of fuel and feedwater by "fail-safe" power circuit (PG-67.4.3.4)

working pressure of the parts to which they are connected, but the set pressures shall be such that when all of these valves (together with the power-actuated pressure relieving valves) are in operation the pressure will not rise more than 20% above the maximum allowable working pressure of any part of the boiler, except for the steam piping between the boiler and the prime mover.

**PG-67.4.3** The total installed capacity of springloaded safety valves may be less than the requirements of PG-67.4.2 provided all of the following conditions are met.

**PG-67.4.3.1** The boiler shall be of no less steaming capacity than 1,000,000 lb/hr (450 000 kg/hr) and installed in a unit system for power generation (i.e., a single boiler supplying a single turbine-generator unit).

**PG-67.4.3.2** The boiler shall be provided with automatic devices, responsive to variations in steam pressure, which include not less than all the following:

**PG-67.4.3.2.1** A control capable of maintaining steam pressure at the desired operating level and of modulating firing rates and feedwater flow in proportion to a variable steam output.

**PG-67.4.3.2.2** A control that overrides PG-67.4.3.2.1 by reducing the fuel rate and feedwater flow when the steam pressure exceeds the maximum allowable working pressure as shown in the master stamping (PG-106.3) by 10%, and

**PG-67.4.3.2.3** A direct-acting overpressure-trip- actuating mechanism, using an independent pressure sensing device, that will stop the flow of fuel and feedwater to the boiler, at a pressure higher than the set pressure of PG-67.4.3.2.2, but less than 20% above the maximum allowable working pressure as shown in the master stamping (PG-106.3).

**PG-67.4.3.3** There shall be not less than two spring-loaded safety valves and the total rated relieving capacity of the spring-loaded

safety valves shall be not less than 10% of the maximum designed steaming capacity of the boiler as determined by the Manufacturer. These spring-loaded safety valves may be set above the maximum allowable working pressure of the parts to which they are connected but shall be set such that the valves will lift at a pressure no higher than 20% above the maximum allowable working pressure as shown in the master stamping (PG-106.3).

**PG-67.4.3.4** At least two of these spring-loaded safety valves shall be equipped with a device that directly transmits the valve stem lift action to controls that will stop the flow of fuel and feedwater to the boiler. The control circuitry to accomplish this shall be arranged in a “fail-safe” manner (see Note).

**NOTE:** “Fail-safe” shall mean a circuitry arranged as either of the following:

(a) *Energize to trip:* There shall be at least two separate and independent trip circuits served by two power sources, to initiate and perform the trip action. One power source shall be a continuously charged DC battery. The second source shall be an AC-to-DC converter connected to the DC system to charge the battery and capable of performing the trip action. The trip circuits shall be continuously monitored for availability.

It is not mandatory to duplicate the mechanism that actually stops the flow of fuel and feedwater.

(b) *De-energize to trip:* If the circuits are arranged in such a way that a continuous supply of power is required to keep the circuits closed and operating and such that any interruption of power supply will actuate the trip mechanism, then a single trip circuit and single power supply will be enough to meet the requirements of this subparagraph.

**PG-67.4.3.5** The power supply for all controls and devices required by PG-67.4.3 shall include at least one source contained within the same plant as the boiler and which is arranged to actuate the controls and devices continuously in the event of failure or interruption of any other power sources.

**PG-67.4.4** When stop valves are installed in the water-steam flow path between any two sections of a forced-flow steam generator with no fixed steam and waterline,

**PG-67.4.4.1** The power-actuated pressure relieving valve(s) required by PG-67.4.1

shall also receive a control impulse to open when the maximum allowable working pressure of the component, having the lowest pressure level upstream to the stop valve, is exceeded, and

**PG-67.4.4.2** The spring-loaded safety valves shall be located to provide the pressure protection requirements in PG-67.4.2 or PG-67.4.3.

**PG-67.4.5** A reliable pressure-recording device shall always be in service and records kept to provide evidence of conformity to the above requirements.

**PG-67.5** All safety valves or safety relief valves shall be so constructed that the failure of any part cannot obstruct the free and full discharge of steam and water from the valve. Safety valves shall be of the direct spring-loaded pop type, with seat inclined at any angle between 45 deg and 90 deg, inclusive, to the center line of the spindle. The coefficient of discharge of safety valves shall be determined by actual steam flow measurements at a pressure not more than 3% above the pressure at which the valve is set to blow and when adjusted for blowdown in accordance with PG-69.1.4. The valves shall be credited with capacities as determined by the provisions of PG-69.2.

Safety valves or safety relief valves may be used that give any opening up to the full discharge capacity of the area of the opening of the inlet of the valve, provided the movement of the steam safety valve is such as not to induce lifting of water in the boiler.

Deadweight or weighted lever safety valves or safety relief valves shall not be used.

For high-temperature water boilers safety relief valves shall be used. Such valves shall have a closed bonnet. For purposes of selection the capacity rating of such safety relief valves shall be expressed in terms of actual steam flow determined on the same basis as for safety valves. In addition the safety relief valves shall be capable of

satisfactory operation when relieving water at the saturation temperature corresponding to the pressure at which the valve is set to blow.

**PG-67.6** A safety valve or safety relief valve over NPS 3 (DN 80), used for pressures greater than 15 psig (100 kPa), shall have a flanged inlet connection or a weld-end inlet connection. The dimensions of flanges subjected to boiler pressure shall conform to the applicable ASME Standards as given in PG-42. The facing shall be similar to those illustrated in the Standard.

**PG-67.7** Safety valves or safety relief valves may have bronze parts complying with either SB-61, SB-62, or SB-148, provided the maximum allowable stresses and temperatures do not exceed the values given in Table 1B of Section II, Part D, and shall be marked to indicate the class of material used. Such valves shall not be used on superheaters delivering steam at a temperature over 450°F (230°C) for SB-61 and SB-148, and 306°F (150°C) for SB-62, and shall not be used for high-temperature water boilers.

## **PG-68 SUPERHEATER AND REHEATER SAFETY VALVE REQUIREMENTS**

**PG-68.1** Except as permitted in PG-58.3.1, every attached superheater shall have one or more safety valves in the steam flow path between the superheater outlet and the first stop valve. The location shall be suitable for the service intended and shall provide the overpressure protection required. The pressure drop upstream of each safety valve shall be considered in the determination of set pressure and relieving capacity of that valve. If the superheater outlet header has a full, free steam passage from end to end and is so constructed that steam is supplied to it at practically equal intervals throughout its length so that there

is a uniform flow of steam through the superheater tubes and the header, the safety valve, or valves, may be located anywhere in the length of the header.

**PG-68.2** The discharge capacity of the safety valve, or valves, on an attached superheater may be included in determining the number and size of the safety valves for the boiler, provided there are no intervening valves between the superheater safety valve and the boiler, and provided the discharge capacity of the safety valve, or valves, on the boiler, as distinct from the superheater is at least 75% of the aggregate valve capacity required.

**PG-68.3** Every isolable superheater that may be shut off from the boiler and permit the superheater to become a fired pressure vessel and all nonintegral separately fired superheaters shall have one or more safety valves having a discharge capacity equal to  $6 \text{ lb/ft}^2$  ( $29 \text{ kg/m}^2$ ) of steam per hour, using the superheater surface measured on the side exposed to the hot gases. As an alternative the Manufacturer may also calculate the minimum safety valve discharge capacity in lb (kg) of steam per hour from the maximum expected heat absorption (as determined by the Manufacturer) in Btu/hr (W), divided by 1,000 (1.6). In the case of electrically heated superheaters, the safety valve capacity shall be based upon  $3\frac{1}{2}$  lb (1.6 kg)/hr/kW input. The number of safety valves installed shall be such that the total capacity is at least equal to that required.

**PG-68.4** Every reheater shall have one or more safety valves, such that the total relieving capacity is at least equal to the maximum steam flow for which the heater is designed. The capacity of the reheater safety valves shall not be included in the required relieving capacity for the boiler and superheater.

One or more valves with a combined relieving capacity not less than 15% of the required total shall be located along the

steam flow path between the reheater outlet and the first stop valve. The pressure drop upstream of the valves on the outlet side of the reheater shall be considered in determining their set pressure.

**PG-68.5** A soot blower connection may be attached to the same outlet from the superheater or reheater that is used for the safety valve connection.

**PG-68.6** Every safety valve used on a superheater or reheater discharging superheated steam at a temperature over  $450^\circ\text{F}$  ( $230^\circ\text{C}$ ) shall have a casing, including the base, body, and bonnet and spindle, of steel, steel alloy, or equivalent heat-resisting material.

The valve shall have a flanged inlet connection, or a weld-end inlet connection. It shall have the seat and disk of suitable heat erosive and corrosive resisting material, and the spring fully exposed outside of the valve casing so that it shall be protected from contact with the escaping steam.

**PG-68.7** The capacity of a safety valve on superheated steam shall be calculated by multiplying the capacity determined in accordance with PG-69.2 by the appropriate superheat correction factor  $K_{sh}$ , from Table PG-68.7.

TABLE PG-68.7  
SUPERHEAT CORRECTION FACTOR,  $K_{sh}$

Flowing Pressure (psia)	Superheat Correction Factor, $K_{sh}$ Total Temperature, °F, of Superheated Steam																
	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200
50	0.987	0.957	0.930	0.905	0.882	0.861	0.841	0.823	0.805	0.789	0.774	0.759	0.745	0.732	0.719	0.708	0.696
100	0.998	0.963	0.935	0.909	0.885	0.864	0.843	0.825	0.807	0.790	0.775	0.760	0.746	0.733	0.720	0.708	0.697
150	0.984	0.970	0.940	0.913	0.888	0.866	0.846	0.826	0.808	0.792	0.776	0.761	0.747	0.733	0.721	0.709	0.697
200	0.979	0.977	0.945	0.917	0.892	0.869	0.848	0.828	0.810	0.793	0.777	0.762	0.748	0.734	0.721	0.709	0.698
250	...	0.972	0.951	0.921	0.895	0.871	0.850	0.830	0.812	0.794	0.778	0.763	0.749	0.735	0.722	0.710	0.698
300	...	0.968	0.957	0.926	0.898	0.874	0.852	0.832	0.813	0.796	0.780	0.764	0.750	0.736	0.723	0.710	0.699
350	...	0.968	0.963	0.930	0.902	0.877	0.854	0.834	0.815	0.797	0.781	0.765	0.750	0.736	0.723	0.711	0.699
400	...	...	0.963	0.935	0.906	0.880	0.857	0.836	0.816	0.798	0.782	0.766	0.751	0.737	0.724	0.712	0.700
450	...	...	0.961	0.940	0.909	0.883	0.859	0.838	0.818	0.800	0.783	0.767	0.752	0.738	0.725	0.712	0.700
500	...	...	0.961	0.946	0.914	0.886	0.862	0.840	0.820	0.801	0.784	0.768	0.753	0.739	0.725	0.713	0.701
550	...	...	0.962	0.952	0.918	0.889	0.864	0.842	0.822	0.803	0.785	0.769	0.754	0.740	0.726	0.713	0.701
600	...	...	0.962	0.958	0.922	0.892	0.867	0.844	0.823	0.804	0.787	0.770	0.755	0.740	0.727	0.714	0.702
650	...	...	0.968	0.958	0.927	0.896	0.869	0.846	0.825	0.806	0.788	0.771	0.756	0.741	0.728	0.715	0.702
700	...	...	...	0.958	0.931	0.899	0.872	0.848	0.827	0.807	0.789	0.772	0.757	0.742	0.728	0.715	0.703
750	...	...	...	0.958	0.936	0.903	0.875	0.850	0.828	0.809	0.790	0.774	0.758	0.743	0.729	0.716	0.703
800	...	...	...	0.960	0.942	0.906	0.878	0.852	0.830	0.810	0.792	0.774	0.759	0.744	0.730	0.716	0.704
850	...	...	...	0.962	0.947	0.910	0.880	0.855	0.832	0.812	0.793	0.776	0.760	0.744	0.730	0.717	0.704
900	...	...	...	0.965	0.953	0.914	0.883	0.857	0.834	0.813	0.794	0.777	0.760	0.745	0.731	0.718	0.705
950	...	...	...	0.969	0.958	0.918	0.886	0.860	0.836	0.815	0.796	0.778	0.761	0.746	0.732	0.718	0.705
1000	...	...	...	0.974	0.959	0.923	0.890	0.862	0.838	0.816	0.797	0.779	0.762	0.747	0.732	0.719	0.706
1050	...	...	...	...	0.960	0.927	0.893	0.864	0.840	0.818	0.798	0.780	0.763	0.748	0.733	0.719	0.707
1100	...	...	...	...	0.962	0.931	0.896	0.867	0.842	0.820	0.800	0.781	0.764	0.749	0.734	0.720	0.707
1150	...	...	...	...	0.964	0.936	0.899	0.870	0.844	0.821	0.801	0.782	0.765	0.749	0.735	0.721	0.708
1200	...	...	...	...	0.966	0.941	0.903	0.872	0.846	0.823	0.802	0.784	0.766	0.750	0.735	0.721	0.708
1250	...	...	...	...	0.969	0.946	0.906	0.875	0.848	0.825	0.804	0.785	0.767	0.751	0.736	0.722	0.709
1300	...	...	...	...	0.973	0.952	0.910	0.878	0.850	0.826	0.805	0.786	0.768	0.752	0.737	0.723	0.709
1350	...	...	...	...	0.977	0.958	0.914	0.880	0.852	0.828	0.807	0.787	0.769	0.753	0.737	0.723	0.710
1400	...	...	...	...	0.982	0.963	0.918	0.883	0.854	0.830	0.808	0.788	0.770	0.754	0.738	0.724	0.710
1450	...	...	...	...	0.987	0.968	0.922	0.886	0.857	0.832	0.809	0.790	0.771	0.754	0.739	0.724	0.711
1500	...	...	...	...	0.993	0.970	0.926	0.889	0.859	0.833	0.811	0.791	0.772	0.755	0.740	0.725	0.711
1550	...	...	...	...	...	0.972	0.930	0.892	0.861	0.835	0.812	0.792	0.773	0.756	0.740	0.726	0.712
1600	...	...	...	...	...	0.973	0.934	0.894	0.863	0.836	0.813	0.792	0.774	0.756	0.740	0.726	0.712
1650	...	...	...	...	...	0.973	0.936	0.895	0.863	0.836	0.812	0.791	0.772	0.755	0.739	0.724	0.710
1700	...	...	...	...	...	0.973	0.938	0.895	0.863	0.835	0.811	0.790	0.771	0.754	0.738	0.723	0.709
1750	...	...	...	...	...	0.974	0.940	0.896	0.862	0.835	0.810	0.789	0.770	0.752	0.736	0.721	0.707
1800	...	...	...	...	...	0.975	0.942	0.897	0.862	0.834	0.810	0.788	0.768	0.751	0.735	0.720	0.705
1850	...	...	...	...	...	0.976	0.944	0.897	0.862	0.833	0.809	0.787	0.767	0.749	0.733	0.718	0.704
1900	...	...	...	...	...	0.977	0.946	0.898	0.862	0.832	0.807	0.785	0.766	0.748	0.731	0.716	0.702
1950	...	...	...	...	...	0.979	0.949	0.898	0.861	0.832	0.806	0.784	0.764	0.746	0.729	0.714	0.700
2000	...	...	...	...	...	0.982	0.952	0.899	0.861	0.831	0.805	0.782	0.762	0.744	0.728	0.712	0.698
2050	...	...	...	...	...	0.985	0.954	0.899	0.860	0.830	0.804	0.781	0.761	0.742	0.726	0.710	0.696
2100	...	...	...	...	...	0.988	0.956	0.900	0.860	0.828	0.802	0.779	0.759	0.740	0.724	0.708	0.694
2150	...	...	...	...	...	...	0.956	0.900	0.859	0.827	0.801	0.778	0.757	0.738	0.722	0.706	0.692
2200	...	...	...	...	...	...	0.955	0.901	0.859	0.826	0.799	0.776	0.755	0.736	0.720	0.704	0.690
2250	...	...	...	...	...	...	0.954	0.901	0.858	0.825	0.797	0.774	0.753	0.734	0.717	0.702	0.687
2300	...	...	...	...	...	...	0.953	0.901	0.857	0.823	0.795	0.772	0.751	0.732	0.715	0.699	0.685
2350	...	...	...	...	...	...	0.952	0.902	0.856	0.822	0.794	0.769	0.748	0.729	0.712	0.697	0.682
2400	...	...	...	...	...	...	0.952	0.902	0.855	0.820	0.791	0.767	0.746	0.727	0.710	0.694	0.679
2450	...	...	...	...	...	...	0.951	0.902	0.854	0.818	0.789	0.765	0.743	0.724	0.707	0.691	0.677
2500	...	...	...	...	...	...	0.951	0.902	0.852	0.816	0.787	0.762	0.740	0.721	0.704	0.688	0.674
2550	...	...	...	...	...	...	0.951	0.902	0.851	0.814	0.784	0.759	0.738	0.718	0.701	0.685	0.671
2600	...	...	...	...	...	...	0.951	0.903	0.849	0.812	0.782	0.756	0.735	0.715	0.698	0.682	0.664
2650	...	...	...	...	...	...	0.952	0.903	0.848	0.809	0.779	0.754	0.731	0.712	0.695	0.679	0.664
2700	...	...	...	...	...	...	0.952	0.903	0.846	0.807	0.776	0.750	0.728	0.708	0.691	0.675	0.661
2750	...	...	...	...	...	...	0.953	0.903	0.844	0.804	0.773	0.747	0.724	0.705	0.687	0.671	0.657
2800	...	...	...	...	...	...	0.956	0.903	0.842	0.801	0.769	0.743	0.721	0.701	0.684	0.668	0.653
2850	...	...	...	...	...	...	0.959	0.902	0.839	0.798	0.766	0.739	0.717	0.697	0.679	0.663	0.649
2900	...	...	...	...	...	...	0.963	0.902	0.836	0.794	0.762	0.735	0.713	0.693	0.675	0.659	0.645
2950	...	...	...	...	...	...	...	0.902	0.834	0.790	0.758	0.731	0.708	0.688	0.671	0.655	0.640
3000	...	...	...	...	...	...	...	0.901	0.831	0.786	0.753	0.726	0.704	0.684	0.666	0.650	0.635
3050	...	...	...	...	...	...	...	0.899	0.827	0.782	0.749	0.722	0.699	0.679	0.661	0.645	0.630
3100	...	...	...	...	...	...	...	0.896	0.823	0.777	0.744	0.716	0.693	0.673	0.656	0.640	0.625
3150	...	...	...	...	...	...	...	0.894	0.819	0.772	0.738	0.711	0.688	0.668	0.650	0.634	0.620
3200	...	...	...	...	...	...	...	0.889	0.815	0.767	0.733	0.705	0.682	0.662	0.644	0.628	0.614

## **PG-69 CERTIFICATION OF CAPACITY OF SAFETY AND SAFETY RELIEF VALVES**

**PG-69.1** Before the Code symbol is applied to any safety or safety relief valve, the valve manufacturer shall have the relieving capacity of his valves certified in accordance with the provisions of this paragraph.

**PG-69.1.1** Capacity certification tests shall be conducted using dry saturated steam. The limits for test purposes shall be 98% minimum quality and 20°F (10°C) maximum superheat. Correction from within these limits may be made to the dry saturated condition.

**PG-69.1.2** Tests shall be conducted at a place that meets the requirements of A-312.

**PG-69.1.3** Capacity test data reports for each valve design and size, signed by the manufacturer and Authorized Observer witnessing the tests, together with drawings showing the valve construction, shall be submitted to the ASME designee for review and acceptance.<sup>23</sup>

---

<sup>23</sup> Valve capacities are published in "Pressure Relief Device Certifications." This publication may be obtained from the National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Ave., Columbus, OH 43299.

**PG-69.1.4** Capacity certification tests shall be conducted at a pressure that does not exceed the set pressure by 3% or 2 psi (15 kPa), whichever is greater. Safety and safety relief valves shall be adjusted so that the blowdown does not exceed 4% of the set pressure. For valves set at or below 100 psi (700 kPa), the blowdown shall be adjusted so as not to exceed 4 psi (30 kPa). Safety valves used on forced-flow steam generators with no fixed steam and waterline, and safety relief valves used on high-temperature water boilers shall be adjusted so that the blowdown does not exceed 10%

of the set pressure. The reseating pressure shall be noted and recorded.

**PG-69.2** Relieving capacities shall be determined using one of the following methods.

**PG-69.2.1 Three Valve Method.** A capacity certification test is required on a set of three valves for each combination of size, design, and pressure setting. The capacity of each valve of the set shall fall within a range of ±5% of the average capacity. If one of the three valves tested falls outside this range, it shall be replaced by two valves, and a new average shall be calculated based on all four valves, excluding the replaced valve. Failure of any of the four capacities to fall within a range of ±5% of the new average shall be cause to refuse certification of that particular valve design.

The rated relieving capacity for each combination of design, size, and test pressure shall be 90% of the average capacity.

**PG-69.2.2 Slope Method.** If a Manufacturer wishes to apply the Code Symbol to a design of pressure relief valves, four valves of each combination of pipe size and orifice size shall be tested. These four valves shall be set at pressures that cover the approximate range of pressures for which the valve will be used or covering the range available at the certified test facility that shall conduct the tests. The capacities based on these four tests shall be as follows:

(a) The slope W/P of the actual measured capacity versus the flow pressure for each test point shall be calculated and averaged:

$$\text{slope} = \frac{W}{P} = \frac{\text{measured capacity}}{\text{absolute flow rating pressure}}$$

All values derived from the testing must fall within ±5% of the average value

$$\text{minimum slope} = 0.95 \times \text{average slope}$$

$$\text{maximum slope} = 1.05 \times \text{average slope}$$

If the values derived from the testing do not fall between the minimum and maximum slope values, the Authorized Observer shall require that additional valves

be tested at the rate of two for each valve beyond the maximum and minimum values with a limit of four additional valves.

The relieving capacity to be stamped on the valve shall not exceed 90% of the average slope times the absolute accumulation pressure

rated slope = 0.90 x average slope

(U.S. Customary Units)

stamped customary  $\leq$  rated slope (1.03 x set pressure + 14.7) or (set pressure + 2 psi + 14.7), whichever is greater

(SI Units)

stamped capacity  $\leq$  rated slope (1.03 x set pressure + 0.101) or (set pressure + 0.015 MPa + 0.101), whichever is greater

**PG-69.2.3 Coefficient of Discharge Method.** A coefficient of discharge for the design,  $K$ , may be established for a specific valve design according to the following procedure:

(a) For each design, the safety or safety relief valve manufacturer shall submit for test at least three valves for each of three different sizes (a total of nine valves). Each valve of a given size shall be set at a different pressure, covering the range of pressures for which the valve will be used or the range available at the facility where the tests are conducted.

(b) Tests shall be made on each safety or safety relief valve to determine its lift at capacity, popping, and blowdown pressures, and actual relieving capacity. An individual coefficient,  $K_D$ , shall be established for each valve as follows:

$$K_D = \frac{\text{actual flow}}{\text{theoretical flow}} = \text{individual coefficient of discharge}$$

Where actual flow is determined by test and theoretical flow,  $W_T$  is calculated by one of the following equations:

For 45 deg seat

(U.S. Customary Units)

$$W_T = 51.5 \times \pi DLP \times 0.707$$

(SI Units)

$$W_T = 5.25 \times \pi DLP \times 0.707$$

For flat seat

(U.S. Customary Units)

$$W_T = 51.5 \times \pi DLP$$

(SI Units)

$$W_T = 5.25 \times \pi DLP$$

For nozzle

(U.S. Customary Units)

$$W_T = 51.5 AP$$

(SI Units)

$$W_T = 5.25 AP$$

where

$A$  = nozzle throat area, in.<sup>2</sup> (mm<sup>2</sup>)

$D$  = seat diameter, in. (mm)

$L$  = lift at pressure  $P$ , in. (mm)

$P$  = (1.03 x set pressure + 14.7), psia, or  
= (set pressure + 2 + 14.7), psia,

whichever is greater

= (1.03 x set pressure + 0.101), MPa, or

= (set pressure + 0.014 + 0.101), MPa,

whichever is greater

$W_T$  = theoretical flow, lb/hr (kg/hr)

The average of the coefficients  $K_D$  of the nine tests required shall be multiplied by 0.90, and this product shall be taken as the coefficient  $K$  of that design. All individual coefficients of discharge,  $K_D$ , shall fall within a range of  $\pm 5\%$  of the average coefficient found. If a valve fails to meet this requirement, the Authorized Observer shall require two additional valves to be tested as replacements for each valve having an individual coefficient,  $K_D$ , outside the  $\pm 5\%$  range, with a limit of four additional valves. Failure of a coefficient,  $K_D$ , to fall within  $\pm 5\%$  of the new average value, excluding the replaced valve(s), shall be cause to refuse certification of that particular valve design.

The rated relieving capacity of all sizes and set pressures of a given design, for which  $K$  has been established under the provision of this paragraph, shall be determined by the following equation:

$$W \leq W_T \times K$$

where

$K$  = coefficient of discharge for the design

$W$  = rated relieving capacity, lb/hr (kg/hr)

$W_T$  = theoretical flow, defined by the same equation used to determine  $K_D$ , lb/hr (kg/hr)

The coefficient of discharge for the design shall be not greater than 0.878 (the product of  $0.9 \times 0.975$ ). The coefficient shall not be applied to valves whose beta ratio (ratio of valve throat to inlet diameter) lies outside the range of 0.15 to 0.75, unless tests have demonstrated that the individual coefficient of discharge,  $K_D$ , for valves at the extreme ends of a larger range, is within  $\pm 5\%$  of the average coefficient,  $K_D$ .

For designs where the lift is used to determine the flow area, all valves shall have the same nominal lift to seat diameter ratio ( $L/D$ ).

For pressures over 1,500 psig (10.3 MPa) and up to 3,200 psig (22.1 MPa), the value of  $W$  shall be multiplied by the correction factor

$$(U.S. Customary Units) \quad \frac{0.1906P - 1,000}{0.2292P - 1,061}$$

$$(SI Units) \quad \frac{27.6P - 1,000}{33.2P - 1,061}$$

**PG-69.3** If a manufacturer wishes to apply the Code symbol to a power-actuated pressure relieving valve under PG-67.4.1, one valve of each combination of inlet pipe size and orifice size to be used with that inlet pipe size shall be tested. The valve shall be capacity tested at four different pressures approximately covering the range of the certified test facility on which the tests are conducted. The capacities, as determined by these four tests, shall be plotted against the absolute flow test pressure and a line drawn through these four test points. All points must lie within  $\pm 5\%$  in capacity value of the plotted line and must pass through 0-0. From the plotted line, the slope of the line  $dW/dP$  shall be determined and a factor of  $(0.90/51.45) \times (dW/dP)$  shall be applied to capacity computations in the supercritical region at elevated pressures by means of the isentropic flow equation.

(U.S. Customary Units)

$$W = 1,135.8 \frac{0.90}{51.45} \times \frac{dW}{dP} \sqrt{\frac{P}{v}}$$

(SI Units)

$$W = 1,135.8 \frac{0.95}{5.25} \times \frac{dW}{dP} \sqrt{\frac{P}{v}}$$

where

$dW/dP$  = rate of change of measured capacity with respect to absolute pressure

$P$  = absolute inlet pressure, psia (MPa)

$v$  = inlet specific volume, ft<sup>3</sup>/lb (m<sup>3</sup>/kg)

$W$  = capacity, lb of steam/hr (kg/hr)

**NOTE:** The constant 1,135.8 is based on a  $\gamma$  factor of 1.30, which is accurate for superheated steam at temperature above approximately 800°F (430°C). In interest of accuracy, other methods of capacity computations must be used at temperatures below 800°F (430°C) at supercritical pressures.

**PG-69.4** Power-actuated pressure relieving valves, having capacities certified in accordance with the provision of PG-69.3 and computed in accordance with the formula contained therein, shall be marked as required by PG-110 with the computed capacity, corresponding to 3% above the full load operating pressure and temperature conditions at the valve inlet when the valve is operated by the controller, and they shall also be stamped with the set pressure of the controller. When the valve is marked as required by this paragraph, it shall be the guarantee by the manufacturer that the valve also conforms to the details of construction herein specified.

**PG-69.6** When changes are made in the design of a safety or safety relief valve in such a manner as to affect the flow path, lift, or performance characteristics of the valve, new tests in accordance with this Section shall be performed.

## **PG-70 CAPACITY OF SAFETY VALVES**

**PG-70.1** Subject to the minimum number required by PG-67.1, the number of safety valves or safety relief valves required shall be determined on the basis of the maximum

designed steaming capacity, as determined by the boiler Manufacturer, and the relieving capacity marked on the valves by the manufacturer.

## **PG-71 MOUNTING**

**PG-71.1** When two or more safety valves are used on a boiler, they may be mounted either separately or as twin valves made by placing individual valves on Y-bases, or duplex valves having two valves in the same body casing. Twin valves made by placing individual valves on Y-bases, or duplex valves having two valves in the same body, shall be of approximately equal capacity. When not more than two valves of different sizes are mounted singly the relieving capacity of the smaller valve shall be not less than 50% of that of the larger valve.

**PG-71.2** The safety valve or safety relief valve or valves shall be connected to the boiler independent of any other connection, and attached as close as possible to the boiler or the normal steam flow path, without any unnecessary intervening pipe or fitting. Such intervening pipe or fitting shall be not longer than the face-to-face dimension of the corresponding tee fitting of the same diameter and pressure under the applicable ASME Standard listed in PG-42 and shall also comply with PG-8 and PG-39. Every safety valve or safety relief valve shall be connected so as to stand in an upright position, with spindle vertical. On high-temperature water boilers of the watertube forced-circulation type, the valve shall be located at the boiler outlet.

**PG-71.3** The opening or connection between the boiler and the safety valve or safety relief valve shall have at least the area of the valve inlet. No valve of any description shall be placed between the required safety valve or safety relief valve or valves and the boiler, nor on the discharge pipe between the safety valve or safety relief valve and the atmosphere. When a

discharge pipe is used, the cross-sectional area shall be not less than the full area of the valve outlet or of the total of the areas of the valve outlets, discharging there-into. It shall be as short and straight as possible and so arranged as to avoid undue stresses on the valve or valves.

All safety valve or safety relief valve discharges shall be so located or piped as to be carried clear from running boards or platforms. Ample provision for gravity drain shall be made in the discharge pipe at or near each safety valve or safety relief valve, and where water of condensation may collect. Each valve shall have an open gravity drain through the casing below the level of the valve seat. For iron- and steel-bodied valves exceeding NPS 2½ (DN 65), the drain hole shall be tapped not less than NPS 3/8 (DN 10).

Discharge piping from safety relief valves on high-temperature water boilers shall be provided with adequate provisions for water drainage as well as the steam venting.

The installation of cast iron bodied safety relief valves for high-temperature water boilers is prohibited.

**PG-71.4** If a muffler is used on a safety valve or safety relief valve, it shall have sufficient outlet area to prevent back pressure from interfering with the proper operation and discharge capacity of the valve. The muffler plates or other devices shall be so constructed as to avoid a possibility of restriction of the steam passages due to deposit. Mufflers shall not be used on high-temperature water boiler safety relief valves.

When a safety valve or safety relief valve is exposed to outdoor elements that may affect operation of the valve, it is permissible to shield the valve with a satisfactory cover. The shield or cover shall be properly vented and arranged to permit servicing and normal operation of the valve.

**PG-71.5** When a boiler is fitted with two or more safety valves or safety relief valves on one connection, this connection to the boiler shall have a cross-sectional area not less than the combined areas of inlet connections of all the safety valves or safety relief valves with which it connects and shall also meet the requirements of PG-71.3.

**PG-71.6** Safety valves may be attached to drums or headers by welding provided the welding is done in accordance with Code requirements.

**PG-71.7** Every boiler shall have proper outlet connections for the required safety valve, or safety relief valve, or valves, independent of any other outside steam connection, the area of opening to be at least equal to the aggregate areas of inlet connections of all of the safety valves or safety relief valves to be attached thereto. An internal collecting pipe, splash plate, or pan may be used, provided the total area for inlet of steam thereto is not less than twice the aggregate areas of the inlet connections of the attached safety valves. The holes in such collecting pipes shall be at least ¼ in. (6 mm) in diameter and the least dimension in any other form of opening for inlet of steam shall be ¼ in. (6 mm).

Such dimensional limitations to operation for steam need not apply to steam scrubbers or driers provided the net free steam inlet area of the scrubber or drier is at least 10 times the total area of the boiler outlets for the safety valves.

**PG-71.8** If safety valves are attached to a separate steam drum or dome, the opening between the boiler proper and the steam drum or dome shall be not less than required by PG-71.7.

## **PG-72 OPERATION**

**PG-72.1** Safety valves and safety relief valves shall be designed and constructed to operate without chattering, with a minimum

blowdown of 2 psi (15 kPa) or 2% of the set pressure, whichever is greater, and to attain full lift at a pressure not greater than 3% above their set pressure.

Safety valves used on forced-flow steam generators with no fixed steam and waterline, and safety relief valves used on high-temperature water boilers must be marked for these special services by the valve Manufacturer or Assembler.

**PG-72.2** The popping point tolerance plus or minus shall not exceed that specified in the following table:

Set Pressure, psi (MPa)	Tolerance, Plus or Minus From Set Pressure
≤ 70 (0.5)	2 psi (15 kPa)
> 70 (0.5) and ≤ 300 (2.1)	3% of set pressure
> 300 (2.1) and ≤ 1,000 (7.0)	10 psi (70 kPa)
> 1,000 (7.0)	1% of set pressure

**PG-72.3** The spring in a safety valve or safety relief valve shall not be reset for any pressure more than 5% above or below that for which the valve is marked unless the new setting is within the spring design range established by the manufacturer or is determined to be acceptable to the manufacturer.

If the set pressure is to be adjusted within the limits specified above, the adjustment shall be performed by the manufacturer, his authorized representative, or an assembler. An additional valve data tag identifying the new set pressure, capacity, and date shall be furnished and installed, and the valve shall be resealed.

**PG-72.4** If the set pressure of a valve is changed so as to require a new spring, the spring shall be acceptable to the manufacturer. The spring installation and valve adjustment shall be performed by the manufacturer, his authorized representative, or an assembler. A new nameplate as described in PG-110 shall be furnished and installed, and the valve shall be resealed.

## **PG-73 MINIMUM REQUIREMENTS FOR SAFETY AND SAFETY RELIEF VALVES**

### **PG-73.1 Mechanical Requirements**

**PG-73.1.1** The design shall incorporate guiding arrangements necessary to insure consistent operation and tightness.

**PG-73.1.2** The spring shall be designed so that the full lift spring compression shall be no greater than 80% of the nominal solid deflection. The permanent set of the spring (defined as the difference between the free height and height measured 10 min after the spring has been compressed solid three additional times after presetting at room temperature) shall not exceed 0.5% of the free height.

**PG-73.1.3** To provide a means for verifying whether it is free, each safety valve or safety relief valve shall have a substantial lifting device, which when activated will release the seating force on the disk when the valve is subjected to pressure of at least 75% of the set pressure. The lifting device shall be such that it cannot lock or hold the valve disk in lifted position when the exterior lifting force is released. Disks of safety relief valves used on high-temperature water boilers shall not be lifted while the temperature of the water exceeds 200°F (93°C). If it is desired to lift the valve disk to assure that it is free, this shall be done when the valve is subjected to a pressure of at least 75% of the set pressure. For high-temperature water boilers, the lifting mechanism shall be sealed against leakage.

**PG-73.1.4** The seat of a safety valve shall be fastened to the body of the valve in such a way that there is no possibility of the seat lifting.

**PG-73.1.5** A body drain below seat level shall be provided in the valve and this drain shall not be plugged during or after field installation. For valves exceeding NPS 2½ (DN 65), the drain hole or holes shall be

tapped not less than NPS 3/8 (DN 10). For valves of NPS 2½ (DN 65) or smaller, the drain hole shall not be less than ¼ in. (6 mm) in diameter.

**PG-73.1.6** In the design of the body of the valve, consideration shall be given to minimizing the effects of water deposits.

**PG-73.1.7** Valves having screwed inlet or outlet connections shall be provided with wrenching surfaces to allow for normal installation without damaging operating parts.

**PG-73.1.8** Means shall be provided in the design of all valves for use under this Section, for sealing all external adjustments. Seals shall be installed by the manufacturer, his authorized representative, or an assembler at the time of the initial adjustment. After spring replacement and/or subsequent adjustment, the valve shall be resealed. Seals shall be installed in such a manner as to prevent changing the adjustment without breaking the seal and, in addition, shall serve as a means of identifying the manufacturer, his authorized representative, or the assembler making the adjustment.

### **PG-73.2 Material Selections**

**PG-73.2.1** Cast iron seats and disks are not permitted.

**PG-73.2.2** Adjacent sliding surfaces such as guides and disks or disk holders shall both be of corrosion-resistant material. Springs of corrosion-resistant material or having a corrosion-resistant coating are required. The seats and disks of safety valves or safety relief valves shall be of suitable material to resist corrosion by the lading fluid.

**NOTE:** The degree of corrosion resistance, appropriate to the intended service, shall be a matter of agreement between the manufacturer and the purchaser.

**PG-73.2.3** Materials used in bodies and bonnets or yokes shall be listed in Section II, Parts A and B, and identified in Tables 1A and 1B of Section II Part D, as permitted for Section I construction. Materials used in

body to bonnet or body to yoke bolting shall be listed in ASME B16.34. Materials used in all other parts required for the

pressure relieving or retaining function shall be

(a) listed in ASME Section II

(b) listed in ASTM Specifications (see Note below) or

(c) controlled by the manufacturer of the safety or safety relief valve by a specification ensuring control of chemical and physical properties and quality at least equivalent to ASTM Standards (see Note below)

**NOTE:** It shall be the manufacturer's responsibility to ensure that the allowable stresses at temperature meet the requirements of Section II, Part D, Appendix 1, Mandatory Basis for Establishing Stress Values in Tables 1A and 1B.

### **PG-73.3 Inspection of Manufacturing and/or Assembly**

**PG-73.3.1** A manufacturer shall demonstrate to the satisfaction of an ASME designee that his manufacturing, production, and test facilities and quality control procedures will ensure close agreement between the performance of random production samples and the performance of those valves submitted for capacity certification.

**PG-73.3.2** Manufacturing, assembly, inspection, and test operations including capacity, are subject to inspections at any time by an ASME designee.

**PG-73.3.3** A Manufacturer or Assembler may be granted permission to apply the V Code Symbol to production pressure relief valves capacity-certified in accordance with PG-69, provided the following tests are successfully completed. This permission shall expire on the fifth anniversary of the date it is initially granted. This permission may be extended for 5-year periods if the following tests are successfully repeated within the 6-month period before expiration.

(a) Two sample production pressure relief valves of a size and capacity within the capability of an ASME-accepted laboratory

shall be selected by an ASME designee.

The maximum blowdown for these samples shall not exceed the value specified in the following table:

Set Pressure, psi (kPa)	Maximum Blowdown
< 67 (500)	4 psi (30 kPa)
≥ 67 (500) and 250 (1 700)	6% of set pressure
> 250 (1 700) and < 375 (2 500)	15 psi (100 kPa)
≥ 375 (2 500)	4% of set pressure

The blowdown for sample valves designed for use on forced flow steam generators with no fixed steam and waterline or high-temperature water boilers shall not exceed 10% of the set pressure.

(b) Operational and capacity tests shall be conducted in the presence of an ASME designee at an ASME-accepted laboratory. The valve manufacturer or assembler shall be notified of the time of the test and may have representatives present to witness the test.

(c) Should any valve fail to relieve at or above its certified capacity or should it fail to meet performance requirements in PG-72, the test shall be repeated at the rate of two replacement valves, selected in accordance with PG-73.3.3 (1), for each valve that failed.

(d) Failure of any of the replacement valves to meet capacity or the performance requirements of this Section shall be cause for revocation within 60 days of the authorization to use the Code symbol on that particular type of valve. During this period, the Manufacturer or assembler shall demonstrate the cause of such deficiency and the action taken to guard against future occurrence, and the requirements of PG-73.3.3 above shall apply.

**PG-73.3.4** Use of the Code Symbol Stamp by an assembler indicates the use of original unmodified parts in strict accordance with the instructions of the manufacturer of the valve.

(a) An assembler may transfer original and unmodified pressure relief parts produced by the Manufacturer to other Assemblers, provided the following conditions are met:

(1) both Assemblers have been granted permission to apply the V or UV Code Symbol to the specific valve type in which the parts are to be used

(2) the Quality Control System of the Assembler receiving the pressure relief valve parts shall define the controls for the procurement and acceptance of those parts

(3) the pressure relief valve parts are appropriately packaged, marked, or sealed by the Manufacturer to ensure that the parts are

(a) produced by the Manufacturer

(b) the parts are original and unmodified

(b) However, an assembler may convert original finished parts by either machining to another finished part or applying a corrosion-resistant coating to valve springs for a specific application under the following conditions:

(1) Conversions shall be specified by the Manufacturer. Drawings and/or written instructions used for part conversion shall be obtained from the Manufacturer and shall include a drawing or description of the converted part before and after the conversion.

(2) The Assembler's quality control system, as accepted by a representative from an ASME-designated organization, must describe in detail the conversion of original parts, provisions for inspection and acceptance, personnel training, and control of current Manufacturer's drawings and/or written instructions.

(3) The Assembler must document each use of a converted part.

(4) The Assembler must demonstrate to the Manufacturer the ability to perform each type of conversion. The Manufacturer shall document all authorizations granted to

perform part conversions. The Manufacturer and Assembler shall maintain a file of such authorizations.

(5) At least annually a review shall be performed by the Manufacturer of an assembler's system and conversion capabilities. The Manufacturer shall document the results of these reviews. A copy of this documentation shall be kept on file by the Assembler. The review results shall be made available to a representative from an ASME designated organization.

(c) An assembler may apply or contract to have applied a corrosion-resistant coating to springs when authorized by the Manufacturer and provided the following conditions have been met:

(1) The Assembler's Quality Control System as accepted by a designated representative of ASME shall describe in detail the procedure for cleaning, preparation, application, inspection, and acceptance of the applied corrosion-resistant coating.

(2) The springs to be coated shall be obtained from the valve Manufacturer.

(3) The corrosion-resistant coating shall be appropriate to the intended service.

(4) The springs shall be cleaned, prepared, coated, and marked per the valve Manufacturer's specification.

(5) The Assembler shall demonstrate to the satisfaction of the Manufacturer the ability to coat or contract to have coated springs for pressure relief valves.

(6) The Manufacturer shall document all authorizations granted to an Assembler to apply or contract to have applied corrosion-resistant coatings to springs for pressure relief valves. The Manufacturer and Assembler shall maintain a file of such authorizations. At least annually, a review shall be performed by the Manufacturer of an Assembler's spring coating systems and capabilities. The Manufacturer shall document the results of the review. A copy

of this documentation shall be kept on file by the Assembler. The review shall be made available upon request to the designated representative of ASME.

(7) In addition, "CRCS" shall be marked on

(a) the valve nameplate

(b) the valve or

(c) for valves smaller than NPS ½ on a metal tag securely attached to the valve

**NOTE:** Within the requirements of PG-73.3 and PG-73.4, a *manufacturer* is defined as a person or organization who is completely responsible for design, material selection, capacity certification, manufacture of all component parts, assembly, testing, sealing, and shipping of safety and safety relief valves certified under this Section.

An *assembler* is defined as a person or organization who purchases or receives from a manufacturer the necessary component parts or valves and assembles, adjusts, tests, seals, and ships safety or safety relief valves certified under this Section at a geographical location other than and using facilities other than those used by the manufacturer.

#### **PG-73.4 Testing by Manufacturers or Assemblers**

##### **PG-73.4.1 Hydrostatic Pressure Testing**

(a) The pressure-containing parts of each valve shall be hydrostatically tested at a pressure at least 1.5 times the design pressure of the parts. Parts meeting the following criteria shall be exempt from hydrostatic testing:

(1) The applied stress under hydrostatic test conditions does not exceed 50% of the allowable stress.

(2) The part is not cast or welded.

(b) Testing may be performed pneumatically at a pressure of 1.1 times the design pressure of the part, provided appropriate safety measures are taken.

(c) Testing may be done in the component or assembled condition.

(d) When the valve is designed for discharging directly to atmosphere, the valve components downstream of the valve disk are exempt from hydrostatic testing.

(e) Valve components downstream of the disk and fully contained within the body are exempt from hydrostatic testing.

(f) These tests shall be conducted after all machining and welding operations on the parts have been completed.

(g) There shall be no visible sign of leakage.

**PG-73.4.2** Every valve shall be tested with steam by the manufacturer or assembler to demonstrate its popping point and pressure-containing integrity. The blow-down control elements of the safety valve shall be set to the Manufacturer's specifications.

**PG-73.4.2.1** Tests shall be conducted either on equipment that meets the requirements of PG-73.4.6, or on the boiler, by raising the pressure to demonstrate the popping pressure.

**PG-73.4.2.2** When the valve is beyond the production test equipment capabilities, an alternative test method presented in PG-73.4.2.2.1 or PG-73.4.2.2.2 may be used, provided all of the following conditions are met:

(a) testing the valve at full pressure may cause damage to the valve, or testing of the valve is impractical due to boiler system operational safety considerations

(b) the valve lift has been mechanically verified to meet or exceed the required lift

(c) the blowdown control elements of the safety valve are set to the valve manufacturer's specification

(d) the valve design is compatible with the alternative test method selected

**PG-73.4.2.2.1** The valve, with its lift temporarily restricted during the test, if required to prevent valve damage, shall be tested on steam to demonstrate popping pressure.

**PG-73.4.2.2.2** The valve may be fitted with a hydraulic or pneumatic lift assist device and tested on steam at a pressure less than the valve set pressure. The lift assist device and test procedure shall be calibrated to provide the set pressure setting within the tolerance of PG-72.2.

### **PG-73.4.3 Leak Test**

(a) A seat tightness test shall be conducted at maximum expected operating pressure but at a pressure not exceeding the reseating pressure of the valve. When being tested, a valve exhibiting no visible signs of leakage shall be considered adequately tight.

(b) Closed bonnet pressure relief valves designed for discharge to a closed system shall be tested with a minimum of 30 psig (200 kPa) air or other gas in the secondary pressure zone. There shall be no visible signs of leakage.<sup>24</sup>

---

<sup>24</sup>The user may specify a higher test pressure commensurate with the back pressure anticipated in service.

**PG-73.4.4** A manufacturer or assembler shall have a documented program for the application, calibration, and maintenance of test gages.

**PG-73.4.5** Testing time on steam valves shall be sufficient to assure that test results are repeatable and representative of field performance.

**PG-73.4.6** Test fixtures and test drums, where applicable, shall be of adequate size and capacity to assure that the observed set pressure is consistent with the stamped set pressure within the tolerance required by PG-72.2.

**PG-73.5 Design Requirements.** At the time of submission of valves for capacity certification or testing in accordance with PG-69, the ASME designee has the authority to review design for conformity with the requirements of this Section and to reject or require modification of designs that do not conform, prior to capacity testing.

**PG-73.6 Code Symbol “V” Stamp.** Each safety valve or safety relief valve to which the Code “V” symbol (see Fig. PG-105.4) will be applied shall have been fabricated or assembled by a manufacturer or assembler holding a valid Certificate of Authorization (PG-105.2) and capacity certified in accordance with the

requirements of this Section. A Certified Individual (CI) shall provide oversight to assure that each use of the Code “V” symbol on a safety valve or safety relief valve is in accordance with the requirements of this Section, and that each use of the Code “V” symbol is documented on a Certificate of Conformance, Form P-8.

**PG-73.6.1 Requirements for the Certified Individual (CI).** The CI shall

(a) be an employee of the manufacturer or assembler

(b) be qualified and certified by the manufacturer or assembler. Qualifications shall include as a minimum

(1) knowledge of the requirements of this Section for the application of the Code “V” symbol

(2) knowledge of the manufacturer’s or assembler’s quality program

(3) training commensurate with the scope, complexity, or special nature of the activities to which oversight is to be provided

(c) have a record, maintained and certified by the manufacturer or assembler, containing objective evidence of the qualifications of the CI and the training program provided

**PG-73.6.2 Duties of the Certified Individual (CI).** The CI shall

(a) verify that each item to which the Code “V” symbol is applied has a current capacity certification and meets all applicable requirements of this Section

(b) review documentation for each lot of items to be stamped to verify, for the lot, that requirements of this Section have been completed

(c) sign the Certificate of Conformance, Form P-8, prior to release of control of the safety or safety relief valves

**PG-73.6.3 Certificate of Conformance, Form P-8**

(a) The Certificate of Conformance, Form P-8, shall be filled out by the manufacturer

or assembler and signed by the Certified Individual. Multiple duplicate safety valves or safety relief valves may be recorded as a single entry, provided the valves are identical and are produced in the same lot.

(b) The manufacturer's or assembler's written quality control program shall include requirements for completion of Certificates of Conformance, Form P-8, and retention, by the manufacturer or assembler, for a minimum of 5 years.

## FABRICATION

### PG-75 GENERAL

The fabrication of boilers and parts thereof shall conform to the general fabrication requirements in the following paragraphs and in addition to the specific requirements for fabrication in the Parts of this Section that pertain to the methods of construction used.

### PG-76 CUTTING PLATES AND OTHER STOCK

**PG-76.1** Plates may be cut by machining, punching, shearing, or cutting by the electric arc or gas process, providing enough metal is left at any unfinished edges to meet the requirements of PG-79.

**PG-76.2** When end faces of nozzle or manhole necks are to remain unwelded in the completed vessel, these end faces shall not be cut by shearing unless at least 1/8 in. (3 mm) of additional metal is removed by any method that will produce a smooth finish.

### PG-91 QUALIFICATION OF INSPECTORS

The inspection required by this Section shall be by an Inspector employed by an ASME accredited Authorized Inspection Agency,<sup>25</sup> that is, the inspection organization of a state or municipality of the United States, a Canadian province, or of an insurance company authorized to write boiler and pressure vessel insurance. These

Inspectors shall have been qualified by written examination under the rules of any state of the United States or province of Canada which has adopted the Code.

---

<sup>25</sup> Whenever *Authorized Inspection Agency* or *AI* is used in this Code, it shall mean an Authorized Inspection Agency accredited by ASME in accordance with the requirements in the latest edition of ASME QAI-1, Qualification for Authorized Inspection.

### PG-93 INSPECTION AND REPAIR OF FLAT PLATE IN CORNER JOINTS

**PG-93.1** When flat plate greater than 1/2 in. (13 mm) thickness is welded to other pressure parts to form a corner joint, such as in flat heads [Fig. PG-31, illustrations (g), (i-1), and (i-2)], waterlegs of firebox boilers or combustion chambers of wetback boilers [Fig. A-8, illustrations (l) through (n) and (p)], and the exposed edges of the plate are closer to the edge of the weld than a distance equal to the thickness of the plate, the peripheral plate edges and any remaining exposed surface of the weld joint preparation shall be examined after welding by either the magnetic particle or liquid penetrant method. When the plate is nonmagnetic, only the liquid penetrant method shall be used. The requirements of this paragraph shall not apply to those joints when 80% or more of the pressure load is carried by tubes, stays, or braces, or when the exposed edges of the plate are farther from the edge of the weld than a distance equal to the thickness of the plate.

**PG-93.2** Laminations, cracks, or other imperfections found during the examination required by PG-93.1 that would affect the safety of the vessel shall be repaired in accordance with PG-78. The imperfection(s) may be pursued by any suitable method (grinding, chipping, etc.). The repaired area shall be subjected to the same examination that first revealed the imperfection.

**PG-93.3** Methods and acceptance criteria for magnetic particle and liquid penetrant

examination shall be in accordance with A-260 or A-270, respectively.

### **PG-99 HYDROSTATIC TEST**

Hydrostatic testing of the completed boiler unit shall be conducted in accordance with the following requirements:

After a boiler has been completed (see PG-104), it shall be subjected to pressure tests using water at not less than ambient temperature, but in no case less than 70°F (20°C). Where required test pressures are specified in this paragraph, whether minimum or maximum pressures, they apply to the highest point of the boiler system. When the boiler is completed in the Manufacturer's shop without boiler external piping, subsequent hydrostatic testing of the boiler external piping shall be the responsibility of any holder of a valid "S," "A," or "PP" stamp. The safety valves need not be included in the hydrostatic test. The tests shall be made in two stages in the following sequence:

**PG-99.1** Hydrostatic pressure tests shall be applied by raising the pressure gradually to not less than 1½ times the maximum allowable working pressure as shown on the data report to be stamped on the boiler. No part of the boiler shall be subjected to a general membrane stress greater than 90% of its yield strength (0.2% offset) at test temperature. The primary membrane stress to which boiler components are subjected during hydrostatic test shall be taken into account when designing the components. Close visual inspection for leakage is not required during this stage.

**PG-99.2** The hydrostatic test pressure may then be reduced to the maximum allowable working pressure, as shown on the Data Report, to be stamped on the boiler and maintained at this pressure while the boiler is carefully examined. The metal temperature shall not exceed 120°F (50°C) during the close examination.

**PG-99.3** A completed forced-flow steam generator with no fixed steam and waterline, having pressure parts designed for different pressure levels along the path of water-steam flow, shall be subjected to a hydrostatic pressure test by the above procedure (PG-99.1 and PG-99.2) based upon

**PG-99.3.1** For the first stage test (PG-99.1) a hydrostatic test pressure of not less than 1½ times the maximum allowable working pressure at the superheater outlet as shown in the master stamping (PC-106.3) but no less than 1¼ times the maximum allowable working pressure of any part of the boiler, excluding the boiler external piping.

**PG-99.3.2** For the second stage test (PG-99.2) the hydrostatic test pressure may be reduced to not less than the maximum allowable working pressure at the superheater outlet.

### **PG-99.4 Test Gages**

**PG-99.4.1** An indicating gage, visible to the operator controlling the pressure applied, shall be connected to the pressure parts. Hydrostatic head on the gage shall be considered such that the required test pressure is achieved at the top of the boiler.

**PG-99.4.2** Dial pressure gages used in testing shall preferably have dials graduated over their entire range of about double the intended maximum test pressure, but in no case shall the range be less than 1½ times that pressure. The spacing between graduations shall be such that the inspector and the operator controlling the test shall be able to determine when the required test pressure has been applied. Digital pressure gages having a wider range of pressure readings may be used provided the readings give the same or greater degree of accuracy as obtained with dial pressure gages.

## **CERTIFICATION BY STAMPING AND DATA REPORTS**

## **PG-101 HEATING SURFACE COMPUTATION**

**PG-101.1** For the stamping required by PG-106, the heating surface shall be computed as specified in PG-101.1.1 through PG-101.1.3.

**PG-101.1.1** Heating surface, as part of a circulating system in contact on one side with water or wet steam being heated and on the other side with gas or refractory being cooled, shall be measured on the side receiving heat.

**PG-101.1.2** Boiler heating surface and other equivalent surface outside the furnace shall be measured circumferentially plus any extended surface.

**PG-101.1.3** Waterwall heating surface and other equivalent surface within the furnace shall be measured as the projected tube area (diameter × length) plus any extended surface on the furnace side. In computing the heating surface for this purpose, only the tubes, fireboxes, shells, tubesheets, and the projected area of headers need to be considered, except that for vertical firetube steam boilers only that portion of the tube surface up to the middle of the gage glass is to be computed.

## **PG-104 GENERAL**

**PG-104.1** The completed boiler unit includes all piping and piping components as defined in the Preamble.

The Manufacturer [see Note (1) below] of any complete boiler unit to be stamped with the Code symbol has the responsibility of assuring through proper Code certification that all work performed by him or others responsible to him complies with all requirements of the Code, including design, construction, materials, and workmanship. With the exception of field installed boiler external piping, when some portions of a complete boiler unit are supplied by, or Code work is performed by others not

responsible to the Manufacturer, the Manufacturer has the duty of obtaining from these other organizations their proper Code certification, covering such portions of work.

When the Manufacturer furnishes a shop assembled boiler that is complete except for boiler external piping, and the boiler has been hydrostatically tested in the shop and properly stamped with the Manufacturer's "S" symbol, the subsequent installation in the field of the external piping within the scope of Section I is not by itself considered "field assembly of the boiler" [see Note (2) below].

No Manufacturer or assembler may accept Code responsibility for work that falls within the scope of the Code, that is performed by workmen employed by any other organization, except through proper Code certification. The responsibilities set forth herein relate only to Code compliance and are not to be construed as involving contractual relations or legal liabilities.

**NOTES:** (1) Boiler Manufacturer or Manufacturer as used in PG-104 or other paragraphs referenced to this Note may also be an Engineering-Contractor organization with or without fabricating facilities, but having the capability of providing a design specification that establishes the pressure and temperature conditions for each component of a complete boiler unit and of assembling the fabricated parts in the field with authorization from the Society to use the Code symbol stamp "S" in accordance with the Code provisions in PG-105.3.

(2) When boiler external piping within the scope of Section I is furnished by other than the boiler Manufacturer, the boiler Manufacturer is not responsible for the Code certification of such piping. The organizations that furnish and that install such external piping by welding shall furnish proper Code certification (PG-104.2) for such piping including Manufacturers' Data Report Form P-4A as required by PG-112.2.5 and PG-112.3.

**PG-104.2** Proper Code certification refers to the furnishing of stamping and Data Reports as evidence to establish the following:

**PG-104.2.1** The organization that performed that portion of the work held an appropriate Certificate of Authorization.

**PG-104.2.2** By signing and furnishing the appropriate data report, that organization

certified compliance with Code rules for that portion of the work.

**PG-104.2.3** By proper use of the Code symbol stamp, that organization identified the portions of the work covered by its Data Report Form.

**PG-104.2.4** By countersignature on the same Data Report a qualified Inspector confirmed that portion of the work complied with applicable Code rules.

## PG-105 CODE SYMBOL STAMPS

FIG. PG-105.1 OFFICIAL SYMBOLS FOR STAMPS TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR BOILERS



FIG. PG-105.2 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR ASSEMBLY

FIG. PG-105.3 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR WELDED PIPING



FIG. PG-105.4 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR SAFETY VALVES

**PG-105.1 Authorization.** Except as permitted in PG-105.5, no organization may assume responsibility for Code construction without having first received from the ASME a Certificate of Authorization to use one of the Code symbol stamps shown in Figs. PG-105.1 through PG-105.4. There are six such stamps, defined as follows:

(a) S - power boiler symbol stamp (see Fig. PG-105.1)

(b) M - miniature boiler symbol stamp (see Fig. PG-105.1)

(c) E - electric boiler symbol stamp (see Fig. PG-105.1)

(d) A - boiler assembly symbol stamp (see Fig. PG-105.2)

(e) PP - pressure piping symbol stamp (see Fig. PG-105.3)

(f) V - safety valve symbol stamp (see Fig. PG-105.4)

Stamps for applying the Code symbol shall be obtained from the Society. Each boiler, superheater, waterwall, economizer, or boiler part to which a Code symbol is to be applied shall be fabricated by a Manufacturer who is in possession of an appropriate Code symbol stamp. A Certificate of Authorization to use the Code symbol "S," "M," "E," "A," "PP," or "V" stamp will be granted by the Society pursuant to the provisions of these paragraphs.

## PG-109 STAMPING OF PRESSURE PIPING

**PG-109.1** Boiler external piping, as defined in the Preamble, may be fabricated by a manufacturer other than the Manufacturer of the boiler, provided that the manufacturer has been issued a Certificate of Authorization to use the "S" or "PP" symbol stamp. Boiler external piping may be installed by welding by a manufacturer or contractor other than the Manufacturer of the boiler, provided such an organization has been issued a Certificate of Authorization to use the "S," "PP," or "A" symbol stamp. When boiler external piping is installed by welding, the welding, including the qualification of welding procedures, welders, and welding operators, shall be done in accordance with the applicable rules of ASME B31.1. The welding shall be inspected by an Authorized Inspector at such stages of the work as he may elect. The organizations which fabricate or install such

piping shall furnish proper code certification (PG-104.2) for it including a Manufacturer's Data Report Form P-4A as required by PG-112.2.5 and PG-112.3.

**PG-109.2** Welded boiler external piping included within the scope of this Code, over NPS 2 (DN 50), shall be stamped with a Code symbol, together with the manufacturer's or contractor's name and serial number. Such stamping shall be on the pipe, valve, or fitting adjacent to the welded joint farthest from the boiler. For piping operating at temperatures above 800°F (425°C) the symbol may be stamped on a nameplate that is irremovably attached by welding, provided such welding is postweld heat treated, or on a circular metal band at least ¼ in. (6 mm) thick. This band around the pipe shall be secured in such a manner as to prevent it from slipping off during handling and installation.

Welded piping NPS 2 (DN 50) or less included within the scope of this Code shall be marked with an identification acceptable to the Inspector and traceable to the required Data Report. Such marking shall be of a type that will remain visible until the piping has been installed.

**PG-109.3** A manufacturer in possession of the pressure piping symbol stamp may

(a) design and fabricate welded piping. Such fabrications shall be stamped and reported on a Form P-4A, Manufacturer's Data Report for Fabricated Piping, as called for in PG-112.2.5.

(b) fabricate other parts of boilers, such as superheater, waterwall, or economizer headers, where complete design requirements are provided by others. Such parts shall be stamped or marked as required by PG-106.8 and reported on a Form P-4, Manufacturer's Partial Data Report, as called for in PG-112.2.4.

**PG-109.4** Mechanically assembled boiler external piping which contains no pressure

boundary welds does not require stamping, and as such may be assembled by a nonstamp holder. Note that the responsibility for documentation and hydrostatic testing of a mechanically assembled boiler external piping must be assumed by a holder of a valid "S," "A," or "PP" stamp (see PG-112.2.5).

## **PG-110 STAMPING OF SAFETY VALVES**

Each safety valve shall be plainly marked with the required data by the Manufacturer or Assembler (see PG-73.3.4) in such a way that the marking will not be obliterated in service. The marking shall be placed on the valve or on a nameplate securely fastened to the valve. The Code "V" symbol shall be stamped on the valve or nameplate by the Manufacturer or Assembler, as applicable. The other required data may be stamped, etched, impressed, or cast on the valve or nameplate. The marking shall include the following:

- (a) the name (or an acceptable abbreviation) of the Manufacturer and Assembler, as applicable
- (b) Manufacturer's design or type number
- (c) NPS (DN) (the nominal pipe size of the valve inlet)
- (d) set pressure \_\_\_\_\_ psi (MPa)
- (e) *Capacity*
  - (1) capacity \_\_\_\_\_ lb/hr (kg/hr) (for saturated steam service in accordance with PG-69.2 or
  - (2) \_\_\_\_\_ capacity lb/hr (kg/hr) at \_\_\_\_\_ °F (°C) (for superheated steam service in accordance with PG-68.7
- (f) year built, or alternatively, a coding may be marked on the valve such that the valve Manufacturer or Assembler can identify the year the valve was assembled and tested
- (g) ASME symbol as shown in Fig. PG-105.4

## **PG-111 LOCATION OF STAMPINGS**

The location of the required stampings shall be as listed below. These stampings shall be left uncovered or an easily removable marked cover may be provided over the stamping when a boiler is covered with insulation, or jacketed. No piping, boiler appliance, or other obstructions shall interfere with reading of the stamping.

**PG-111.1** Horizontal-return tubular boilers - on the front head above the central rows of tubes.

**PG-111.2** Horizontal-flue boilers - on the front head above the flues.

**PG-111.3** Traction, portable, or stationary boilers of the locomotive type or Star watertube boilers - on the furnace end above the handhole. Or on traction boilers of the locomotive type - on the left wrapper sheet forward of the driving wheel.

**PG-111.4** Vertical firetube and vertical submerged tube boilers - on the shell above the firedoor and handhole opening.

### **PG-111.5 Watertube Boilers**

**PG-111.5.1** Drum type - on a head of the steam outlet drum near and above the manhole.

**PG-111.5.2** Forced-flow steam generator with no fixed steam and waterline - the master stamping (PG-106.3) shall be located on a major pressure part, located near the main operating floor where readily visible. The Data Report Form shall record the location of the master stamping.

**PG-111.6** Scotch marine boilers - on either side of the shell near the normal water level line and as near as practical to the front tubesheet.

**PG-111.7** Economic boilers - on the front head, above the center row of tubes.

**PG-111.8** Miniature and electric boilers - on some conspicuous and accessible place on the boiler proper, or on a stamping plate at least 3/64 in. (1.2 mm) thick, permanently fastened (adhesives prohibited) to the boiler.

**PG-111.9** On any of the above types where there is not sufficient space in the place designated, and for other types and new designs - in a conspicuous place on the boiler proper. The Data Report Form shall record the location of the required stamping.

**PG-111.10** Superheaters - on superheater header near the outlet. Other headers shall carry identifying marks.

**PG-111.11** Economizers - at a handy location on water inlet header or drums. Other headers shall carry identifying marks.

**PG-111.12** Waterwalls - on one end of a lower header. Other headers shall carry identifying marks.

**PG-111.13** When required by PG-106.6 and PG-106.7, the Manufacturer [see PG-104, Note (1)] shall furnish a nameplate or plates on which the appropriate Code Symbol and design data for the scope of his responsibility are permanently imprinted. The nameplate shall be securely attached to the front of the boiler, its setting or casing, at a place readily visible from the operating floor or platform.

## **PG-112 MANUFACTURER'S DATA REPORT FORMS**

**PG-112.1** Ten types of Manufacturer's Data Report Forms are shown in the Appendix under the heading "Data Report Forms and Guides7" at the end of this Section. These forms shall be used by the Manufacturer [see PC-104, Note (1)] to record all the items of a complete boiler unit, in accordance with the provisions of PG-112.2. When the certification of the complete boiler unit is accomplished by more than one Data Report, the principal Data Report (P-2, P-2A, P-3, or P-3A) shall be designated as the Master Data Report (see PG-113).

For forced-flow steam generators with no fixed steam and waterline consisting of groups of pressure parts or components designed at several different pressure levels,

a separate Manufacturer's Data Report shall clearly identify the pressure parts at each pressure level and show the maximum allowable working pressure. These several Data Reports shall be attached to a Master Data Report (PG-113) that shall clearly identify each component as part of the complete unit.

**PG-112.2 Types of Data Report Forms.**

The types of Data Report Forms and the purposes for which they are to be used are specified in PG-112.2.1 through PG-112.2.8.

**PG-112.2.1** Form P-2, Manufacturer's Data Report for All Types of Boilers Except Watertube and Electric, shall be used to record all types of boilers other than watertube boiler units and parts thereof, which are included under Form P-3.

**PG-112.2.1.1** Form P-2A, Manufacturer's Data Report for All Types of Electric Boilers, shall be used to record all types of electric boilers.

**PG-112.2.1.2** Form P-2B, Manufacturer's Data Report for Electric Superheaters and Reheaters, shall be used to record electric superheaters and reheaters installed external to the boiler setting.

**PG-112.2.2** Form P-3, Manufacturer's Data Report for Watertube Boilers, Superheaters (except electric), Waterwalls, and Economizers, shall be used to record all of the items comprising a watertube boiler.

The Form P-3 shall also be used to record a superheater, waterwall, or economizer when the design of such an item is certified by a manufacturer other than the boiler Manufacturer, or when such an item is to be added to an existing boiler. The item shall be stamped with the ASME "S" symbol and the additional information, as applicable, shown in PG-106.4.2.

Item 10 on Form P-3 shall be used to record other parts connected at the openings listed in Item 11 if such parts are fabricated of materials or by processes that require Code inspection. If such parts have not been

connected prior to the hydrostatic test, a notation shall be made under Item 10 reading: "No parts connected to the openings listed in Item 11 except as noted."

**PG-112.2.3** Form P-3A, Engineering-Contractor Data Report for a Complete Boiler Unit, shall be used when such an organization assumes the Manufacturer's Code responsibility as provided for by PG-104, Note (1). This form shall be used to certify Code responsibility for the design specification of the complete boiler unit, of which the components are individually certified by their individual manufacturers in accordance with the Code rules. This form also provides for field assembly certification.

**PG-112.2.4** Form P-4, Manufacturer's Partial Data Report, shall be used to record boiler parts requiring inspection and stamping under this Section which are furnished by other than the Manufacturer responsible for the completed boiler, superheater, waterwall, or economizer.

(a) Except as provided in PG-112.2.4(b), Form P-4 shall be used only to provide supporting data for the information given on the Master Data Report (see PG-113) or on the Form P-3 used to record a superheater, waterwall, or economizer.

(b) When used to record parts furnished to the user of an existing boiler as replacement or repair parts, Form P-4 is sufficient and need not support a Master Data Report. A copy of the parts Manufacturer's Form P-4 shall be forwarded to the purchaser.

(c) The parts manufacturer shall indicate under "remarks" the extent to which he has performed the design functions. When the parts manufacturer performed only a portion of the design, he shall state which portion of the design he has performed.

**PG-112.2.5** Form P-4A, Manufacturer's Data Report for Fabricated Piping, shall be used to record all shop or field-welded boiler external piping that falls within the

scope of this Section but is not furnished by the boiler Manufacturer. Form P-4B, Manufacturer's Data Report for Field-Installed Mechanically Assembled Piping, shall be used to record all field-installed mechanically assembled boiler external piping. Form P-4B shall be used only for piping that contains no joints brazed or welded by the field installer.

**PG-112.2.6** Form P-5, Summary Data Report for Process Steam Generators, may be used by the Manufacturer [see PG-104, Note (1)] to record all items of field-assembled process steam generators of the waste heat or heat recovery type, comprising one or more drums and one or more arrays of heat exchange surface designed for different pressure levels. All such component items shall be constructed to the applicable rules of the Code and shall be certified by individual Data Report Forms executed by the component manufacturer and the Authorized Inspector. When used, the Summary Data Report Form P-5 shall list all the properly executed data report forms for components comprising the complete process steam generator and shall be attached to the Manufacturer's Data Report.

**PG-112.2.7** When using a print version of a Data Report Form, Form P-6, Manufacturer's Data Report Supplementary Sheet, shall be used to record additional data where space was insufficient on a Data Report Form. This Manufacturer's Data Report Supplementary Sheet will be attached to the Manufacturer's Data Report Form where used. When using an electronic version of a Data Report Form, it may be expanded to include all additional data, or Form P-6 may be used in accordance with para. PG-112.2.6.

**PG-112.2.8** Form P-7, Manufacturer's Data Report for Safety Valves, shall be used to record required safety valves. Form P-7 shall be used as supporting data for Form P-

2, P-3, or P-3A. Form P-7 is not required for boilers certified on Form P-2A, or for boilers with a single safety valve when the safety valve size, set pressure, and capacity [lb/hr (kg/hr)] are included in the remarks section of Form P-2 or P-3.

**PG-112.3** Manufacturer's Data Reports and all associated Partial Data Reports shall be furnished to the purchaser, the inspection agency, and the state, municipal, or provincial authority at the place of installation. Partial Data Reports for pressure parts requiring inspection under this Section, and which are furnished by other than the Manufacturer having Code responsibility for the boiler or the superheater, waterwall, or economizer, shall be executed by the parts manufacturer and the Inspector in accordance with the requirements of this Section.

Except as provided in PG-112.2.4 (b), the Partial Data Reports shall be forwarded, in duplicate, to the Manufacturer of the boiler or the superheater, waterwall, or economizer. These Partial Data Reports, together with his own inspection, shall be the final Inspector's authority to witness the application of the Code symbol to the boiler or the superheater, waterwall, or economizer. The Partial Data Reports shall be attached to the associated Form P-2, P-2A, P-3, P-3A, or P-5 by the Manufacturer having Code responsibility for the boiler or the superheater, waterwall, or economizer.

**PG-112.4** A-350 includes nonmandatory guides to aid in the completion and certification of the Manufacturer's Data Report Forms

**PG-112.5** Multiple Pressure Steam Generators shall be documented as indicated in PG-112.5.1 and PG-112.5.2.

**PG-112.5.1** Data Report Form P-3 or P-3A shall be used by the Manufacturer as the Master Data Report to record all items comprising a multiple pressure steam generator of the waste heat or heat recovery

type. The Master Data Report shall list all of the properly executed data report forms for the items comprising the complete steam generator unit.

**PG-112.5.2** Other forms such as P-3, P-4, P-5, P-6, and P-7 shall be used as necessary to provide and summarize supporting information for the Master Data Report.

**PG-112.6** Manufacturer's Partial Data Report Form P-4 and stamping in accordance with PG-106 are neither required nor prohibited for pressure parts that do not contain pressure retaining welds (e.g., boiler furnace walls, floor panel assemblies, tubes with support or hanger lugs). However, the Manufacturer shall certify that the material and construction are in accordance with the requirements of this Section.

**PG-112.6.1** Certification may be supplied in the form of bills of material and drawings with a statement of compliance or Certificate of Compliance from the Manufacturer.

**PG-112.6.2** The Certification shall state what materials were used including size (O.D. and wall thickness) and which edition and addenda of the Code were used to construct the parts.

**PG-112.6.3** The parts shall be clearly identified with markings traceable to the certification. The markings may be in the form of labels, tags, stamping, paint, or coded identification.

## **PART PFT REQUIREMENTS FOR FIRETUBE BOILERS**

### **GENERAL**

#### **PFT-1 GENERAL**

The rules in Part PFT are applicable to firetube boilers and parts thereof and shall be used in conjunction with the general requirements in Part PG as well as with the specific requirements in the applicable Parts

of this Section that apply to the method of fabrication used.

## **MATERIALS**

### **PFT-5 GENERAL**

**PFT-5.1** Materials used in the construction of pressure parts for firetube boilers shall conform to one of the specifications given in Section II and shall be limited to those for which allowable stress values are given in Tables 1A and 1B of Section II, Part D, or as otherwise specifically permitted in Parts PG and PFT.

**PFT-5.2** Waterleg and doorframe rings of vertical firetube boilers and of locomotive and other type boilers shall be of wrought iron or steel or cast steel as designated in the SA-216. The ogee or other flanged construction may be used as a substitute in any case.

## **DESIGN**

### **PFT-8 GENERAL**

The rules in the following paragraphs apply specifically to the design of firetube boilers and parts thereof and shall be used in conjunction with the general requirements for design in Part PG as well as with the specific requirements for design in the applicable Parts of this Section that apply to the method of fabrication used.

### **PFT-9 THICKNESS REQUIREMENTS**

**PFT-9.1 Shell and Dome.** The thickness after forming shall be as determined in accordance with the rules in Part PG but shall be not less than the values shown in the following table.

Inside Diameter of Shell or Dome, in. (mm)	Minimum Thickness, in. (mm)
36 (900) or under	¼ (6)
Over 36 (900) to 54 (1 350)	5/16 (8)
Over 54 (1 350) to 72 (1 800)	3/8 (10)
Over 72 (1 800)	½ (13)

### **PFT-9.2 Tubesheet**

**PFT-9.2.1** The thickness shall be as determined in accordance with Part PG and Part PFT but shall not be less than the values given in the following table.

Inside Diameter of Shell, in. (mm)	Minimum Thickness, in. (mm)
42 (1 100) or under	3/8 (10)
Over 42 (1 100) to 54 (1 350)	7/16 (11)
Over 54 (1 350) to 72 (1 800)	½ (13)
Over 72 (1 800)	9/16 (14)

**PFT-9.2.2** When butt welded to the shell of a firetube boiler, a formed tubesheet with a straight flange longer than 1½ times the tubesheet thickness shall have a straight flange thickness not less than that specified in the table in PFT-9.2.1, but in no case less than 0.75 times the thickness of the shell to which it is attached.

#### **PFT-10 SHELL JOINTS**

Longitudinal and circumferential welded joints of a shell or drum shall comply with the rules in Part PW.

#### **PFT-11 ATTACHMENT OF HEADS AND TUBESHEETS**

Flat heads and tubesheets of firetube boilers shall be attached by one of the following methods:

**PFT-11.2** By flanging and butt welding in accordance with Parts PG and PW.

**PFT-11.3** By attaching an outwardly or inwardly flanged tubesheet to the shell by fillet welding provided the following requirements are met:

**PFT-11.3.1** The tubesheet is supported by tubes, or stays, or both.

**PFT-11.3.2** The joint attaching an outwardly flanged tubesheet is wholly within the shell and forms no part thereof.

**PFT-11.3.3** Inwardly flanged tubesheets are full fillet welded inside and outside.

**PFT-11.3.4** The throat dimension of the full fillet weld is equal to not less than 0.7 of the thickness of the head.

**PFT-11.3.6** The construction conforms in all other respects to the requirements of this

Section, including welding and postweld heat treating, except that radiographic examination is not required.

**PFT-11.3.7** This construction shall not be used on the rear head of a horizontal-return tubular boiler and inwardly flanged tubesheets shall not be used on a boiler with an extended shell.

**PFT-11.3.8** On inwardly flanged tubesheets, the length of flange shall conform to the requirements of PW-13 and the distance of the outside fillet weld to the point of tangency of the knuckle radius shall be not less than ¼ in. (6 mm).

**PFT-11.4** By attaching an unflanged tubesheet to the shell by welding, provided the requirements of PFT-11.4.1 through PFT-11.4.7 are met

**PFT-11.4.1** The tubesheet is supported by tubes, or stays, or both.

**PFT-11.4.2** The welded joint may be made through the tubesheet or shell thickness. When the weld joint is made through the shell, a minimum of 80% of the pressure load shall be carried by the tubes, stays, or both.

**PFT-11.4.3** The weld is a full penetration weld equal at least to the full thickness of the base metal applied from either or both sides. When the full penetration weld is made through the shell, an external fillet weld with a minimum throat of ¼ in. (6 mm) shall be provided, and no weld prep machining shall be performed on the flat tubesheet. The distance from the edge of the completed weld to the peripheral edge of the tubesheet shall not be less than the thickness of the tubesheet.

**PFT-11.4.4** The shell or wrapper sheet, where exposed to primary furnace gases<sup>1</sup> and not water cooled, does not extend more than 1/8 in. (3 mm) beyond the outside face of the tubesheet.

---

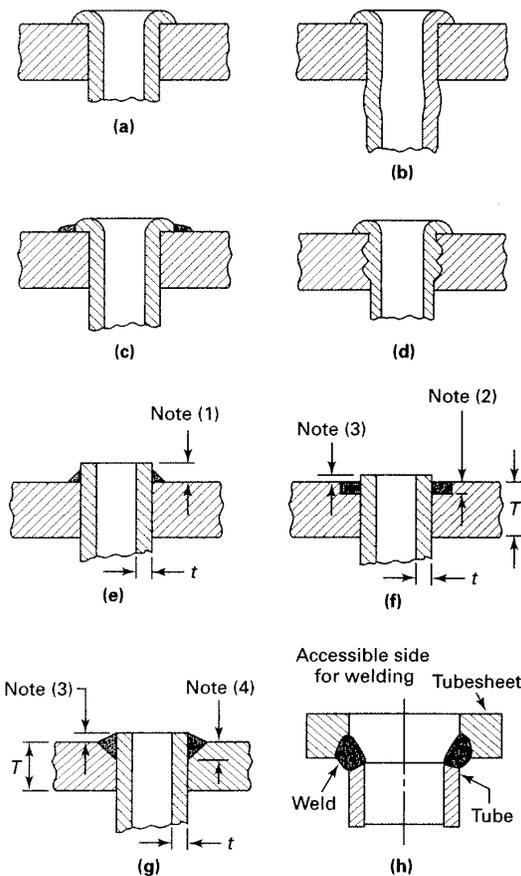
<sup>1</sup> Primary furnace gases are those in a zone where the design temperature of those gases exceeds 850°F (455°C).

**PFT-11.4.5** The weld attaching a furnace or a lower tubesheet of a vertical firetube boiler to the furnace sheet is wholly within the furnace sheet and is ground flush with the upper or water side of the tubesheet.

**PFT-11.4.6** The construction conforms in all other aspects to the requirements of this Section including welding, and postweld heat treatment, except that radiographic examination is not required.

**PFT-11.4.7** This construction shall not be used on the rear head of a horizontal-return tubular boiler.

FIG. PFT-12.1 SOME ACCEPTABLE FORMS OF TUBE ATTACHMENT ON FIRETUBE BOILERS



NOTES:

- (1) Not less than  $t$  or  $\frac{3}{8}$  in. (3 mm), whichever is the greater, nor more than  $2t$  or  $\frac{1}{4}$  in. (6 mm), whichever is the lesser.
- (2) Not less than  $t$  or  $\frac{3}{8}$  in. (3 mm), whichever is the greater, nor more than  $7/3$  (see PFT-12.2.1.2).
- (3) Not more than  $t$ .
- (4) Not less than  $t$  or  $\frac{3}{8}$  in. (3 mm), whichever is the greater, nor more than  $7/3$  (see PFT-12.2.1.2).

## PFT-12 TUBES

### PFT-12.1 Allowable Working Pressure

**PFT-12.1.1** The maximum allowable working pressure of tubes or flues of firetube boilers shall be as given in PFT-50 and PFT-51.

**PFT-12.1.2** The maximum allowable working pressure for copper tubes or nipples subjected to internal or external pressure shall not exceed 250 psi (1.7 MPa). The maximum temperature shall not exceed 406°F (208°C).

The maximum allowable working pressure for copperclad tubes subjected to external pressure shall be determined by the formula in PFT-51, in which  $t$  may be increased by one-half the thickness of the cladding.

### PFT-12.2 Attachment of Tubes

**PFT-12.2.1** Figure PFT- 12.1 illustrates some of the acceptable types of tube attachments. Such connections shall be

(a) expanded and beaded as in illustrations (a), (b), and (d)

(b) expanded and beaded and seal welded as in illustration (c)

(c) expanded and seal welded as in illustration (e)

(d) welded, as in illustrations (f) and (g)

Tube ends attached by expanding and welding are subject to the provisions specified in PFT-12.2.1.1 through PFT-12.2.1.3.

**PFT-12.2.1.1** Where no bevel or recess is employed, the tube shall extend beyond the tubesheet not less than a distance equal to the tube thickness or  $\frac{1}{8}$  in. (3 mm), whichever is the greater, nor more than twice the tube thickness or  $\frac{1}{4}$  in. (6 mm), whichever is the lesser [see Fig. PFT- 12.1, illustration (e)].

**PFT-12.2.1.2** The tubesheet hole may be beveled or recessed. The depth of any bevel or recess shall not be less than the tube thickness or  $\frac{1}{8}$  in. (3 mm), whichever is greater, nor more than one-third of the

tubesheet thickness, except that when tube thicknesses are equal to or greater than 0.150 in. (4 mm), the bevel or recess may exceed  $T/3$ . Where the hole is beveled or recessed, the projection of the tube beyond the tubesheet shall not exceed a distance equal to the tube wall thickness [see Fig. PFT-12.1, illustrations (f) and (g)].

**PFT-12.2.1.3** On types of welded attachment shown in Fig. PFT-12.1, illustrations (c) and (e), the tubes shall be expanded before and after welding. On types shown in illustrations (f) and (g), the tubes may be expanded.

**PFT-12.2.2** Expanding of tubes by the Prosser method may be employed in combination with any beaded or seal welded attachment method [see Fig. PFT-12.1, illustration (b)].

**PFT-12.2.3** After seal welding as shown by Fig. PFT-12.1, illustrations (c) and (e), a single hydrostatic test of the boiler shall suffice.

**PFT-12.2.4** The inner surface of the tube hole in any form of attachment may be grooved or chamfered.

**PET-12.2.5** The sharp edges of tube holes shall be taken off on both sides of the plate with a file or other tool.

**PFT-12.2.6** Welded tube attachments as shown by Fig. PFT-12.1, illustration (h), may be made with partial or no insertion of the tube into the flat tubesheet. The

following requirements shall be met for these attachments:

(a) The tube and tubesheet materials shall be restricted

to P-No. 1, P-No. 3, or P-No. 4 materials.

(b) The maximum design temperature at the weld joint shall not exceed 700°F (370°C).

(c) The weld shall be a full-penetration weld made from the I.D. of the tube. The throat of the weld shall be equal to or greater than the thickness of the tube. The root pass shall be made using the GTAW process.

(d) PWHT per PW-39 is mandatory. The exemptions to PWHT noted in Table PW-39 shall not apply.

(e) In addition to meeting the performance qualification requirements of Section IX, before making a production weld each welder and welding operator shall demonstrate his or her ability to achieve complete weld penetration and minimum thickness by successfully welding six test pieces. The test pieces shall be welded in a mockup of the production weld. The mockup shall be of identical position, dimensions, and materials as that of the production weld. The test pieces shall be visually examined to verify complete penetration and sectioned to verify minimum weld thickness. The results shall be recorded and maintained with the performance qualification record.

(f) Each weld surface on the tube I.D. shall receive either a magnetic particle or liquid penetrant examination in accordance with A-260 or A-270 of Appendix A, as applicable. In addition, a visual examination of the weld surface on the tube O.D. shall be performed. The maximum practicable number of these welds, but in no case fewer than 50%, shall be visually examined. Visual examination shall show complete penetration of the joint root and freedom from cracks.

## COMBUSTION CHAMBERS

### PFT-13 COMBUSTION CHAMBER TUBESHEET

**PFT-13.1** The maximum allowable working pressure on a tubesheet of a combustion chamber, where the crown sheet is not suspended from the shell of the boiler, shall be determined by the following equation:

*(US. Customary Units)*

$$P = 27,000 \frac{t(D-d)}{WD}$$

*(SI Units)*