EXCERPTS FROM
ASME CODE

NOTES:

EXCERPTS FROM ASME CODE SECTION I

NOTES:

SAFETY VALVES AND SAFETY RELIEF VALVES[16]

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 sq ft (47 m^2) of bare tube water-heating surface, or if an electric boiler has a power input more than 1100 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 sq ft (47 m^2), two or more safety valves or safety relief valves are required only if the design steam generating capacity of the boiler exceeds 4000 lb/hr (1800 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 not be less than the maximum designed steaming capacity 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 for a high-temperature water boiler shall be determined by dividing the maximum output in Btu/hr at the boiler nozzle, produced by the highest heating value fuel for which the boiler is designed, by 1000.

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 which 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 lbs/hr, calculated from the maximum expected heat absorption in Btu/hr, as determined by the Manufacturer, divided by 1000. 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[17] may exceed this 10% range.

PG-67.4 For a forced-flow steam generator with no fixed steam and waterline, 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[18] shall be provided in direct communication with the boiler when the boiler is under pressure and shall

[16]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 1 of ASME PTC 25-1994, Pressure Relief Devices shall apply.

[17]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.

[18]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 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.

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.

An isolating stop valve of the outside-screw-and-yoke 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.

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 and PG-69.5.

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 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 primer mover.

PG-67.4.3 The total installed capacity of spring-loaded 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 no 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; and

PG-67.4.3.2.2 A control which 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 connect 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 valve 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).

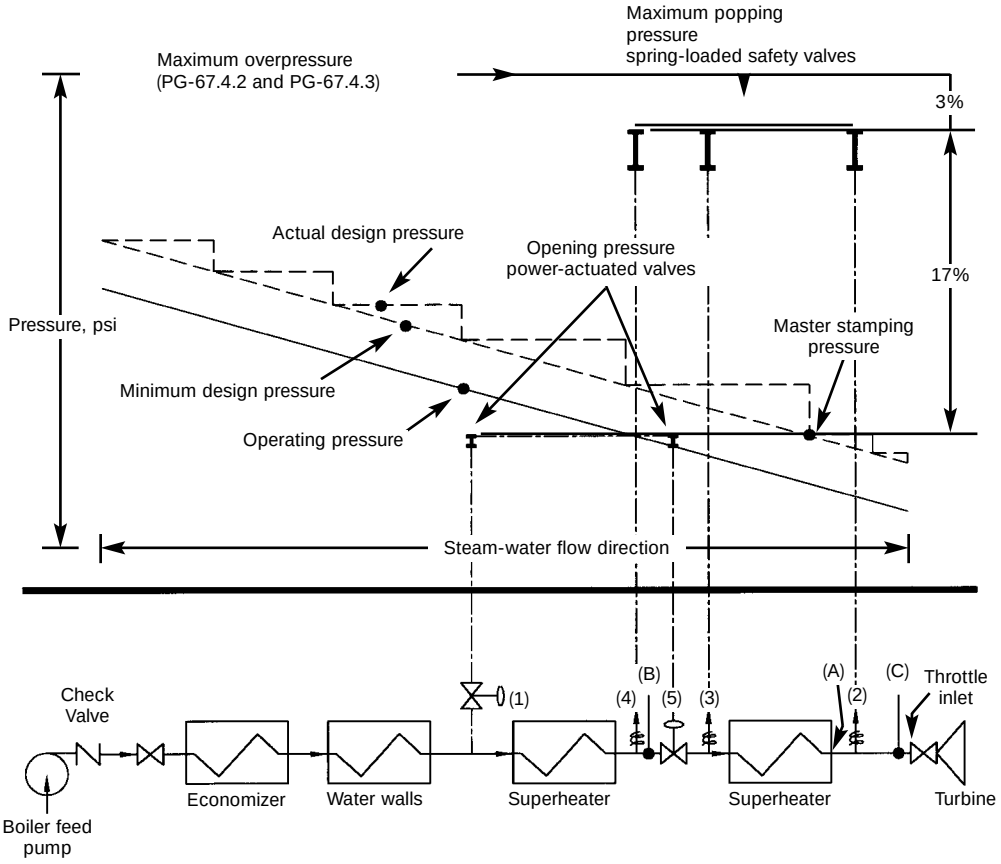
NOTE: "Fail-safe" shall mean a circuitry arranged as either of the following:

(1) 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.

(2) 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.



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)**

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

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 valve 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-72. 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 which give any opening up to the full discharge capacity of the area of the opening of the inlet of the valve (see PG-69.5), 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.

A99 **PG-67.6** A safety valve or safety relief valve over NPS 3 (DN 80), used for pressures greater than 15 psig (103 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 or SB-62, 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 450ºF (232ºC) and 306ºF (152ºC) respectively, and shall not be used for high-temperature water boilers.

PG-68 SUPERHEATER AND REHEATER SAFETY VALVE REQUIREMENTS 98

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 separately fired superheater which may 98
be shut off from the boiler and permit the superheater to become a fired pressure vessel shall have one or more safety valves having a discharge capacity equal to 6 lb of steam per hour per square foot of 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 lbs. of steam per hour from the maximum expected heat absorption (as determined by the Manufacturer) in Btu/hr, divided by 1,000. In the case of electrically heated superheaters, the safety valve capacity shall be based upon 3½ lb/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 450ºF (232ºC) 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-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 20ºF (11ºC) 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 which meets the requirements of Appendix 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.[19]

PG-69.1.4 Capacity certification tests shall be conducted at a pressure which does not exceed the set pressure by 3% or 2 psi, 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 (690 kPa), the blowdown shall be adjusted so as not to exceed 4 psi (28 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 which 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: 98

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

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

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

minimum slope = 0.95 x average slope

maximum slope = 1.05 x 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:

[19]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, Ohio 43229.

rated slope = 0.90 x average slope

stamped capacity ≤ rated slope (1.03 x set pressure + 14.7) or (set pressure + 2 psi + 14.7), whichever is greater

98 **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

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

For flat seat

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

For nozzle

$$W_T = 51.5\,AP$$

Where

W_T = theoretical flow, lb/hr
A = nozzle throat area, sq in.
P = (1.03 x set pressure + 14.7), or
= (set pressure + 2 + 14.7), whichever is greater, psia
L = lift pressure at P, in.
D = seat diameter, in.

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 ±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 ±5% range, with a limit of four additional valves. Failure of a coefficient, K_D, to fall within ±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 equation:

$$W \le W_T \times K$$

where

W = rated relieving capacity lb/hr
W_T = theoretical flow defined by the same equation used to determine K_D lb/hr
K = coefficient of discharge for the design

The coefficient of discharge for the design shall not be greater than 0.878 (the product of 0.9 x 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 ±5% of the average coefficient, K.

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 1500 psig and up to 3200 psig, the value of W shall be multiplied by the correction factor:

$$\frac{0.1906P - 1000}{0.2292P - 1061}$$

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 ±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) x(dW/dP) shall be applied to capacity computations in the supercritical region at elevated pressures by means of the isentropic flow equation

$$W_T = 1135.8 \frac{0.90}{51.45} \times \frac{dW}{dP} \sqrt{\frac{P}{v}}$$

where

W = capacity, lb of steam/hr
P = absolute inlet pressure, psia
V = inlet specific volume, cu ft/lb
dW/dP = rate of change of measured capacity with respect to absolute pressure

NOTE: The constant 1135.8 is based on a y factor of 1.30 which is accurate for superheated steam at temperature above approximately 800ºF. In interest of accuracy, other methods of capacity computations must be used at temperatures below 800ºF 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. A99

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 thereinto. 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 $2^{1}/_{2}$ (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 which 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 $^{1}/_{4}$ in. (6 mm) in diameter and the least dimension in any other form of opening for inlet of steam shall be $^{1}/_{4}$ 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.

98 PG-72 OPERATION

PG-72.1 Safety valves shall be designed and constructed to operate without chattering and to attain full lift at a pressure no greater than 3% above their set pressure. After blowing down, all valves set at pressures of 375 psi or greater shall close at a pressure not lower than 96% of their set pressure, except that all drum valves installed on a single boiler may be set to reseat at a pressure not lower than 96% of the set pressure of the lowest set drum valve. All valves set at pressures below 375 psi shall have a blowdown not greater than that specified in the following table:

Set Pressure, psi	Maximum Blowdown
< 67	4 psi
≥ 67 and ≤ 250	6% of set pressure
> 250 and < 375	15 psi

The minimum blowdown for all safety or safety relief valves shall be 2 psi (13.8 kPa) or 2% of the set pressure, whichever is greater.

Safety valves used on forced-flow steam generators with no fixed steam and waterline, and safety relief valves used on high-temperature water boilers may be set and adjusted to close after blowing down not more than 10% of the set pressure. The valves for these special uses must be so adjusted and marked by the manufacturer.

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

Set Pressure, psi	Tolerance, plus or minus from set pressure
≤ 70	2 psi
> 70 and ≤ 300	3% of set pressure
> 300 and ≤ 1000	10 psi
> 1000	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 200ºF (93ºC). 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 ⅜ (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 nozzles, disks, and other parts contained within the external structure of the safety or safety relief valves shall be one of the following categories:

(1) listed in ASME Section II;

(2) listed in ASTM Specifications (see Note below);

(3) controlled by the manufacturer of the safety or safety relief valve by a specification insuring 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 insure that the allowable stresses at temperature meet the requirements of Section II, Part D, Appendix 1, Nonmandatory 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 insure 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.

(1) 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.

(2) 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.

(3) Should any valve fail to relieve at or above its certified capacity or should it fail to meet performance requirements of this Section, 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.

(4) 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.

98 A99 **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. However, an assembler may convert original finished parts by machining to another finished part for a specific application under the following conditions:

(a) 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 machining.

(b) 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.

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

(d) 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.

(e) At least annually a review shall be performed by the Manufacturer of an Assembler's system and machining 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.

PG-73.3.5 In addition to the requirements of PG-110, the same plate marking shall include the name of the Manufacturer and the assembler. The Code Symbol Stamp shall be that of the assembler.

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 Valves exceeding 1 in. (DN 25) inlet size or 300 psig (2070 kPa) set pressure shall meet the following requirements. Primary pressure containing cast and welded parts of pressure relief valves shall be tested at a pressure at 1.5 times the design pressure of the parts. These tests shall be conducted after all machining operations to the parts have been completed. There shall be no visible signs of leakage.

Closed bonnet pressure relief valves designed for discharge to a closed system shall be tested with a minimum of 30 psig (207 kPa) air or other gas in the secondary pressure zone. There shall be no visible signs of leakage.

PG-73.4.2 Every valve shall be tested with steam by the manufacturer or assembler to demonstrate the popping point, blowdown, tightness, and pressure containing integrity. Valves beyond the capability of production test facilities may be shop tested with air, provided required field tests and applicable adjustments are made.

PG-73.4.3 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.

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 which do not conform, prior to capacity testing.

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, but the other required data may be stamped, etched, impressed, or cast on the valve or nameplate. The marking shall include the following:

(1) the name (or an acceptable abbreviation) of the Manufacturer and Assembler;

(2) Manufacturer's design or type number;

(3) NPS (the nominal pipe size of the valve inlet);

(4) set pressure____psi;

(5) capacity____lb/hr (in accordance with PG-67.5 and with the valve adjusted for the blowdown permitted by PG-72);

(6) 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;

(7) ASME symbol as shown in Fig. PG-105.4.

PG-105 CODE SYMBOL STAMPS

PG-105.1 Authorization. Except as permitted in PG-105.6, 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:

S – power boiler symbol stamp	see Fig. PG-105.1
M – miniature boiler symbol stamp	see Fig. PG-105.1
E – electric boiler symbol stamp	see Fig. PG-105.1
A – boiler assembly symbol stamp	see Fig. PG-105.2
PP – pressure piping symbol stamp	see Fig. PG-105.3
V – safety valve symbol stamp	see Fig. PG-105.4

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

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-105.2 Application for Certificate of Authorization. Any organization desiring a Certificate of Authorization shall apply to the Boiler and Pressure Vessel Committee of the Society, on forms issued by the Society, specifying the stamp desired and the scope of Code activities to be

performed. When an organization intends to build Code items in plants in more than one geographical area, separate applications for each plant or a single application listing the addresses of all such plants may be submitted. Each application shall identify the Authorized Inspection Agency providing Code inspection at each plant. A separate Certificate of Authorization will be prepared and a separate fee charged by the Society for each plant.

Each applicant must agree that each Certificate of Authorization and each Code symbol stamp are at all times the property of the Society, that they will be used according to the rules and regulations of this Section of the Code, and that they will be promptly returned to the Society upon demand, or when the applicant discontinues the Code activities covered by his certificate, or when the Certificate of Authorization has expired and no new certificate has been issued. The holder of a Code symbol stamp shall not allow any other organization to use it.

Authorization to use Code symbol stamps may be granted or withheld by the Society in its absolute discretion. If authorization is granted, and the proper administrative fee paid, a Certificate of Authorization evidencing permission to use any such symbol, expiring on the triennial anniversary date thereafter, will be forwarded to the applicant. Each such certificate will identify the Code symbol to be used, and the type of shop and/or field operations for which authorization is granted. (See Appendix A-370). The certificate will be signed by the Chairman of the Boiler and Pressure Vessel Committee and the Director of Accreditation. Six months prior to the date of expiration of any such certificate, the applicant must apply for a renewal of such authorization and the issuance of a new certificate. The Society reserves the absolute right to cancel or refuse to renew such authorization returning pro rata, fees paid for the unexpired term.

PG-105.3 Agreement With Authorized Inspection Agency. As a condition of obtaining and maintaining a Certificate of Authorization to use the "S", "M", "E", "A", or "PP" Code symbol stamps, the Manufacturer or Assembler must have in force at all times, an inspection contract or agreement with an Authorized Inspection Agency as defined in PG-91 to provide inspection services. This inspection contract is a written agreement between the Manufacturer or Assembler and the inspection agency which specifies the terms and conditions under which the inspection services are to be furnished and which states the mutual responsibilities of the Manufacturer or Assembler and the Authorized Inspectors. The certificate holder shall notify the Society whenever its agreement with an Authorized Inspection Agency is cancelled or changed to another Authorized Inspection Agency.

Manufacturers or assemblers of safety valves are not required to have an inspection agreement with an Authorized Inspection Agency. A Certificate of Authorization may be granted to a manufacturer or assembler of safety valves to use the safety valve symbol stamp providing such stamp is applied only to safety valves that have been capacity certified in accordance with the requirements of this Section.

PG-105.4 Quality Control System. Any Manufacturer or Assembler holding or applying for a Certificate of Authorization to use the "S", "M", "E", "A", "PP", or "V" stamp shall have, and demonstrate, a quality control system to establish that all Code requirements including material, design, fabrication, examination (by the Manufacturer), and inspection for boilers and boiler parts (by the Authorized Inspector) will be met. The quality control system shall be in accordance with the requirements of Appendix A-300.

Before issuance or renewal of a Certificate of Authorization for use of the "S", "M", "E", "A", or "PP" stamps, the Manufacturer's facilities and organization are subject to a joint review by a representative of his inspection agency and an individual certified as an ASME designee who is selected by the concerned legal jurisdiction. When the jurisdiction assumes responsibility for leading the review, it shall have certified that its representative has met ASME criteria. A written description or checklist of the quality control system which identifies what documents and what procedures the Manufacturer will use to produce a Code item shall be available for review. The purpose of the review is to evaluate the applicant's quality control system and its implementation. The applicant shall demonstrate sufficient administrative and fabrication functions of the system to show that he has the knowledge and ability to produce the Code items covered by his quality control system. Fabrication functions may be demonstrated using current work, a mock-up, or a combination of the two. A written report to the Society shall be made jointly by the jurisdiction and the inspection agency employed by the Manufacturer to do his Code inspection. This report is then reviewed by the Subcommittee on Boiler and Pressure Vessel Accreditation, which will either issue a Certificate of Authorization or notify the applicant of deficiencies revealed by the review. In such a case, the applicant will be given an opportunity to explain or correct these deficiencies.

Certificates of Authorization will be endorsed to indicate the scope of activity authorized. Authorization may include field operations if the review team determines that these operations are adequately described in the quality

control manual, and this determination is accepted by the Society.

Before issuance or renewal of a Certificate of Authorization for use of the "V" stamp, the valve manufacturer's or assembler's facilities or organization are subject to a review by an ASME designee. A written description or checklist of the quality control system, which identifies the documents and procedures the manufacturer or assembler will use to produce Code safety and safety relief valves, shall be available for review. The ASME designee shall make a written report to the Society, where the Subcommittee on Boiler and Pressure Vessel Accreditation will act on it as described above.

The Manufacturer may at any time make changes in the quality control system concerning the methods of achieving results subject to acceptance by the Authorized Inspector. For manufacturers and assemblers of "V" stamped safety or safety relief valves, such acceptance shall be by the ASME designee.

For those areas where there is no jurisdiction or where a jurisdiction does not choose to select an ASME designee to review a vessel or vessel parts manufacturer's facility, that function shall be performed by an ASME designee selected by ASME. In either case, the ASME designee shall certify its representative has met ASME criteria. Where the jurisdiction is the Manufacturer's inspection agency, the joint review and joint report shall be made by the jurisdiction and another representative designated by the Society.

PG-105.5 Code Construction Before Receipt of Certificate of Authorization. When used to demonstrate his quality control system, a Manufacturer may start fabricating Code items before receipt of a Certificate of Authorization to use a Code symbol stamp under the following conditions:

(1) The fabrication is done with the participation of the Authorized Inspector and is subject to his acceptance.

(2) The activity shall have been performed in conformance with the applicant's accepted quality control system.

(3) The item is stamped with the appropriate Code symbol and certified once the applicant receives his Certificate of Authorization from the Society.

PG-105.6 Regulations on Use of Code Symbol Stamps. The Boiler and Pressure Vessel Committee may at any time make such regulations concerning the issuance and use of Code symbol stamps as it deems appropriate, and all such regulations shall become binding upon the holders of any valid Certificates of Authorization.

PART PVG
REQUIREMENTS FOR ORGANIC FLUID VAPORIZERS

PVG-12 SAFETY VALVES

PVG-12.1 Safety valves shall be of a totally enclosed type so designed that vapors escaping beyond the valve seat shall not discharge into the atmosphere, except through an escape pipe that will carry such vapors to a safe point of discharge outside of the building. A suitable condenser that will condense all the vapors discharged from the safety valve may be used in lieu of piping the vapors to the atmosphere. The safety valve shall not have a lifting lever. The vaporizer shall be designed in accordance with the rules in this Code for a working pressure of at least 40 psi (256 kPa) above the operating pressure at which it will be used. Valve body drains are not mandatory.

PVG-12.2 Safety valves shall be disconnected from the vaporizer at least once yearly, when they shall be inspected, repaired if necessary, tested, and then replaced on the vaporizer.

PVG-12.3 In order to minimize the loss by leakage of material through the safety valve, a rupture disk may be installed between the safety valve and the vaporizer provided the following requirements are met.

PVG-12.3.1 The cross-sectional area of the connection to a vaporizer shall be not less than the required relief area of the rupture disk.

PVG-12.3.2 Every rupture disk shall have a specified bursting pressure at a specified temperature, shall be marked with a lot number, and shall be guaranteed by its manufacturer to burst within 5% (plus or minus) of its specified bursting pressure.

PVG-12.3.3 The specified bursting pressure at the coincident specified temperature shall be determined by bursting two or more specimens from a lot of the same material and of the same size as those to be used. The tests shall be made in a holder of the same form and pressure area dimensions as that with which the disk is to be used.

PVG-12.3.4 A rupture disk may be installed between a safety valve and the vaporizer provided:

PVG-12.3.4.1 The maximum pressure of the range for which the disk is designed to rupture does not exceed the opening pressure for which the safety valve is set or the maximum allowable working pressure of the vessel.

PVG-12.3.4.2 The opening provided through the rupture disk, after breakage, is sufficient to permit a flow equal to the capacity of the attached valve and there is no chance of interference with the proper functioning of the valve; but in no case shall this area be less than the inlet area of the valve.

PVG-12.3.4.3 The space between a rupture disk and the valve should be provided with a pressure gage, try cock, free vent, or a suitable telltale indicator. This arrangement permits the detection of disk rupture or leakage.[1]

PVG-12.4 Safety valve discharge capacity shall be determined from the formula:

$$W = CKAP\ M/T$$

where

W = flow of vapor lb/hr

C = constant for vapor which is a function of the ratio of Specific Heats $k = Cp/Cv$ (see Fig. PVG-12)
Note: Where k is not known, $k = 1.001$.

[1]Users are warned that a rupture disk will not burst at its designed pressure if back pressure builds up in the space between the disk and the safety valve which will occur should leakage develop in the rupture disk due to corrosion or other cause.

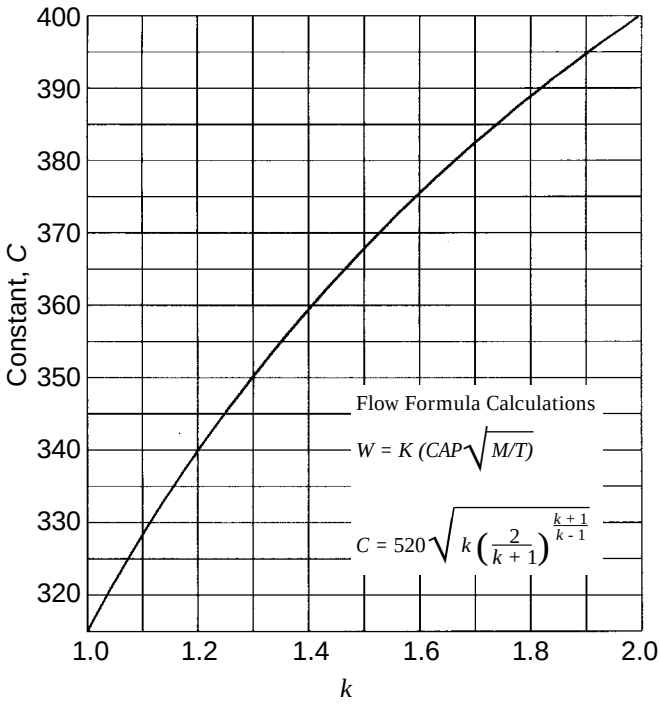


FIG. PVG-12 CONSTANT C FOR VAPOR RELATED TO RATIO OF SPECIFIC HEATS (K=CP/CV)

K = coefficient of discharge for the design
A = discharge area of safety valve, sq in.
P = (set pressure x 1.03) + Atmosphere Pressure, psia
M = molecular weight
T = absolute temperature at inlet, F + 460

PVG-12.5 Safety valves for organic fluid vaporizers shall be tested and certified under PG-69, and they shall be stamped with the rated relieving capacity in pounds per hour at coincident temperature as determined in PVG-12.4. The fluid identification shall be stamped on the nameplate.

PVG-12.6 The required minimum safety valve relieving capacity shall be determined from the formula:

$$W = \frac{C \times H \times 0.75}{h}$$

where
h = latent heat of heat transfer fluid at relieving pressure, Btu/lb
W = weight of organic fluid vapor generated per hour, lb
C = maximum total weight or volume of fuel burned per hour, lb or cu ft
H = heat of combustion of fuel, Btu/lb or Btu/cu ft (see A-17)

The sum of the safety valve capacities marked on the valves shall be equal to or greater than W.

PFT-44 OPENING BETWEEN BOILER AND SAFETY VALVE

The opening or connection between the boiler and safety valve shall have at least the area of the valve inlet.

After the boiler Manufacturer provides for the opening required by the Code, a bushing may be inserted in the opening in the shell to suit a safety valve that will have the capacity to relieve all the steam that can be generated in the boiler and which will meet the Code requirements.

No valve of any description shall be placed between the required safety valve or safety relief valve or valves and the boiler, or 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 thereinto and shall be as short and straight as possible and so arranged as to avoid undue stresses on the valve or valves.

NOTES:

EXCERPTS FROM
ASME CODE
SECTION IV

NOTES:

ARTICLE 4
PRESSURE RELIEVING DEVICES

HG-400 PRESSURE RELIEVING VALVE REQUIREMENTS

HG-400.1 Safety Valve Requirements for Steam Boilers

(a) Each steam boiler shall have one or more officially rated safety valves that are identified with the V or HV Symbol of the spring pop type adjusted and sealed to discharge at a pressure not to exceed 15 psi (103 kPa).

(b) No safety valve for a steam boiler shall be smaller than NPS 1/2 (DN 15). No safety valve shall be larger than NPS 4 1/2 (DN 115). The inlet opening shall have an inside diameter equal to, or greater than, the seat diameter.

(c) The minimum relieving capacity of valve or valves shall be governed by the capacity marking on the boiler called in HG-530.

(d) The minimum valve capacity in pounds per hour shall be the greater of that determined by dividing the maximum Btu output at the boiler nozzle obtained by the firing of any fuel for which the unit is installed by 1000, or shall be determined on the basis of the pounds of steam generated per hour per square foot of boiler heating surface as given in Table HG-400.1. For cast iron boilers constructed to the requirements of Part HC, the minimum valve capacity shall be determined by the maximum output method. In many cases a greater relieving capacity of valves will have to be provided than the minimum specified by these rules. In every case, the requirement of HG-400.1(e) shall be met.

(e) The safety valve capacity for each steam boiler shall be such that with the fuel burning equipment installed, and operated at maximum capacity, the pressure cannot rise more than 5 psi (35 kPa) above the maximum allowable working pressure.

(f) When operating conditions are changed, or additional boiler heating surface is installed, the valve capacity shall be increased, if necessary, to meet the new conditions and be in accordance with HG-400.1(e).

TABLE HG-400.1
MINIMUM POUNDS OF STEAM PER HOUR PER SQUARE FOOT OF HEATING SURFACE

Boiler Heating Surface	Firetube Boilers	Watertube Boilers
Hand fired	5	6
Stoker fired	7	8
Oil, gas, or pulverized fuel fired	8	10
Waterwall heating surface:		
Hand fired	8	8
Stoker fired	10	12
Oil, gas, or pulverized fuel fired	14	16

GENERAL NOTES:
(a) When a boiler is fired only by a gas having a heat value not in excess of 200 Btu/cu ft., the minimum safety valves or safety relief valve relieving capacity may be based on the values given for hand fired boilers above.
(b) The minimum safety valve or safety relief valve relieving capacity for electric boilers shall be 3 1/2 lb/hr/kw input.
(c) For heating surface determination, see HG-403.

The additional valves required, on account of changed conditions, may be installed on the outlet piping provided there is no intervening valve.

HG-400.2 Safety Relief Valve Requirements for Hot Water Boilers

(a) Each hot water heating or supply boiler shall have at least one officially rated safety relief valve, of the automatic reseating type, identified with the V or HV Symbol, and set to relieve at or below the maximum allowable working pressure of the boiler.

(b) Hot water heating or supply boilers limited to a water temperature not in excess of 210ºF (99ºC) may have, in lieu of the valve(s) specified in (a) above, one or more officially rated temperature and pressure safety relief valves of the automatic reseating type identified with the HV symbol, and set to relieve at or below the maximum allowable working pressure of the boiler.

(c) When more than one safety relief valve is used on either hot water heating or hot water supply boilers, the additional valves shall be officially rated and may have a set pressure within a range not to exceed 6 psi (42 kPa), above the maximum allowable working pressure of the boiler up to and including 60 psi (414 kPa), and 5% for those having a maximum allowable working pressure exceeding 60 psi (414 kPa).

(d) No safety relief valve shall be smaller than NPS 3/4 (DN 20) nor larger than NPS 4 1/2 (DN 115) except that boilers having a heat input not greater than 15,000 Btu/hr (4.4 kW) may be equipped with a rated safety relief valve of NPS 1/2 (DN 15).

(e) The required steam relieving capacity, in pounds per hour, of the pressure relieving device or devices on a boiler shall be the greater of that determined by dividing the maximum output in Btu at the boiler nozzle obtained by the firing of any fuel for which the unit is installed by 1000, or shall be determined on the basis of pounds of steam generated per hour per square foot of boiler heating surface as given in Table HG-400.1. For cast iron boilers constructed to the requirements of Part HC, the minimum valve capacity shall be determined by the maximum output method. In many cases a greater relieving capacity of valves

will have to be provided than the minimum specified by these rules. In every case, the requirements of HG-400.2(g) shall be met.

(f) When operating conditions are changed, or additional boiler heating surface is installed, the valve capacity shall be increased, if necessary, to meet the new conditions and shall be in accordance with HG-400.2(g). The additional valves required, on account of changed conditions, may be installed on the outlet piping provided there is no intervening valve.

(g) Safety relief valve capacity for each boiler with a single safety relief valve shall be such that, with the fuel burning equipment installed and operated at maximum capacity, the pressure cannot rise more than 10% above the maximum allowable working pressure. When more than one safety relief valve is used, the overpressure shall be limited to 10% above the set pressure of the highest set valve allowed by HG-400.2(a).

HG-400.3 Safety and Safety Relief Valves for Tanks and Heat Exchangers

(a) Steam to Hot Water Supply. When a hot water supply is heated indirectly by steam in a coil or pipe within the service limitations set forth in HG-101, the pressure of the steam used shall not exceed the safe working pressure of the hot water tank, and a safety relief valve at least NPS 1 (DN 25), set to relieve at or below the maximum allowable working pressure of the tank, shall be applied to the tank.

(b) High Temperature Water to Water Heat Exchanger.[1] When high temperature water is circulated through the coils or tubes of a heat exchanger to warm water for space heating or hot water supply, within the service limitations set forth in HG-101, the heat exchanger shall be equipped with one or more officially rated safety relief valves that are identified with the V or HV Symbol, set to relieve at or below the maximum allowable working pressure of the heat exchanger, and of sufficient rated capacity to prevent the heat exchanger pressure from rising more than 10% above the maximum allowable working pressure of the vessel.

(c) High Temperature Water to Steam Heat Exchanger.[1] When high temperature water is circulated through the coils or tubes of a heat exchanger to generate low pressure steam, within the service limitations set forth in HG-101, the heat exchanger shall be equipped with one or more officially rated safety valves that are identified with the V or HV Symbol, set to relieve at a pressure not to exceed 15 psi (103 kPa), and of sufficient rated capacity to prevent the heat exchanger pressure from rising more than 5 psi (35 kPa) above the maximum allowable working pressure of the vessel. For heat exchangers requiring steam pressures greater than 15 psi (103 kPa), refer to Section I or Section VIII, Division 1.

[1]Suggested installation practices for the secondary side of heat exchangers.

HG-401 MINIMUM REQUIREMENTS FOR SAFETY AND SAFETY RELIEF VALVES

HG-401.1 Mechanical Requirements

(a) The inlet opening shall have an inside diameter approximately equal to, or greater than, the seat diameter. In no case shall the maximum opening through any part of the valve be less than 1/4 in. (6 mm) in diameter or its equivalent area.

(b) Safety relief valves officially rated as to capacity shall have pop action when tested by steam.

(c) O-rings or other packing devices when used on the stems of safety relief valves shall be so arranged as not to affect their operation or capacity.

(d) The design shall incorporate guiding arrangements necessary to insure consistent operation and tightness. Excessive lengths of guiding surfaces should be avoided. Bottom guided designs are not permitted on safety relief valves.

(e) Safety valves shall have a controlled blowdown of 2 psi to 4 psi (13.8 kPa to 28 kPa) and this blowdown need not be adjustable.

(f) Safety valves shall be spring loaded. 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.

(g) There shall be a lifting device and a mechanical connection between the lifting device and the disk capable of lifting the disk from the seat a distance of at least 1/16 in. (1.6 mm) with no pressure on the boiler.

(h) A body drain below seat level shall be provided by the Manufacturer for all safety valves and safety relief valves, except that the body drain may be omitted when the valve seat is above the bottom of the inside diameter of the discharge piping. For valves exceeding NPS 2 1/2 (DN 65) the drain hole or holes shall be tapped not less than NPS 3/8 (DN 10). For valves NPS 2 1/2 (DN 65) or smaller, the drain hole shall not be less than 1/4 in. (6 mm) in diameter. Body drain connections shall not be plugged during or after field installation. In safety relief valves of the diaphragm type, the space above the diaphragm shall be vented to prevent a buildup of pressure above the diaphragm. Safety relief valves of the diaphragm type shall be so designed that failure or deterioration of the diaphragm material will not impair the ability of the valve to relieve at the rated capacity.

(i) In the design of the body of the valve consideration shall be given to minimizing the effects of water deposits.

(j) Valves shall be provided with wrenching surfaces to allow for normal installation without damaging operating parts.

(k) The set pressure tolerances plus or minus, of safety valves shall not exceed 2 psi (13.8 kPa), and for safety relief

valves shall not exceed 3 psi (20.6 kPa) for pressures up to and including 60 psig (414 kPa) and 5% for pressures above 60 psig (414 kPa).

(l) Safety valves shall be arranged so that they cannot be reset to relieve a higher pressure than the maximum allowable working pressure of the boiler.

HG-401.2 Material Selection

(a) Cast iron seats and disks are not permitted.

(b) Adjacent sliding surfaces such as guides and disks shall both be of corrosion resistant material.

(c) Springs of corrosion resistant material or having a corrosion resistant coating are required.

(d) Material for seats and disks should be such as to provide a reasonable degree of resistance to steam cutting.

(e) Material for valve bodies and bonnets or their corresponding metallic pressure containing parts shall be listed in Section II, except that in cases where manufacturer desires to make use of materials other than those listed in Section II, he shall establish and maintain specifications requiring equivalent control of chemical and physical properties and quality.

(f) Synthetic disk inserts of O-ring or other types if used shall be compatible with the maximum design temperature established for the valve.

(g) No materials liable to fail due to deterioration or vulcanization when subjected to saturated steam temperature corresponding to capacity test pressure shall be used.

HG-401.3 Manufacture and Inspection

(a) A Manufacturer shall demonstrate to the satisfaction of an ASME designee that his manufacturing, production, and testing facilities and quality control procedures will insure close agreement between the performance of random production samples and the performance of those valves submitted for capacity certification.

(b) Manufacturing, inspection, and test operations including capacity are subject to inspections at any time by an ASME designee.

(c) A Manufacturer may be granted permission to apply the HV Code Symbol to production pressure relief valves capacity certified in accordance with HG-402.3 provided the following tests are successfully completed. This permission shall expire on the fifth anniversary of the date it is initially granted. The permission may be extended for 5 year periods if the following tests are successfully repeated within the 6 month period before expiration.

(1) 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.

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

(3) Should any valve fail to relieve at or above its certified capacity or should it fail to meet performance requirements of this Section, the test shall be repeated at the rate of two replacement valves, selected in accordance with HG-401.3(c)(1), for each valve that failed.

(4) Failure of any of the replacement valves to meet the 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 shall demonstrate the cause of such deficiency and the action taken to guard against future occurrence, and the requirements of HG-401.3(c) above shall apply.

(d) Safety valves shall be sealed in a manner to prevent the valve from being taken apart without breaking the seal. Safety relief valves shall be set and sealed so that they cannot be reset without breaking the seal.

HG-401.4 Manufacturer's Testing

(a) Every safety valve shall be tested to demonstrate its popping point, blowdown, and tightness. Every safety relief valve shall be tested to demonstrate its opening point and tightness. Safety valves shall be tested on steam or air and safety relief valves on water, steam, or air. When the blowdown is nonadjustable, the blowdown test may be performed on a sampling basis.

(b) A Manufacturer shall have a well-established program for the application, calibration, and maintenance of test gages.

*(c)*Testing time on safety valves shall be sufficient, depending on size and design, to insure that test results are repeatable and representative of field performance.

(d) Test fixtures and test drums shall be of adequate size and capacity to assure representative pop action and accuracy of blowdown adjustment.

(e) A tightness test shall be conducted at maximum expected operating pressure, but not at a pressure exceeding the reseating pressure of the valve.

HG-401.5 Design Requirements. At the time of the submission of valves for capacity certification, or testing in accordance with this Section, the ASME Designee has the authority to review the design for conformity with the requirements of this Section, and to reject or require modification of designs which do not conform, prior to capacity testing.

HG402 DISCHARGE CAPACITIES OF SAFETY AND SAFETY RELIEF VALVES

A99 **HG-402.1 Valve Markings.** Each safety or safety relief valve shall be plainly marked with the required data by the Manufacturer in such a way that the markings will not be obliterated in service. The markings shall be stamped, etched, impressed, or cast on the valve or on a nameplate, which shall be securely fastened to the valve.

(a) The markings shall include the following:

(1) the name or an acceptable abbreviation of the Manufacturer;

(2) Manufacturer's design or type number;

(3) NPS size ____ in. (the nominal pipe size of the valve inlet);

(4) set pressure ____ psi;

(5) capacity ____ lb/hr, or capacity ____ Btu/hr in accordance with HG-402.7(a);

(6) year built or, alternatively, a coding may be marked on the valves such that the valve Manufacturer can identify the year the valve was assembled and tested; and

(7) ASME Symbol as show in Fig. HG-402.

(b) Nameplates of safety or safety-relief valves may be marked solely in metric units under the following conditions:

(1) The pressure-relief device will be installed in a location where metric units are required or accepted by local authorities, if any.

(2) Metric units shall be those required by the user when not mandated by enforcement authorities.

(3) The Manufacturer's quality control system shall provide the conversion from U.S. customary units to the metric units that will be marked on the nameplate.

HG-402.2 Authorization to Use ASME Stamp

Each safety valve to which the Code Symbol (Fig. HG-402) is to be applied shall be produced by a Manufacturer and/or Assembler who is in possession of a valid Certificate of Authorization (See HG-540)

98 **HG-402.3 Determination of Capacity to Be Stamped on Valves.** The Manufacturer of the valves that are to be stamped with the Code symbol shall submit valves for testing to a place where adequate equipment and personnel are available to conduct pressure and relieving-capacity tests which shall be made in the presence of and certified by an authorized observer. The place, personnel, and authorized observer shall be approved by the Boiler and Pressure Vessel Committee. The valves shall be tested in one of the following three methods:

(a) Coefficient Method. Tests shall be made to determine the lift, popping, and blowdown pressures, and the capacity of at least three valves each of three representative sizes (a total of nine valves). Each valve of a given size shall be set at a different pressure. However, safety valves for steam boilers shall have all nine valves set at 15 psig (103 kPa). A coefficient shall be established for each test as follows:

$$K_D = \frac{\text{Actual steam flow}}{\text{Theoretical steam flow}} = \text{Coefficient of discharge}$$

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. The stamped capacity of all sizes and pressures shall not exceed the value determined from the following formulas:

For 45 deg. seat,

$$W = 51.5\,\pi DLP \times 0.707K$$

For flat seat,

$$W = 51.5\,\pi DLPK$$

For nozzle,

$$W = 51.5\,APK$$

Where

W = weight of steam/hr, lb.
D = seat diameter, in.
L = lift, in.
P = (1.10 x set pressure + 14.7) psia for hot water applications or
= (5.0 psi + 15 psi set + 14.7) psia for steam boilers
K = coefficient of discharge for the design
A = nozzle-throat area, sq in.

NOTE: The maximum and minimum coefficient determined by the tests of a valve design shall not vary more than +-5% from the average. If one or more tests are outside the acceptable limits, one valve of the Manufacturer's choice shall be replaced with another valve of the same size and pressure setting or by a modification of the original valve. Following this test a new average coefficient shall be calculated, excluding the replaced the valve test. If one or more tests are now outside the acceptable limits, as determined by the new average coefficient, a valve of the Manufacturer's choice must be replaced by two valves of the same size and pressure as the rejected valve. A new average coefficient, including the replacement valves, shall be calculated. If any valve, excluding the two replaced valves, now falls outside the acceptable limits, the tests shall be considered unsatisfactory.

FIG. HG-402 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD

(b) 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 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 that cover the range available at the certified test facility that shall conduct the tests. The capacities shall be based on these four tests as follows.

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

$$\text{slope} = W/P = \frac{\text{measured capacity}}{\text{absolute flow pressure, psia}}$$

All values derived from the testing must fall within $\pm$5% of the average value:

minimum slope = 0.95 x average slope

maximum slope = 1.05 x 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.

(2) 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

stamped capacity ≤ rated slope x (1.10 x set pressure + 14.7) psia for hot water applications

(c)Three-Valve Method. If a Manufacturer wishes to apply the Code Symbol to steam safety valves or safety relief valves of one or more sizes of a design set at one pressure, he shall submit three valves of each size of each design set at one pressure for testing and the stamped capacity of each size shall not exceed 90% of the average capacity of the three valves tested.

NOTE: The discharge capacity as determined by the test of each valve tested shall not vary by more than +-5% of the average capacity of the three valves tested. If one of the three valve tests falls outside of the limits, it may be replaced by two valves and a new average calculated based on all four valves, excluding the replaced valve.

HG-402.4 Pressures at Which Capacity Tests Shall Be Conducted. Safety valves for steam boilers shall be tested for capacity at 5 psi (35 kPa) over the set pressure for which the valve is set to operate. Capacity certification tests of safety relief valves for hot water heating and hot water supply boilers shall be conducted at 110% of the pressure for which the valve is set to operate.

HG-402.5 Opening Tests of Temperature and Pressure Safety Relief Valves. For the purpose of determining the set (opening) pressure, the test medium shall be room temperature water. The actual set pressure is defined as the pressure at the valve inlet when the flow rate through the valve is 40 cc/min. Capacity tests shall be conducted with steam (see HG-402.7) at a pressure 10% above the actual water set pressure. For production capacity check tests, the rated capacity shall be based on the actual water set pressure.

HG-402.6 Capacity Tests of Temperature and Pressure Safety Relief Valves. For the purpose of determining the capacity of temperature and pressure safety relief valves, dummy elements of the same size and shape as the regularly applied thermal element shall be substituted and the relieving capacity shall be based on the pressure element only. Valves selected to meet the requirements of production testing, HG-401.3, shall have their temperature elements deactivated by the Manufacturer prior to or at the time of capacity testing.

HG-402.7 Fluid Medium for Capacity Tests. The tests shall be made with dry saturated steam. For test purposes the limits of 98% minimum quality and 20ºF (11ºC) maximum superheat shall apply. Correction from within these limits may be made to the dry saturated condition. The relieving capacity shall be measured by condensing the steam or with a calibrated steam flowmeter.

(a) To determine the discharge capacity of safety relief valves in terms of Btu, the relieving capacity in pounds for steam per hour W is multiplied by 1000.

HG-402.8 Where and by Whom Capacity Tests Shall be Conducted

(a) Tests shall be conducted at a place where the testing facilities, methods, procedures, and person supervising the tests (Authorized Observer) meet the applicable requirements of ASME PTC 25-1994. The tests shall be made under the supervision of and certified by an Authorized Observer. The testing facilities, methods, procedures, and qualifications of the Authorized Observer shall be subject to the acceptance of ASME on recommendation of an ASME Designee. Acceptance of the testing facility is subject to review within each 5 year period.

(b) Capacity test data reports for each valve model, type, and size, signed by the Manufacturer and the Authorized Observer witnessing the tests, shall be submitted to the ASME Designee for review and acceptance.[2]

NOTE: When changes are made in the design, capacity certification tests shall be repeated.

[2]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 Avenue, Columbus, OH 43229

HG-402.9 Test Record Data Sheet. A data sheet for each valve shall be filled out and signed by the authorized observer witnessing the test. Such data sheet will be the manufacturer's authority to build and stamp valves of corresponding design and construction. 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.

NOTE: See HG-512 for safety and safety relief valve accumulation test requirements. See HG-701 for safety and safety relief valve installation requirements.

HG-403 HEATING SURFACE

The heating surface shall be computed as follows.

(a) 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.

(b) Boiler heating surface and other equivalent surface outside the furnace shall be measured circumferentially plus any extended surface.

(c) Waterwall heating surface and other equivalent surface within the furnace shall be measured as the projected tube area (diameter x 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 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.

HG-405 TEMPERATURE AND PRESSURE SAFETY RELIEF VALVES

The thermal sensing elements for temperature and pressure safety relief valves shall be so designed and constructed that they will not fail in any manner which could obstruct flow passages or reduce capacities of the valves when the elements are subjected to saturated steam temperature corresponding to capacity test pressure. Temperature and pressure safety relief valves incorporating these elements shall comply with a nationally recognized standard.[3]

HG-512 SAFETY AND SAFETY RELIEF VALVE ACCUMULATION TESTS

If the safety valve or safety relief valve capacity cannot be computed or if it is desirable to prove the computations, it may be checked in any one of the following ways, and if found insufficient, additional capacity shall be provided:

(a) by making an accumulation test, that is, by shutting off all discharge outlets from the boiler and forcing the fires to the maximum, the safety valve equipment shall be sufficient to prevent an excess pressure beyond the specified in HG-400.1(f) and HG-400.2(f);

(b) by measuring the maximum amount of fuel that can be burned, and computing the corresponding evaporative capacity upon the basis the heating value of the fuel. (See B-100, B-101, and B-102.)

[3]An example of a nationally recognized standard is ANSI Z21.22, Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems.

ARTICLE 7
INSTALLATION REQUIREMENTS

HG-701 MOUNTING SAFETY AND SAFETY RELIEF VALVES

HG-701.1 Permissible Mounting. Safety valves and safety relief valves shall be located in the top or side[1] of the boiler. They shall be connected directly to a tapped or flanged opening in the boiler, to a fitting connected to the boiler by a short nipple, to a Y-base, or to a valveless header connecting steam or water outlets on the same boiler. Coil or header type boilers shall have the safety valve or safety relief valve located on the steam or hot water outlet end. Safety valves and safety relief valves shall be installed with their spindles vertical. The opening or connection between the boiler and any safety valve or safety relief valve shall have at least the area of the valve inlet.

HG-701.2 Requirements for Common Connections for Two or More Valves

(a) When a boiler is fitted with two or more safety valves on one connection, this connection shall have a cross-sectional area not less than the combined areas of inlet connections of all the safety valves with which it connects.

(b) When a Y-base is used, the inlet area shall be not less than the combined outlet areas. When the size of the boiler requires a safety valve or safety relief valve larger than 4½ in. (115 mm) in diameter, two or more valves having the required combined capacity shall be used. When two or more valves are used on a boiler, they may be single, directly attached, or mounted on a Y-base.

HG-701.3 Threaded Connections. A threaded connection may be used for attaching a valve.

HG-701.4 Prohibited Mountings. Safety and safety relief valves shall not be connected to an internal pipe in the boiler.

[1]The top or side of the boiler shall mean the highest practicable part of the boiler proper but in no case shall the safety valve be located below the normal operating level and in no case shall the safety relief valve be located below the lowest permissible water level.

HG-701.5 Use of Shutoff Valves Prohibited. No shutoff of any description shall be placed between the safety or safety relief valve and the boiler, or on discharge pipes between such valves and the atmosphere.

HG-701.6 SAFETY AND SAFETY RELIEF VALVE DISCHARGE PIPING

(a) A discharge pipe shall be used. Its internal cross-sectional area shall be not less than the full area of the valve outlet or of the total of the valve outlets discharging thereinto and shall be as short and straight as possible and so arranged as to avoid undue stress on the valve or valves. A union may be installed in the discharge piping close to the valve outlet. When an elbow is placed on a safety or safety relief valve discharge pipe, it shall be located close to the valve outlet downstream of the union.

(b) The discharge from safety or safety relief valves shall be so arranged that there will be no danger of scalding attendants. The safety or safety relief valve discharge shall be piped away from the boiler to the point of discharge, and there shall be provisions made for properly draining the piping. The size and arrangement of discharge piping shall be independent of other discharge piping and shall be such that any pressure that may exist or develop will not reduce the relieving capacity of the relieving devices below that required to protect the boiler.

HG-701.7 Temperature and Pressure Safety Relief Valves. Hot water heating or supply boilers limited to a water temperature of 210ºF (99ºC) may have one or more officially rated temperature and pressure safety relief valves installed. The requirements of HG-701.1 through HG-701.6 shall be met, except as follows:

(a) A Y-type fitting shall not be used.

(b) If additional valves are used they shall be temperature and pressure safety relief valves.

(c) When the temperature and pressure safety relief valve is mounted directly on the boiler with no more than 4 in. (102 mm) maximum interconnecting piping, the valve may be installed in the horizontal position with the outlet pointed down.

ARTICLE 8
INSTALLATION REQUIREMENTS

HLW-800 SAFETY RELIEF VALVES

HLW-800.1 Safety Relief Valve Requirements for Water Heaters

(a) Each water heater shall have at least one officially rated temperature and pressure safety relief valve or at least one officially rated safety relief valve. The valve(s) shall be marked with the ASME Code Symbol V or HV to evidence compliance with the construction and rating requirements of the ASME Boiler and Pressure Vessel Code. No safety relief valve shall be smaller than NPS 3/4 (DN 20).

(b) The pressure setting shall be less than or equal to the maximum allowable working pressure of the water heater. However, if any of the other components in the hot water supply system (such as valves, pumps, expansion or storage tanks, or piping) have a lesser working pressure rating than the water heater, the pressure setting for the relief valve(s) shall be based upon the component with the lowest maximum allowable working pressure rating. If more than one safety relief valve is used, the additional valve(s) may be set within a range not to exceed 10% over the set pressure of the first valve.

(c) The required relieving capacity in Btu/hr of the safety relief valve shall not be less than the maximum allowable input unless the water heater is marked with the rated burner input capacity of the water heater on the casing in a readily visible location, in which case the rated burner input capacity may be used on a basis for sizing the safety relief valves. The relieving capacity for electric water heaters shall be 3500 Btu/hr (1.0 kW) per kW of input. In every case, the following requirements shall be met. Safety relief valve capacity for each water heater shall be such that with the fuel burning equipment installed and operated at maximum capacity the pressure cannot rise more than 10% of maximum allowable working pressures.

(d) If operating conditions are changed or additional heater heating surface is installed, the safety relief valve capacity shall be increased, if necessary, to meet the new conditions and shall be in accordance with the above provisions. In no case shall the increased input capacity exceed the maximum allowable input capacity. The additional valves required, on account of changed conditions, may be installed on the outlet piping provided there is no intervening valve.

HLW-801 MOUNTING SAFETY RELIEF VALVES

HLW-801.1 Installation. Safety relief valves shall be installed by either the installer or the manufacturer before a water heater is placed in operation.

HLW-801.2 Permissible Mountings. Safety relief valves shall be connected to the top of water heaters or directly to a tapped or flanged opening in the water heater, to a fitting connected to the water heater by short nipple, to a Y-base, or to a valveless header connecting water outlets on the same heater. Safety relief valves shall be installed with their spindles upright and vertical with no horizontal connecting pipe, except that, when the safety relief valve is mounted directly on the water heater vessel with no more than 4 in. (102 mm) maximum interconnecting piping, the valve may be installed in the horizontal position with the outlet pointed down. The center line of the safety relief valve connection shall be no lower than 4 in. (102 mm) from the top of the shell. No piping or fitting used to mount the safety relief valve shall be of a nominal pipe size less than that of the valve inlet.

HLW-801.3 Requirements for Common Connection for Two or More Valves

(a) When a water heater is fitted with two or more safety relief valves on one connection, this connection shall have a cross-sectional area not less than the combined areas of inlet connections of all the safety relief valves with which it connects.

(b) When a Y-base is used, the inlet area shall be not less than the combined outlet areas. When the size of the water heater requires a safety relief valve larger than 4 1/2 in. (114 mm) diameter, two or more valves having the required combined capacity shall be used. When two or more valves are used on a water heater, they may be single, directly attached, or mounted on a Y-base.

HLW-801.4 Threaded Connections. A threaded connection may be used for attaching a valve.

HLW-801.5 Prohibited Mounting. Safety relief valves shall not be connected to an internal pipe in the water heater or a cold water feed line connected to the water heater.

HLW-801.6 Use of Shutoff Valves Prohibited. No shutoff of any description shall be placed between the safety relief valve and the water heater, or on discharge pipes between such valves and the atmosphere.

HLW-801.7 Safety Relief Valve Discharge Piping

(a) When a discharge pipe is used, its internal cross-sectional area shall be not less than the full area of the valve outlet or of the total of the valve outlets discharging thereinto, and shall be as short and straight as possible and so arranged as to avoid undue stress on the valve or valves. When an elbow is placed on a safety relief discharge pipe, it shall be located close to the valve outlet.

(b) The discharge from safety relief valves shall be so arranged that there will be no danger of scaling attendants. When the safety relief valve discharge is piped away from the water heater to the point of discharge, there shall be provisions for properly draining the piping and valve body. The size and arrangement of discharge piping shall be such that any pressure that may exist or develop will not reduce the relieving capacity of the relieving devices below that required to protect the water heater.

EXCERPTS FROM
ASME CODE
SECTION VIII

NOTES:

PRESSURE RELIEF DEVICES

98 UG-125 GENERAL

(a) All pressure vessels within the Scope of this Division, irrespective of size or pressure, shall be provided with pressure relief devices in accordance with the requirements of UG-125 through UG-137. It is the responsibility of the user to ensure that the required pressure relief devices are properly installed prior to initial operation. These pressure relief devices need not be supplied by the vessel Manufacturer. Unless otherwise defined in this Division, the definitions relating to pressure relief devices in Section 2 of ASME PTC 25 shall apply.

(b) An unfired steam boiler, as defined in U-1(g), shall be equipped with pressure relief devices required by Section I insofar as they are applicable to the service of the particular installation

(c) All pressure vessels other than unfired steam boilers shall be protected by a pressure relief device that shall prevent the pressure from rising more than 10% or 3psi, whichever is greater, above the maximum allowable working pressure except as permitted in (1) and (2) below. (See UG-134 for pressure settings.)

(1) When multiple pressure relief devices are provided and set in accordance with UG-134(a), they shall prevent the pressure from rising more than 16% or 4 psi, whichever is greater, above the maximum allowable working pressure.

(2) Where an additional hazard can be created by exposure of a pressure vessel to fire or other unexpected sources of external heat, supplemental pressure relief devices shall be installed to protect against excessive pressure. Such supplemental pressure relief devices shall be capable of preventing the pressure from rising more than 21% above the maximum allowable working pressure. The same pressure relief devices may be used to satisfy the capacity requirements of (c) or (c)(1) above and this paragraph provided the pressure setting requirements of UG-134(a) are met.

(3) Pressure relief devices, intended primarily for protection against exposure of a pressure vessel to fire or other unexpected sources of external heat installed on vessels having no permanent supply connection and used for storage at ambient temperatures of nonrefrigerated liquefied compressed gases,[41] are excluded from the requirements of (c)(1) and (c)(2) above, provided:

(a) the pressure relief devices are capable of preventing the pressure from rising more than 20% above the maximum allowable working pressure of the vessels;

(b) the set pressure marked on these devices shall not exceed the maximum allowable working pressure of the vessels;

(c) the vessels have sufficient ullage to avoid a liquid full condition;

(d) the maximum allowable working pressure of the vessels on which these pressure relief devices are installed is greater than the vapor pressure of the stored liquefied compressed gas at the maximum anticipated temperature[42] that the gas will reach under atmospheric conditions; and

(e) pressure relief valves used to satisfy these provisions also comply with the requirements of UG-129(a)(5), UG-131(c)(2), and UG-134(d)(2).

(d) Pressure relief devices shall be constructed, located, and installed so that they are readily accessible for inspection, replacement, and repair so that they cannot be readily rendered inoperative (see Appendix M), and should be selected on the basis of their intended service.

(e) Pressure relief valves or nonreclosing pressure relief devices[43] may be used to protect against overpressure. Nonreclosing pressure relief devices may be used either alone or, if applicable, in combination with pressure relief valves on vessels.

NOTE: Use of nonclosing pressure relief devices of some types may be advisable on vessels containing substances that may render a pressure relief valve inoperative, where a loss of valuable material by leakage should be avoided, or where contamination of the atmosphere by leakage of noxious fluids must be avoided. The use of rupture disk devices may also be advisable when very rapid rates of pressure rise may be encountered.

(f) Vessels that are to operate completely filled with liquid shall be equipped with pressure relief devices designed for liquid service, unless otherwise protected against overpressure.

(g) The pressure relief devices required in (a) above need not be installed directly on a pressure vessel when the source of pressure is external to the vessel and is under such positive control that the pressure in the vessel cannot exceed the maximum allowable working pressure at the operating temperature except as permitted in (c) above (see UG-98).

NOTE: Pressure reducing valves and similar mechanical or electrical control instruments, except for pilot operated pressure relief valves as permitted in UG-126(b), are not considered as sufficiently positive in action to prevent excess pressures from being developed.

(h) Pressure relief valves for steam service shall meet the requirements of UG-131(b).

UG-126 PRESSURE RELIEF VALVES[44]

(a) Safety, safety relief, and relief valves shall be of the direct spring loaded type.

[41]For the purpose of these rules, gases are considered to be substances having a vapor pressure greater than 40 psia at 100ºF.

[42]Normally this temperature should not be less than 115ºF.

[43]A *pressure relief valve* is a pressure relief device which is designed to reclose and prevent the further flow of fluid after normal conditions have been restored. A *nonreclosing pressure relief device* is a pressure relief device designed to remain open after operation.

(b) Pilot operated pressure relief valves may be used, provided that the pilot is self-actuated and the main valve will open automatically at not over the set pressure and will discharge its full rated capacity if some essential part of the pilot should fail.

(c) The spring in a pressure relief valve shall not be set for any pressure more than 5% above or below that for which the valve is marked, unless the setting is within the spring design range established by the valve Manufacturer or is determined to be acceptable to the manufacturer. The initial adjustment shall be performed by the Manufacturer, his authorized representative, or an Assembler, and a valve data tag shall be provided that identifies the set pressure capacity and date. The valve shall be sealed with a seal identifying the Manufacturer, his authorized representative, or the Assembler performing the adjustment.

(d) The set pressure tolerances, plus or minus, of pressure relief valves shall not exceed 2 psi (13.8 kPa) for pressures up to and including 70 psi (483 kPa) and 3% for pressures above 70 psi (483 kPa).

UG-127 NONRECLOSING PRESSURE RELIEF DEVICES

(a) Rupture Disk Devices[45]

A99

(1) General. Every rupture disk shall have a marked burst pressure established by rules of UG-137(d)(3) within a manufacturing design range[46] at a specified disk temperature[47] and shall be marked with a lot[48] number. The burst pressure tolerance at the specified disk temperature shall not exceed ±2% psi (±13.8 kPa) for marked burst pressure up to and including 40 psi (276 kPa) and ±5% for marked burst pressure above 40 psi (276 kPa).

(2) Relieving Capacity. The rated flow capacity of a pressure relief system which uses a rupture disk device as the sole relief device shall be determined by a value calculated under the requirements of (a) using a coefficient of discharge or (b) using flow resistances below.

(a) When the rupture disk device discharges directly to atmosphere and

(1) is installed within eight pipe diameters from the vessel nozzle entry; and

(2) with a length of discharge pipe not greater than five pipe diameters from the rupture disk device; and

(3) the nominal diameters of the inlet and discharge piping are equal to or greater than the stamped NPS designator of the device,

the calculated relieving capacity of a pressure relief system shall not exceed a value based on the applicable theoretical flow equation [see UG-131(e)(2) and Appendix 11] for the various media multiplied by a coefficient of discharge K equal to 0.62. The area A in the theoretical flow equation shall be the minimum net flow area[49] as specified by the rupture disk device Manufacturer.

(b) The calculated capacity of any pressure relief system may be determined by analyzing the total system resistance to flow. This analysis shall take into consideration the flow resistance of the rupture disk device, piping and piping components including the exit nozzle on the vessels, elbows, tees, reducers, and valves. The calculation shall be made using accepted engineering practices for determining fluid flow through piping systems. This calculated relieving capacity shall be multiplied by a factor of 0.90 or less to allow for uncertainties inherent with this method. The certified flow resistance[50] K_R for the rupture disk device, expressed as the velocity head loss, shall be determined in accordance with UG-131(k) through (r).

(3) Application of Rupture Disks

(a) A rupture disk device may be used as the sole pressure relieving device on a vessel.

NOTE: When rupture disk devices are used, it is recommended that the design pressure of the vessel be sufficiently above the intended operating pressure to provide sufficient margin between operating pressure and rupture disk bursting pressure to prevent premature failure of the rupture disk due to fatigue or creep.

Application of rupture disk devices to liquid service should be carefully evaluated to assure that the design of the rupture disk device and the dynamic energy of the system on which it is installed will result in sufficient opening of the rupture disk.

(b) A rupture disk device may be installed between a pressure relief valve51 and the vessel provided:

[44] A *safety valve* is a pressure relief valve actuated by inlet static pressure and characterized by rapid opening or pop action. A *relief valve* is a pressure relief valve actuated by inlet static pressure which opens in proportion to the increase in pressure over the opening pressure. A *safety relief valve* is a pressure relief valve characterized by rapid opening or pop action, or by opening in proportion to the increase in pressure over the opening pressure, depending on application. A *pilot operated pressure relief valve* is a pressure relief valve in which the major relieving device is combined with an is controlled by a self-actuated auxiliary pressure relief valve.

[45] A *rupture disk device* is a nonreclosing pressure relief device actuated by inlet static pressure and designed to function by the bursting of a pressure containing disk. A *rupture disk* is the pressure containing and pressure sensitive element of a *rupture disk device*. Rupture disks may be designed in several configurations, such a plain flat, prebulged, or reverse buckling. A *rupture disk holder* is the structure which encloses and clamps the rupture disk in position.

[46] The *manufacturing design range* is a range of pressure within which the marked burst pressure must fall to be acceptable for a particular requirement as agreed upon between the rupture disk Manufacturer and the user or his agent.

[47] The specified disk temperature supplied to the rupture disk Manufacturer shall be the temperature of the disk when the disk is expected to burst.

[48] A *lot of rupture disks* is those disks manufactured of a material at the same time, of the same size, thickness, type, heat, and manufacturing process including heat treatment.

[49] The *minimum net flow area* is the calculated net area after a complete burst of the disk with appropriate allowance for any structural members which may reduce the net flow area through the rupture disk device. The net flow area for sizing purposes shall not exceed the nominal pipe size area of the rupture disk device.

[50] The *certified flow resistance* K_R is a dimensionless factor used to calculate the velocity head loss that results from the presence of a rupture disk device in a pressure relief system.

[51] Use of a rupture disk device in combination with a pressure relief valve shall be carefully evaluated to ensure that the media being handled and the valve operational characteristics will result in opening of the valve coincident with the bursting of the rupture disk.

(1) the combination of the pressure relief valve and the rupture disk device is ample in capacity to meet the requirements of UG-133(a) and (b);

(2) the marked capacity of a pressure relief valve (nozzle type) when installed with a rupture disk device between the inlet of the valve and the vessel shall be multiplied by a factor of 0.90 of the rated relieving capacity of the valve alone, or alternatively, the capacity of such a combination shall be established in accordance with (3) below;

(3) the capacity of the combination of the rupture disk device and the pressure relief valve may be established in accordance with the appropriate paragraphs of UG-132;

(4) the space between a rupture disk device and a pressure relief valve shall be provided with a pressure gage, a try cock, free vent, or suitable telltale indicator. This arrangement permits detection of disk rupture or leakage.[52]

(5) the opening[49] provided through the rupture disk, after burst, is sufficient to permit a flow equal to the capacity of the valve [(2) and (3) above], and there is no chance of interference with proper functioning of the valve; but in no case shall this area be less than the area of the inlet of the valve unless the capacity and functioning of the specific combination of rupture disk device and pressure relief valve have been established by test in accordance with UG-132.

(c) A rupture disk device may be installed on the outlet side[53] of a pressure relief valve which is opened by direct action of the pressure in the vessel provided:

(1) the pressure relief valve will not fail to open at its proper pressure setting regardless of any back pressure that can accumulate between the pressure relief valve disk and the rupture disk. The space between the pressure relief valve disk and the rupture disk shall be vented or drained to prevent accumulation of pressure, or suitable means shall be provided to ensure that an accumulation of pressure does not affect the proper operation of the pressure relief valve.[54]

(2) the pressure relief valve is ample in capacity to meet the requirements of UG-125(c);

(3) the marked burst pressure of the rupture disk at the specified disk temperature plus any pressure in the outlet piping shall not exceed the design pressure of the outlet portion of the pressure relief valve and any pipe or fitting between the valve and the rupture disk device. However, in no case shall the marked burst pressure of the rupture disk at the specified disk temperature plus any pressure in the outlet piping exceed the maximum allowable working pressure of the vessel or the set pressure of the pressure relief valve.

(4) the opening provided through the rupture disk device after breakage is sufficient to permit a flow equal to the rated capacity of the attached pressure relief valve without exceeding the allowable overpressure;

(5) any piping beyond the rupture disk cannot be obstructed by the rupture disk or fragment;

(6) the system is designed to consider the adverse effects of any leakage through the pressure relief valve or through the outlet side rupture disk device, to ensure system performance and reliability.[62]

(7) the bonnet of a balancing bellows or diaphragm type pressure relief valve shall be vented to prevent accumulation of pressure in the bonnet.

(b) Breaking Pin Device[55]

(1) Breaking pin devices shall not be used as single devices but only in combination between the pressure relief valve and the vessel.

(2) The space between a breaking pin device and a pressure relief valve shall be provided with a pressure gage, a try cock, a free vent, or suitable telltale indicator. This arrangement permits detection of breaking pin device operation or leakage.

(3) Each breaking pin device shall have a rated pressure and temperature at which the pin will break. The breaking pin shall be identified to a lot number and shall be guaranteed by the Manufacturer to break when the rated pressure, within the following tolerances, is applied to the device:

Rated Pressure, psi		
Minimum	Maximum	Tolerance, Plus or Minus, psi
30	150	5
151	275	10
276	375	15

(4) The rated pressure of the breaking pin plus the tolerance in psi shall not exceed 105% of the maximum allowable working pressure of the vessel to which it is applied.

[52]Users are warned that a rupture disk will not burst at its design pressure if back pressure builds up in the space between the disk and the pressure relief valve which will occur should leakage develop in the rupture disk due to corrosion or other cause.

[53]This use of a rupture disk device in series with the pressure relief valve is permitted to minimize the loss by leakage through the valve of valuable or of noxious or otherwise hazardous materials, and where a rupture disk alone or disk located on the inlet side of the valve is impracticable, or to prevent corrosive gases from a common discharge line from reaching the valve internals.

A99 [54]Users are warned that many types of pressure relief valves will not open at the set pressure if pressure builds up in the space between the pressure relief valve disk and the rupture disk device. A specially designed pressure relief valve such as a diaphragm valve, pilot operated valve, or a valve equipped with a balancing bellows above the disk may be required.

[55]A *breaking pin device* is a nonreclosing pressure relief device actuated by inlet static pressure and designed to function by the breakage of a load-carrying section of a pin which supports a pressure containing member. A *breaking pin* is the load-carrying element of a breaking pin device. A *breaking pin housing* is the structure which encloses the breaking pin mechanism. The material of the housing shall be listed in Section II and be permitted for use in this Division.

[56]The specified temperature supplied to the breaking pin manufacturer shall be the temperature of the breaking pin when an emergency condition exists and the pin is expected to break.

[62]Some adverse effects resulting from leakage may include obstructing the flow path, corrosion of pressure relief valve components, and undesirable bursts of the outlet side rupture disk.

(5) The rated pressure at the specified temperature[56] shall be verified by breaking two or more sample breaking pins from each lot of the same material and the same size as those to be used. The lot size shall not exceed 25. The test shall be made in a device of the same form and pressure dimensions as that in which the breaking pin is to be used.

(c) Spring Loaded Nonreclosing Pressure Relief Device

(1) A spring loaded nonreclosing pressure relief device, pressure actuated by means which permit the spring loaded portion of the device to open at the specified set pressure and remain open until manually reset, may be used provided the design of the spring loaded nonreclosing device is such that if the actuating means fail, the device will achieve full opening at or below its set pressure. Such a device may not be used in combination with any other pressure relief device. The tolerance on opening point shall not exceed ±5%.

(2) The calculated capacity rating of the spring loaded nonreclosing pressure relief device shall not exceed a value based on the applicable theoretical formula (see UG-131) for the various media, multiplied by: K = coefficient = 0.62.

The area A (square inches) in the theoretical formula shall be the flow area through the minimum opening of the spring loaded nonreclosing pressure relief device.

(3) In lieu of the method of capacity rating in (2) above, a Manufacturer may have the capacity of a spring loaded nonreclosing pressure relief device design certified in general accordance with the procedures of UG-131, as applicable.

UG-128 LIQUID PRESSURE RELIEF VALVES

Any liquid pressure relief valve used shall be at least NPS ½.

UG-129 MARKING

(a) Safety, Safety Relief, Relief, Liquid Pressure Relief, and Pilot Operated Pressure Relief Valves. Each safety, safety relief, relief, liquid pressure relief, and pilot operated pressure relief valve NPS ½ (DN 15) and larger shall be plainly marked by the Manufacturer or Assembler with the required data in such a way that the marking will not be obliterated in service. The marking may be placed on the valve or on a plate or plates that satisfy the requirements of UG-119:

(1) the name, or an acceptable abbreviation, of the Manufacturer and the Assembler;

(2) Manufacturer's design or type number;

(3) NPS size ____ (the nominal pipe size of the valve inlet);

(4) set pressure ____ psi, and if applicable per UG-136(d)(4), cold differential test pressure ____ psi.

(5) certified capacity (as applicable);

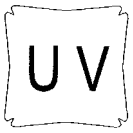


FIG. UG-129.1 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR PRESSURE RELIEF VALVES

(a) lb/hr of saturated steam at an overpressure of 10% or 3 psi (20.6 kPa), whichever is greater for valves certified on steam complying with UG-131(b); or

(b) gal/min of water at 70ºF (21ºC) at an overpressure of 10% or 3 psi (20.6 kPa), whichever is greater for valves certified on water; or

(c) SCFM [standard cubic feet per minute at 60ºF and 14.7 psia (16ºC and 101 kPa), or lb/min, of air at an overpressure of 10% or 3 psi (20.6 kPa), whichever is greater. Valves that are capacity certified in accordance with UG-131(c)(2) shall be marked "at 20% overpressure".

(d) In addition to one of the fluids specified above, the Manufacturer may indicate the capacity in other fluids (see Appendix 11).

(6) 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 or tested;

(7) ASME Symbol as shown in Fig. UG-129.1. The pilot of a pilot operated pressure relief valve shall be plainly marked by the Manufacturer or Assembler showing the name of the Manufacturer, the Manufacturer's design or type number, the set pressure in pounds per square inch, and the year built, or alternatively, a coding that the Manufacturer can use to identify the year built.

On valves smaller than NPS ½ (DN 15), the markings may be made on a metal tag attached by wire or adhesive meeting the requirements of UG-119 or other means suitable for the service conditions.

(b) Safety and safety relief valves certified for a steam discharging capacity under the provisions of Section I and bearing the official code Symbol Stamp of Section I for safety valves may be used on pressure vessels. The rated capacity in terms of other fluids shall be determined by the method of conversion given in Appendix 11. [See UG-131(h)].

(c) Pressure Relief Valves in Combination With Rupture Disk Devices. Pressure relief valves in combination with rupture disk devices shall be marked with the capacity as established in accordance with UG-127(a)(3)(b)(2) (using 0.90 factor) or the combination capacity factor established by test in accordance with UG-132(a) or (b), in addition to the marking of UG-129(a) and (f) below. The marking may be placed on the pressure relief valve or rupture disk device or on a plate or plates that satisfy the requirements of UG-119. The marking shall include the following:

(1) name of Manufacturer of valve;
(2) design or type number of valve;
(3) name of Manufacturer of rupture disk device;
(4) design or type number of rupture disk device;
(5) capacity or combination capacity factor;
(6) name of organization responsible for this marking. This shall be either the vessel user, vessel Manufacturer, rupture disk Manufacturer, or pressure relief valve Manufacturer.

(d) Pressure Relief Valves in Combination With Breaking Pin Devices. Pressure relief valves in combination with breaking pin devices shall be marked in accordance with (a) above. In addition, the rated pressure shall be marked on the breaking pin and the breaking pin housing.

(e) Rupture Disk Devices. Every rupture disk shall be plainly marked by the Manufacturer in such a way that the marking will not be obliterated in service. The rupture disk marking may be placed on the flange of the disk or on a metal tab that satisfies the requirements of UG-119. The marking shall include the following:

(1) the name or identifying trademark of the Manufacturer;
(2) Manufacturer's design or type number;
(3) lot number;
(4) disk material;
(5) size ____ (NPS of rupture disk holder);
(6) marked burst pressure ____ psi;
(7) specified disk temperature ____ °F;
(8) minimum net flow area ____ sq in.;
(9) certified flow resistance K_R ____ ;
(10) ASME symbol as shown in Fig. UG-129.2;
(11) year built, or alternatively, a coding may be marked on the rupture disk such that the rupture disk device Manufacturer can identify the year the rupture disk device was assembled and tested.

Items (1), (2), and (5) above and flow direction shall also be marked on the rupture disk holder.

(f) Spring Loaded Nonreclosing Pressure Relief Devices. Spring loaded nonreclosing pressure relief devices shall be marked in accordance with (a) above except that the Code Symbol Stamp is to be applied only when the capacity has been established and certified in accordance with UG-127(c)(3) and all other requirements of UG-130 have been met.

A99 UG-130 CODE SYMBOL STAMP

Each pressure relief device[57] to which the Code Symbol (see Figs. UG-129.1 and UG-129.2) will be applied shall have been fabricated or assembled by a Manufacturer or Assembler holding a valid Certificate of Authorization (UG-117) and capacity certified in accordance with the requirements of this Division.

[57]Vacuum relief devices are not covered by Code Symbol Stamp requirements.

FIG. UG-129.2 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR RUPTURE DISK DEVICES

UG-131 CERTIFICATION OF CAPACITY OF PRESSURE RELIEF DEVICES

(a) Before the Code Symbol is applied to any pressure relief device, the device Manufacturers shall have the capacity of their devices certified in accordance with the provisions of these paragraphs. For pressure relief valves, (b) through (j) below apply for rupture disk devices, (k) through (r) below apply except where noted.

(b)(1) Capacity certification tests for pressure relief valves for compressible fluids shall be conducted on dry saturated steam, or air, or gas. When dry saturated steam is used, the limits for test purposes shall be 98% minimum quality and 20ºF (11ºC) maximum superheat. Correction from within these limits may be made to the dry saturated condition. Pressure relief valves for steam service may be rated as above, but at least one valve of each series shall be tested on steam to demonstrate the steam capacity and performance.

(2) Capacity certification tests for pressure relief valves for incompressible fluids shall be conducted on water at a temperature between 40F and 125ºF (4ºC and 52ºC).

(c)(1) Capacity certification tests shall be conducted at a pressure which does not exceed the pressure for which the pressure relief valve is set to operate by more than 10% or 3 psi (20.6 kPa), whichever is greater, except as provided in (c)(2) below. Minimum pressure for capacity certification tests shall be at least 3 psi (20.6 kPa) above set pressure. The reseating pressure shall be noted and recorded.

(2) Capacity certification tests of pressure relief valves for use in accordance with UG-125(c)(3) may be conducted at a pressure not to exceed 120% of the stamped set pressure of the valve.

(3) (a) Pressure relief valves for compressible fluids having an adjustable blowdown construction shall be adjusted prior to testing so that the blowdown does not exceed 5% of the set pressure or 3 psi (20.6 kPa), whichever is greater.

(b) The blowdown of pressure relief valves for incompressible fluids and pressure relief valves for compressible fluids having nonadjustable blowdown shall be noted and recorded.

(4) Capacity certification of pilot operated pressure relief valves may be based on tests without the pilot valves installed, provided prior to capacity tests it has been demonstrated by test to the satisfaction of the Authorized

Observer that the pilot valve will cause the main valve to open fully at a pressure which does not exceed the set pressure by more than 10% or 3 psi (20.6 kPa), whichever is greater, and that the pilot valve in combination with the main valve will meet all the requirements of this Division.

(d)(1) A capacity certification test is required on a set of three valves for each combination of size, design, and pressure setting. The stamped capacity rating for each combination of design, size, and test pressure shall not exceed 90% of the average capacity of the three valves tested. The capacity for each set of three valves shall fall within a range of ±5% of the average capacity. Failure to meet this requirement shall be cause to refuse certification of that particular pressure relief valve design.

(2) 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 which 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) For compressible fluids, the slope *W/P* of the actual measured capacity versus the flow pressure for each test point shall be calculated and averaged:

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

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

minimum slope = 0.95 x average slope

maximum slope = 1.05 x 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

stamped capacity ≤ rated slope (1.10 x set pressure + 14.7) or (set pressure + 3 psi + 14.7), whichever is greater

For valves certified in accordance with (c)(2) above,

stamped capacity ≤ rated slope (1.20 x set pressure + 14.7) or (set pressure + 3 psi + 14.7), whichever is greater

(b) For incompressible fluids, the capacities shall be plotted on log-log paper against the differential (inlet minus discharge pressure) test pressure and a straight line drawn through these four points. If the four points do not establish a straight line, two additional valves shall be tested for each unsatisfactory point, with a limit of two unsatisfactory points. Any point that departs from the straight line by more than 5% should be considered an unsatisfactory point. The relieving capacity shall be determined from this line. The certified capacity shall not exceed 90% of the capacity taken from the line.

(e) Instead of individual capacity certification as provided in (d) above, a coefficient of discharge *K* may be established for a specific pressure relief valve design according to the following procedure.

(1) For each design, the pressure relief valve Manufacturer shall submit for test at least three valves for each of three different sizes (a total of nine valves) together with detailed drawings showing the valve construction. Each valve of a given size shall be set at a different pressure.

(2) Tests shall be made on each pressure relief valve to determine its capacity-lift, popping and blowdown pressures, and actual capacity in terms of the fluid used in the test. A coefficient KD shall be established for each test run as follows:

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

where actual flow is determined quantitatively by test, and theoretical flow is calculated by the appropriate formula which follows:

For tests with dry saturated steam,

$$W_T = 51.5AP$$

NOTE: For dry saturated steam pressures over 1500 psig and up to 3200 psig, the value of W_T, calculated by the above equation, shall be corrected by being multiplied by the following factors:

$$\left(\frac{0.1906P - 1000}{0.2292P - 1061} \right)$$

For tests with air,

$$W_T = 356AP \sqrt{\frac{M}{T}}$$

For tests with natural gas,

$$W_T = CAP \sqrt{\frac{M}{ZT}}$$

For tests with water,

$$W_T = 2407A\sqrt{(P-P_d)w}$$

where

W_T = theoretical flow, lb/hr
A = actual discharge area through the valve at developed lift, sq in.
P = (set pressure x 1.10) plus atmospheric pressure, psia, or set pressure plus 3 psi plus atmospheric pressure, whichever is greater
P_d = pressure at discharge from valve, psia
M = molecular weight
T = absolute temperature at inlet, °F + 460°F
C = constant for gas or vapor based on the ratio of specific heats
k = c_p/c_v (see Fig. 11-1)
Z = compressibility factor corresponding to P and T
w = specific weight of water at valve inlet conditions

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. The coefficient of the design shall not be greater than 0.878 (the product of 0.9 x 0.975).

NOTE: All experimentally determined coefficients K_D shall fall within a range of ±5% of the average K_D found. Failure to meet this requirement shall be cause to refuse certification of that particular valve design.

To convert lb/hr of water to gal/min of water, multiply the capacity in lb/hr by 1/500.

(3) The official relieving capacity of all sizes and pressures of a given design, for which K has been established under the provisions of (e)(2) above, that are manufactured subsequently shall not exceed the value calculated by the appropriate formula in (e)(2) above multiplied by the coefficient K (see Appendix 11).

(4) 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 ±5% of the average coefficient K. For designs where lift is used to determine the flow area, all valves shall have the same nominal lift-to-seat diameter ratio *(L/D)*.

(f) Tests shall be conducted at a place where the testing facilities, methods, procedures, and person supervising the tests (Authorized Observer) meet the applicable requirements of ASME PTC 25. The tests shall be made under the supervision of and certified by an Authorized Observer. The testing facilities, methods, procedures, and qualifications of the Authorized observer shall be subject to the acceptance of the ASME on recommendation of a representative from an ASME designated organization. Acceptance of the testing facility is subject to review within each 5 year period.

(g) Capacity test data reports for each valve model, type, and size, signed by the Manufacturer and the Authorized Observer witnessing the tests shall be submitted to the ASME designated organization for review and acceptance.[58] Where changes are made in the design, capacity certification tests shall be repeated.

(h) For absolute pressures up to 1500 psia, it is permissible to rate safety valves under PG-69.1.2 of Section I with capacity ratings at a flow pressure of 103% of the set pressure, for use on pressure vessels, without further test. In such instances, the capacity rating of the valve may be increased to allow for the flow pressure permitted in (c)(1) and (c)(3) above, namely, 110% of the set pressure, by the multiplier

$$\frac{1.10p + 14.7}{1.03p + 14.7}$$

where

p = set pressure, psig

Such valves shall be marked in accordance with UG-129. This multiplier shall not be used as a divisor to transform test ratings from a higher to a lower flow.

For steam pressures above 1500 psig (10 MPa), the above multiplier is not applicable. For pressure relief valves with relieving pressures between 1500 psig (10 MPa) and 3200 psig (22 MPa), the capacity shall be determined by using the equation for steam and the correction factor for high pressure steam in (e)(2) above with the permitted absolute relieving pressure (1.10p + 14.7) and the coefficient K for that valve design.

(i) Rating of nozzle type pressure relief valves, i.e., coefficient K_D, greater than 0.90 and nozzle construction, for saturated water shall be according to 11-2.

(j) When changes are made in the design of a pressure 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 Division shall be performed.

(k) The certified flow resistance K_R of the rupture disk device used in UG-127(a)(2) shall be either $K_R = 2.4$, or as determined in accordance with (1) through (r) below.

(l) Flow resistance certification tests for rupture disk devices shall be conducted with air or gas.

(m) Flow resistance certification tests shall be conducted at a rupture disk device inlet pressure which does not exceed 110% of the device set pressure.

(n)(1) The flow resistance for rupture disk devices tested with nonpressure containing disk items, such as seals, support rings, and vacuum supports, is applicable for the same rupture device design without seals, support rings, or vacuum supports.

[58] Valve capacities and rupture disk device flow resistances are published in "Pressure Relief Device Certifications". This publication may be obtained from the National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, Ohio 43229.

(2) A change in material for rupture disks and their nonpressure containing disk items, such as seals, support rings, and vacuum supports, is not considered a design change and does not require retesting.

(3) Additional linings, coatings, or platings may be used for the same design of rupture disk devices provided:

(a) the certificate holder has performed a verification burst test of rupture disks with the additional linings, coatings, or platings and has documented that the addition of these materials does not affect the rupture disk opening configuration; and

(b) such verification tests shall be conducted with rupture disks of the smallest size and minimum burst pressure for which the certified flow resistance with additional materials to be used.

(o) Flow resistance certification of rupture disk devices shall be determined by one of the following methods.

(1) One Size Method

(a) For each rupture disk device design, three rupture disks from the same lot shall be individually burst and flow tested in accordance with (p) below. The burst pressure shall be the minimum of the rupture disk device design of the size tested.

(b) The certified flow resistance K_R determined in (p) below shall apply only to the rupture disk design of the size tested.

(c) When additional rupture disks of the same design are constructed at a later date, the test results on the original rupture disks may be included as applicable in the three size method described in (o)(2) below.

(2) Three Size Method

(a) This method of flow resistance certification may be used for a rupture disk device design of three or more sizes. The burst pressure shall be the minimum of the rupture disk device design for each of the sizes submitted for test.

(b) For each rupture disk device design, three rupture disks from the same lot shall be burst and flow tested in accordance with (p) below for each of three different sizes of the same design.

(c) The certified flow resistance K_R shall apply to all sizes and pressures of the design of the rupture disk device tested.

(p) A certified flow resistance K_R may be established for a specific rupture disk device design according to the following procedure.

(1) For each design, the rupture disk Manufacturer shall submit for test the required rupture disk devices in accordance with (o) above together with the cross section drawings showing the rupture disk device design.

(2) Tests shall be made on each rupture disk device to determine its burst pressure and flow resistance at a facility which meets the requirements of (f) above.

(3) Calculate an average flow resistance using the individual flow resistances determined in (p)(2) above. All individual flow resistances shall fall within the average flow resistance by an acceptance band of plus or minus three times the average of the absolute values of the deviations of the individual flow resistances from the average flow resistance. Any individual flow resistance that falls outside of this band shall be replaced on a two for one basis. A new average flow resistance shall be computed and the individual flow resistances evaluated as stated above.

(4) The certified flow resistance KR for a rupture disk design shall not be less than zero and shall not be less than the sum of the average flow resistance plus three times the average of the absolute values of the deviations of individual flow resistances from the average flow resistance.

(q) Flow resistance test data reports for each rupture disk device design, signed by the Manufacturer and the Authorized Observer witnessing the tests, shall be submitted to the ASME designated organization for review and acceptance.[58]

(r) When changes are made in the design of a rupture disk device which affect the flow path or burst performance characteristics of the device, new tests in accordance with this Division shall be performed.

UG-132 CERTIFICATION OF CAPACITY OF PRESSURE RELIEF VALVES IN COMBINATION WITH NONRECLOSING PRESSURE RELIEF DEVICES A99

(a) Capacity of Pressure Relief Valves in Combination With a Rupture Disk Device at the Inlet

(1) For each combination of pressure relief valve design and rupture disk device design, the pressure relief valve Manufacturer or the rupture disk device Manufacturer may have the capacity of the combination certified as prescribed in (3) and (4) below.

(2) Capacity certification tests shall be conducted on saturated steam, air, or natural gas. When saturated steam is used, corrections for moisture content of the steam shall be made.

(3) The pressure relief valve Manufacturer or the rupture disk device Manufacturer may submit for tests the smallest rupture disk device size with the equivalent size of pressure relief valve that is intended to be used as a combination device. The pressure relief valve to be tested shall have the largest orifice used in the particular inlet size.

(4) Tests may be performed in accordance with the following subparagraphs. The rupture disk device and pressure relief valve combination to be tested shall be arranged to duplicate the combination assembly design.

(a) The test shall embody the minimum burst pressure of the rupture disk device design which is to be used in combination with the pressure relief valve design. The marked burst pressure shall be between 90% and 100% of the marked set pressure of the valve.

(b) The test procedure to be used shall be as follows.

The pressure relief valve (one valve) shall be tested for capacity as an individual valve, without the rupture disk device at a pressure 10% or 3 psi (13.8 kPa), whichever is greater, above the valve set pressure.

The rupture disk device shall then be installed at the inlet of the pressure relief valve and the disk burst to operate the valve. The capacity test shall be performed on the combination at 10% or 3 psi (13.8 kPa), whichever is greater, above the valve set pressure duplicating the individual pressure relief valve capacity test.

(c) Tests shall be repeated with two additional rupture disks of the same nominal rating for a total of three rupture disks to be tested with the single pressure valve. The results of the test capacity shall fall within a range of 10% of the average capacity of the three tests. Failure to meet this requirement shall be cause to require retest for determination of cause of the discrepancies.

(d) From the results of the tests, a Combination Capacity Factor shall be determined. The Combination Capacity Factor is the ratio of the average capacity determined by the combination tests to the capacity determined on the individual valve.

The Combination Capacity Factor shall be used as a multiplier to make appropriate changes in the ASME rated relieving capacity of the pressure relief valve in all sizes of the design. The value of the Combination Capacity Factor shall not be greater than one. The Combination Capacity Factor shall apply only to combinations of the same design of pressure relief valve and the same design of rupture disk device as those tested.

(e) The test laboratory shall submit the test results to the ASME designated organization for acceptance of the Combination Capacity Factor.[58]

(b) Optional Testing of Rupture Disk Devices and Pressure Relief Valves

(1) If desired, a valve Manufacturer or a rupture disk Manufacturer may conduct tests in the same manner as outlined in (a)(4)(c) and (a)(4)(d) above using the next two larger sizes of the design of rupture disk device and pressure relief valve to determine a Combination Capacity Factor applicable to larger sizes. If a greater Combination Capacity Factor is established and can be certified, it may be used for all larger sizes of the combination, but shall not be greater than one.

(2) If desired, additional tests may be conducted at higher pressures in accordance with (a)(4)(c) and (a)(4)(d) above to establish a maximum Combination Capacity Factor to be used at all pressures higher than the highest tested, but shall not be greater than one.

(c) Capacity of Breaking Pin Devices in Combination With Pressure Relief Valves

(1) Breaking pin devices in combination with pressure relief valves shall be capacity tested in compliance with UG-131(d) or UG-131(e) as a combination.

(2) Capacity certification and Code Symbol stamping shall be based on the capacity established in accordance with these paragraphs.

UG-133 DETERMINATION OF PRESSURE RELIEVING REQUIREMENTS

(a) Except as permitted in (b) below, the aggregate capacity of the pressure relief devices connected to any vessel or system of vessels for the release of a liquid, air, steam, or other vapor shall be sufficient to carry off the maximum quantity that can be generated or supplied to the attached equipment without permitting a rise in pressure within the vessel of more than 16% above the maximum allowable working pressure when the pressure relief devices are blowing.

(b) Pressure relief devices as permitted in UG-125(c)(2), a protection against excessive pressure caused by exposure to fire or other sources of external heat, shall have a relieving capacity sufficient to prevent the pressure from rising more than 21% above the maximum allowable working pressure of the vessel when all pressure relief devices are blowing.

(c) Vessels connected together by a system of adequate piping not containing valves which can isolate any vessel may be considered as one unit in figuring the required relieving capacity of pressure relief devices to be furnished.

(d) Heat exchangers and similar vessels shall be protected with a pressure relief device of sufficient capacity to avoid overpressure in case of an internal failure.

(e) The official rated capacity, or the certified flow resistance and minimum net flow area, of a pressure relief device shall be that which is stamped on the device and guaranteed by the Manufacturer.

(f) The rated pressure relieving capacity of a pressure relief valve for other than steam or air shall be determined by the method of conversion given in Appendix 11.

(g) To prorate the relieving capacity at any relieving pressure greater than 1.10p, as permitted under UG-125, a multiplier may be applied to the official relieving capacity of a pressure relief device as follows:

$$\frac{P + 14.7}{1.10p + 14.7}$$

where

P = relieving pressure, psig

p = set pressure, psig

For steam pressures above 1500 psig, the above multiplier is not applicable. For steam valves with relieving pressures greater than 1500 psig and less than or equal to 3200 psig, the capacity at relieving pressures greater than 1.10p shall be determined using the equation for steam and the correction factor for high pressure steam in UG-131(e)(2) with the permitted absolute relieving pressure and the coefficient K for that valve design.

UG-134 PRESSURE SETTING OF PRESSURE RELIEF DEVICES

(a) When a single pressure relief device is used, the set pressure[59] marked on the device shall not exceed the maximum allowable working pressure of the vessel. When the required capacity is provided in more than one pressure relief device, only one pressure relief device need be set at or below the maximum allowable working pressure, and the additional pressure relief devices may be set to open at higher pressures but in no case at a pressure higher than 105% of the maximum allowable working pressure, except as provided in (b) below.

(b) For pressure relief devices permitted in UG-125(c)(2) as protection against excessive pressure caused by exposure to fire or other sources of external heat, the device marked set pressure shall not exceed 110% of the maximum allowable working pressure of the vessel. If such a pressure relief device is used to meet the requirements of both UG-125(c) and UG-125(c)(2), the device marked set pressure shall not be over the maximum allowable working pressure.

(c) The pressure relief device set pressure shall include the effects of static head and constant back pressure.

(d)(1) The set pressure tolerance for pressure relief valves shall not exceed (2 psi (13.8 kPa) for pressures up to and including 70 psi (483 kPa) and (3% for pressures above 70 psi (483 kPa), except as covered in (d)(2) below.

(2) The set pressure tolerance of pressure relief valves which comply with UG-125(c)(3) shall be within -0%, + 10%.

(e) The burst pressure tolerance for rupture disk devices at the specified disk temperature shall not exceed (2 psi (13.8 kPa) of marked burst pressure up to 40 psi (276 kPa) and (5% of marked burst pressure 40 psi (276 kPa) and over.

UG-135 INSTALLATION

(a) Pressure relief devices intended for use in compressible fluid service shall be connected to the vessel in the vapor space above any contained liquid or to piping connected to the vapor space in the vessel which is to be protected. Pressure relief devices intended for use in liquid service shall be connected below the normal liquid level.

(b)(1) The opening through all pipe, fittings, and nonreclosing pressure relief devices (if installed) between a pressure vessel and its pressure relief valve shall have at least the area of the pressure relief valve inlet. The characteristics of this upstream system shall be such that the pressure drop will not reduce the relieving capacity below that required or adversely affect the proper operation of the pressure relief valve.

(2) The opening in the vessel wall shall be designed to provide unobstructed flow between the vessel and its pressure relief device (see Appendix M).[60]

(c) When two or more required pressure relief devices are placed on one connection, the inlet internal cross-sectional area of this connection shall be either sized to avoid restricting flow to the pressure relief devices or made at least equal to the combined inlet areas of the safety devices connected to it. The flow characteristics of the upstream system shall satisfy the requirements of (b) above. (See Appendix M.)

(d) There shall be no intervening stop valves between the vessel and its pressure relief device or devices, or between the pressure relief device or devices and the point of discharge, except:

(1) when these stop valves are so constructed or positively controlled that the closing of the maximum number of block valves possible at one time will not reduce the pressure relieving capacity provided by the unaffected pressure relief devices below the required relieving capacity; or

(2) under conditions set forth in Appendix M.

(e) The pressure relief devices on all vessels shall be so installed that their proper functioning will not be hindered by the nature of the vessel's contents.

(f) Discharge lines from pressure relief devices shall be designed to facilitate drainage or shall be fitted with drains to prevent liquid from lodging in the discharge side of the pressure relief device, and such lines shall lead to a safe place of discharge. The size of the discharge lines shall be such that any pressure that may exist or develop will not reduce the relieving capacity of the pressure relief devices below that required to properly protect the vessel, or adversely affect the proper operation of the pressure relief devices. [See UG-136(a)(8) and Appendix M.]

UG-136 MINIMUM REQUIREMENTS FOR PRESSURE RELIEF VALVES A99

UG-136(a) Mechanical Requirements

UG-136(a)(1) The design shall incorporate guiding arrangements necessary to ensure consistent operation and tightness.

[59]The set pressure is the value of increasing inlet static pressure at which a pressure relief device displays one of the operational characteristics as defined by opening pressure, popping pressure, start-to-leak pressure, burst pressure, or breaking pressure. (The applicable operating characteristic for a specific device design is specified by the device Manufacturer.

[60]Users are warned that the proper operation of various rupture disk devices depends upon following the Manufacturer's installation instructions closely with regard to the flow direction marked on the device. Some device designs will burst at pressures much greater than their marked burst pressure when installed with the process pressure on the vent side of the device.

UG-136(a)(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.

UG-136(a)(3) Each pressure relief valve on air, water over 140F (60C), or steam service shall have a substantial lifting device which when activated will release the seating force on the disk when the pressure relief valve is subjected to a pressure of at least 75% of the set pressure of the valve. Pilot operated pressure relief valves used on these services shall be provided with either a lifting device as described above or means for connecting and applying pressure to the pilot adequate to verify that the moving parts critical to proper operation are free to move.

UG-136(a)(4) The seat of a pressure relief valve shall be fastened to the body of the pressure relief valve in such a way that there is no possibility of the seat lifting.

UG-136(a)(5) In the design of the body of the pressure relief valve, consideration shall be given to minimizing the effects of deposits.

UG-136(a)(6) Pressure relief valves having screwed inlet or outlet connections shall be provided with wrenching surfaces to allow for normal installation without damaging operating parts.

UG-136(a)(7) Means shall be provided in the design of all pressure relief valves for use under this Division for sealing all initial adjustments which can be made without disassembly of the valve. Seals shall be installed by the Manufacturer or Assembler at the time of initial adjustment. Seals shall be installed in a manner to prevent changing the adjustment without breaking the seal. For pressure relief valves larger than NPS 1/2 (DN 15), the seal shall serve as a means of identifying the Manufacturer or Assembler making the initial adjustment.

UG-136(a)(8) If the design of a pressure relief valve is such that liquid can collect on the discharge side of the disk, except as permitted in (a)(9) below, the valve shall be equipped with a drain at the lowest point where liquid can collect (for installation, see UG-135).

UG-136(a)(9) Pressure relief valves that cannot be equipped with a drain as required in (a)(8) above because of design or application may be used provided:

(a) the pressure relief valves are used only on gas service where there is neither liquid discharged from the valve nor liquid formed by condensation on the discharge side of the valve; and

(b) the pressure relief valves are provided with a cover or discharge piping per UG-135(g) to prevent liquid or other contaminant from entering the discharge side of the valve; and

(c) the pressure relief valve is marked FOR GAS SERVICE ONLY in addition to the requirements of UG-129.

UG-136(a)(10) For pressure relief valves of the diaphragm type, the space above the diaphragm shall be vented to prevent a buildup of pressure above the diaphragm. Pressure relief valves of the diaphragm type shall be designed so that failure or deterioration of the diaphragm material will not impair the ability of the valve to relieve at the rated capacity.

UG-136(b) Material Selections

UG-136(b)(1) Cast iron seats and disks are not permitted.

UG-136(b)(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 pressure relief valves shall be of suitable material to resist corrosion by the fluid to be contained.

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

UG-136(b)(3) Materials used in bodies and bonnets or yokes shall be listed in Section II and this Division. Carbon and low alloy steel bodies, bonnets, yokes and bolting (UG-20) subject to in-service temperatures colder than -20ºF (-23ºC) shall meet the requirements of UCS-66, unless exempted by the following.

(a) The coincident ratio defined in Fig. UCS-66.1 is 0.35 or less.

(b) The material(s) is exempted from impact testing per Fig. UCS-66.

UG-136(b)(4) Materials used in nozzles, disks, and other parts contained within the external structure of the pressure relief valves shall be one of the following categories:

(a) listed in Section II;

(b) listed in ASTM specifications;

(c) controlled by the Manufacturer of the pressure relief valve by a specification ensuring control of chemical and physical properties and quality at least equivalent to ASTM standards.

UG-136(c) Inspection of Manufacturing and/or Assembly of Pressure Relief Valves

UG-136(c)(1) A Manufacturer or Assembler shall demonstrate to the satisfaction of a representative from an ASME designated organization that his manufacturing, production, and testing facilities and quality control procedures will insure close agreement between the performance of random production samples and the performance of those valves submitted for Capacity Certification.

UG-136(c)(2) Manufacturing, assembly, inspection and test operations including capacity are subject to inspections at any time by a representative from an ASME designated organization.

UG-136(c)(3) A Manufacturer or Assembler may be granted permission to apply the UV Code Symbol to production pressure relief valves capacity certified in accordance with UG-131 provided the following tests are successfully completed. This permission shall expire on the fifth anniversary of the date it is initially granted. The 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 a representative from an ASME designated organization.

(b) Operational capacity tests shall be conducted in the presence of a representative from an ASME designated organization at an ASME accepted laboratory. The pressure relief valve Manufacturer or Assembler shall be notified of the time of the test and may have representatives present to witness the test. Pressure relief valves having an adjustable blowdown construction shall be adjusted by the Manufacturer or Assembler following successful testing for operation but prior to flow testing so that the blowdown does not exceed 7% of the set pressure or 3 psi (20.6 kPa), whichever is greater. This adjustment may be made on the flo*w test facility*.

(c) Should any pressure relief valve fail to relieve at or above its certified capacity or should it fail to meet performance requirements of this Division, the test shall be repeated at the rate of two replacement pressure relief valves, selected in accordance with (c)(3)(a) above, for each pressure relief valve that failed.

(d) Failure of any of the replacement pressure relief valves to meet the capacity or the performance requirements of this Division shall be cause for revocation within 60 days of the authorization to use the Code Symbol on that particular type of pressure relief 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 (c)(3) above shall apply.

UG-136(c)(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 pressure relief 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) the Assemblers hold a V or UV Code Symbol Stamp and are authorized by the Manufacturer to assemble and test the specific valve type in which 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; and

(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; and

(b) the parts are original and unmodified.

UG-136(c)(5) In addition to the requirements of UG-129, the marking shall include the name of the Manufacturer and the final Assembler. The Code Symbol Stamp shall be that of the final Assembler.

NOTE: Within the requirements of UG-136(c) and (d): 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 pressure relief valves certified under this Division. An Assembler is defined as a person or organization who purchases or receives from a Manufacturer or another Assembler the necessary component parts or pressure relief valves and assembles, adjusts, tests, seals, and ships pressure relief valves certified under this Division, at a geographical location other than and using facilities other than those used by the Manufacturer. An Assembler may be organizationally independent of a Manufacturer or may be wholly or partly owned by the Manufacturer.

UG-136(d) Production Testing by Manufacturers and Assemblers

UG-136(d)(1) Each pressure relief valve to which the Code Symbol Stamp is to be applied shall be subjected to the following tests by the Manufacturer or Assembler. A Manufacturer or Assembler shall have a documented program for the application, calibration, and maintenance of gages and instruments used during these tests.

UG-136(d)(2) The primary pressure parts of each pressure relief valve exceeding NPS 1 (DN 25) inlet size or 300 psi (2070 kPa) set pressure where the materials used are either cast or welded shall be tested at a pressure of at least 1.5 times the design pressure of the parts. These tests shall be conducted after all machining operations on the parts have been completed. There shall be no visible sign of leakage.

UG-136(d)(3) The secondary pressure zone of each closed bonnet pressure relief valve exceeding NPS 1 (DN 25) inlet size when such pressure relief valves are designed for discharge to a closed system shall be tested with air or other gas at a pressure of at least 30 psi (207 kPa). There shall be no visible sign of leakage.

UG-136(d)(4) Each pressure relief valve shall be tested to demonstrate its popping or set pressure. Pressure relief valves marked for steam service or having special internal parts for steam service shall be tested with steam, except that pressure relief valves beyond the capability of the production steam test facility either because of size or set pressure may be tested on air. Necessary corrections for differentials in popping pressure between steam and air shall be established by the Manufacturer and applied to the popping point on air. Pressure relief valves marked for gas or vapor may be tested with air. Pressure relief valves marked for liquid service shall be tested with water or other suitable liquid. When a valve is adjusted to correct for

service conditions of superimposed back pressure, temperature, or the differential in popping pressure between steam and air, the actual test pressure (cold differential test pressure) shall be marked on the valve per UG-129. Test fixtures and test drums where applicable shall be of adequate size and capacity to ensure that pressure relief valve action is consistent with the stamped set pressure within the tolerances required by UG-134(d).

UG-136(d)(5) After completion of the tests required by (d)(4) above, a seat tightness test shall be conducted. Unless otherwise designated by a Manufacturer's published pressure relief valve specification, the seat tightness test and acceptance criteria shall be in accordance with API 527.

UG-136(d)(6) Testing time on steam pressure relief valves shall be sufficient, depending on size and design, to insure that test results are repeatable and representative of field performance.

UG-136(e) Design Requirements. At the time of the submission of pressure relief valves for capacity certification, or testing in accordance with (c)(3) above, the ASME designated organization has the authority to review the design for conformity with the requirements of UG-136(a) and UG-136(b) and to reject or require modification of designs which do not conform, prior to capacity testing.

UG-136(f) Welding and Other Requirements. All welding, brazing, heat treatment, and nondestructive examination used in the construction of bodies, bonnets, and yokes shall be performed in accordance with the applicable requirements of this Division.

UG-137 MINIMUM REQUIREMENTS FOR RUPTURE DISK DEVICES

UG-137(a) Mechanical Requirements

UG-137(a)(1) The design shall incorporate arrangements necessary to ensure consistent operation and tightness.

UG-137(a)(2) Rupture disk devices having threaded inlet or outlet connections shall be designed to allow for normal installation without damaging the rupture disk.

UG-137(b) Material Selections

UG-137(b)(1) The rupture disk material is not required to conform to a material specification listed in ASME Section II. The rupture disk material shall be controlled by the Manufacturer of the rupture disk device by a specification ensuring the control of material properties.

UG-137(b)(2) Materials used in rupture disk holders shall be listed in Section II and this Division. Carbon and low alloy steel holders and bolting (UG-20) subject to in-service temperatures colder than -20ºF shall meet the requirements of UCS-66, unless exempted by the following.

(a) The coincident ratio defined in Fig. UCS-66.1 is 0.40 or less.

(b) The material(s) is exempted from impact testing per Fig. UCS-66.

UG-137(b)(3) Materials used in other parts contained within the external structure of the rupture disk holder shall be one of the following categories.

(a) listed in Section II; or

(b) listed in ASTM specifications; or

(c) controlled by the Manufacturer of the rupture disk device by a specification insuring control of chemical and physical properties and quality at least equivalent to ASTM standards.

UG-137(c) Inspection of Manufacturing of Rupture Disk Devices

UG-137(c)(1) A Manufacturer shall demonstrate to the satisfaction of a representative of an ASME designated organization that its manufacturing, production, and testing facilities and quality control procedures will insure close agreement between the performance of random production samples and the performance of those devices submitted for Certification.

UG-137(c)(2) Manufacturing, assembly, inspection, and test operations are subject to inspections at any time by an ASME designee.

UG-137(c)(3) A Manufacturer may be granted permission to apply the UD Code Symbol to production rupture disk devices certified in accordance with UG-131 provided the following tests are successfully completed. This permission shall expire on the fifth anniversary of the date it is initially granted. The permission may be extended for five year periods if the following tests are successfully repeated within the 6 month period before expiration.

(a) Two production sample rupture disk devices of a size and capacity within the capability of an ASME accepted laboratory shall be selected by a representative of an ASME designated organization.

(b) Burst and flow testing shall be conducted in the presence of a representative of an ASME designated organization at a place which meets the requirements of UG-131(f). The device Manufacturer shall be notified of the time of the test and may have representatives present to witness the test.

(c) Should any device fail to meet or exceed the performance requirements (burst pressure, minimum net flow area, and flow resistance) of UG-127, the test shall be repeated at the rate of two replacement devices, selected and tested in accordance with (c)(3)(a) and (c)(3)(b) above for each device that failed.

(d) Failure of any of the replacement devices to meet the performance requirements of this Division shall be cause for revocation within 60 days of the

NOTES:

APPENDIX M
INSTALLATION AND OPERATION

M-1 INTRODUCTION

(a) The rules in this Appendix are for general information only, because they pertain to the installation and operation of pressure vessels, which are the prerogative and responsibility of the law enforcement authorities in those states and municipalities which have made provision for the enforcement of Section VIII.

(b) It is permissible to use any departures suggested herein from provisions in the mandatory parts of this Division when granted by the authority having legal jurisdiction over the installation of pressure vessels.

M-2 CORROSION

(a) Vessels subject to external corrosion shall be so installed that there is sufficient access to all parts of the exterior to permit proper inspection of the exterior, unless adequate protection against corrosion is provided or unless the vessel is of such size and is so connected that it may readily be removed from its permanent location for inspection.

(b) Vessels having manholes, handholes, or cover plates to permit inspection of the interior shall be so installed that these openings are accessible.

(c) In vertical cylindrical vessels subject to corrosion, to insure complete drainage, the bottom head, if dished should preferably be concave to pressure.

M-3 MARKING ON THE VESSEL

The marking required by this Division shall be so located that it will be accessible after installation and when installed shall not be covered with insulation or other material that is not readily removable [see UG-116(j)].

M-4 PRESSURE RELIEVING SAFETY DEVICES

The general provisions for the installation of pressure relieving devices are fully covered in UG-135. The following paragraphs contain details in arrangement of stop valves for shutoff control of safety pressure relief devices which are sometimes necessary to the continuous operation of processing equipment of such a complex nature that the shutdown of any part of it is not feasible. There are also rules with regard to the design of inlet and discharge piping to and from safety and relief valves, which can only be general in nature because the design engineer must fit the arrangement and proportions of such a system to the particular requirements in the operation of the equipment involved.

M-5 STOP VALVES BETWEEN PRESSURE RELIEVING DEVICE AND VESSEL

(a) A vessel, in which pressure can be generated because of service conditions, may have a full-area stop valve between it and its pressure relieving device for inspection and repair purposes only. When such a stop valve is provided, it shall be so arranged that it can be locked or sealed open, and it shall not be closed except by an authorized person who shall remain stationed there during that period of the vessel's operation within which the valve remains closed, and who shall again lock or seal the stop valve in the open position before leaving the station.

(b) A vessel or system [see UG-133(c)] for which the pressure originates from an outside source exclusively may have individual pressure relieving devices on each vessel, or connected to any point on the connecting piping, or on any one of the vessels to be protected. Under such an arrangement, there may be a stop valve between any vessel and the pressure relieving devices, and this stop valve need not be locked open, provided it also closes off that vessel from the source of pressure.

M-6 STOP VALVES ON THE DISCHARGE SIDE OF A PRESSURE RELIEVING DEVICE [SEE UG-135(E)]

A full-area stop valve may be placed on the discharge side of a pressure relieving device when its discharge is

connected to a common header with other discharge lines from other pressure relieving devices on nearby vessels that are in operation, so that this stop valve when closed will prevent a discharge from any connected operating vessels from backing up beyond the valve so closed. Such a stop valve shall be so arranged that it can be locked or sealed in either the open or closed position, and it shall be locked or sealed in either position only by an authorized person. When it is to be closed while the vessel is in operation, an authorized person shall be present, and he shall remain stationed there; he shall again lock or seal the stop valve in the open position before leaving the station. Under no condition should this valve be closed while the vessel is in operation except when a stop valve on the inlet side of the safety relieving device is installed and is first closed.

M-7 INLET PRESSURE DROP FOR HIGH LIFT, TOP GUIDED SAFETY, SAFETY RELIEF, AND PILOT OPERATED PRESSURE RELIEF VALVES IN COMPRESSIBLE FLUID SERVICE

(a) The nominal pipe size of all piping, valves and fittings, and vessel components between a pressure vessel and its safety, safety relief, or pilot operated pressure relief valves shall be at least as large as the nominal size of the device inlet, and the flow characteristics of the upstream system shall be such that the cumulative total of all nonrecoverable inlet losses shall not exceed 3% of the valve set pressure. The inlet pressure losses will be based on the valve nameplate capacity corrected for the characteristics of the flowing fluid.

(b) When two or more required safety, safety relief or pilot operated pressure relief valves are placed on one connection, the inlet internal cross-sectional area of this connection shall be either sized to avoid restricting flow to the pressure relief valves or made at least equal to the combined inlet areas of the safety valves connected to it. The flow characteristics of the upstream system shall meet the requirements of (a) above with all valves relieving simultaneously.

M-8 DISCHARGE LINES FROM SAFETY DEVICES

(a) Where it is feasible, the use of short discharge pipe or vertical riser, connected through long-radius elbows from each individual device, blowing directly to the atmosphere, is recommended. Such discharge pipes shall be at least of the same size as the valve outlet. Where the nature of the discharge permits, telescopic (sometimes called “broken”) discharge lines, whereby condensed vapor in the discharge line, or rain, is collected in a drip pan and piped to a drain, are recommended.[1]

(b) When discharge lines are long, or where outlets of two or more valves having set pressures within a comparable range are connected into a common line, the effect of the back pressure that may be developed therein when certain valves operate must be considered [see UG-135(g)]. The sizing of any section of a common-discharge header downstream from each of the two or more pressure relieving devices that may reasonably be expected to discharge simultaneously shall be based on the total of their outlet areas, with due allowance for the pressure drop in all downstream sections. Use of specially designed valves suitable for use on high or variable back pressure service should be considered.

(c) The flow characteristics of the discharge system of high lift, top guided safety, safety relief, or pilot operated pressure relief valves in compressible fluid service shall be such that the static pressure developed at the discharge flange of a conventional direct spring loaded valve will not exceed 10% of the set pressure when flowing at stamp capacity. Other valve types exhibit various degrees of tolerance to back pressure and the manufacturer’s recommendation should be followed.

(d) All discharge lines shall be run as direct as is practicable to the point of final release for disposal. For the longer lines, due consideration shall be given to the advantage of long-radius elbows, avoidance of closeup fittings, and the minimizing of excessive line strains by expansion joints and well-known means of support to minimize line-sway and vibration under operating conditions.

(e) Provisions should be made in all cases for adequate drainage of discharge lines.

NOTE: It is recognized that no simple rule can be applied generally to fit the many installation requirements, which vary from simple short lines that discharge directly to the atmosphere to the extensive manifold discharge piping systems where the quantity and rate of the product to be disposed of requires piping to a distant safe place.

M-9 PRESSURE DROP, NONRECLOSING PRESSURE RELIEF DEVICES

Piping, valves and fittings, and vessel components comprising part of a nonreclosing device pressure relieving system shall be sized to prevent the vessel pressure from rising above the allowable overpressure.

[1]This construction has the further advantage of not transmitting discharge-pipe strains to the valve. In these types of installation, the back pressure effect will be negligible, and no undue influence upon normal valve operation can result.

M-10 GENERAL ADVISORY INFORMATION ON THE CHARACTERISTICS OF SAFETY RELIEF VALVES DISCHARGING INTO A COMMON HEADER

Because of the wide variety of types and kinds of safety relief valves, it is not considered advisable to attempt a description in this Appendix of the effects produced by discharging them into a common header. Several different types of valves may conceivably be connected into the same discharge header and the effect of back pressure on each type may be radically different. Data compiled by the manufacturers of each type of valve used should be consulted for information relative to its performance under the conditions anticipated.

M-11 PRESSURE DIFFERENTIALS FOR PRESSURE RELIEF VALVES

Due to the variety of service conditions and the various designs of safety and safety relief valves, only general guidance can be given regarding the differential between the set pressure of the valve (see UG-134) and the operating pressure of the vessel. Operating difficulty will be minimized by providing an adequate differential for the application. The following is general advisory information on the characteristics of the intended service and of the safety or safety relief valves that may bear on the proper pressure differential selection for a given application. These considerations should be reviewed early in the system design since they may dictate the MAWP of the system.

(a) Consideration of the Process Characteristics in the Establishment of the Operating Margin to Be Provided. To minimize operational problems, it is imperative that the user consider not only normal operating conditions of fluids, pressures, and temperatures, but also start-up and shutdown conditions, process upsets, anticipated ambient conditions, instrument response times, pressure surges due to quick closing valves, etc. When such conditions are not considered, the pressure relieving device may become, in effect, a pressure controller, a duty for which it is not designed. Additional consideration should be given to hazard and pollution associated with the release of the fluid. Larger differentials may be appropriate for fluids which are toxic, corrosive, or exceptionally valuable.

(b) Consideration of Safety Relief Valve Characteristics. The blowdown characteristic and capability is the first consideration in selecting a compatible valve and operating margin. After a self-actuated release of pressure, the valve must be capable of reclosing above the normal operating pressure. For example, if the valve is set at 100 psig with a 7% blowdown, it will close at 93 psig. The operating pressure must be maintained below 93 psig in order to prevent leakage or flow from a partially open valve. Users should exercise caution regarding the blowdown adjustment of large spring-loaded valves. Test facilities, whether owned by Manufacturers, repair houses, or users, may not have sufficient capacity to accurately verify the blowdown setting. The settings cannot be considered accurate unless made in the field on the actual installation.

Pilot-operated valves represent a special case from the standpoints of both blowdown and tightness. The pilot portion of some pilot-operating valves can be set at blowdowns as short as 2%. This characteristic is not, however, reflected in the operation of the main valve in all cases. The main valve can vary considerably from the pilot depending on the location of the two components in the system. If the pilot is installed remotely from the main valve, significant time and pressure lags can occur, but reseating of the pilot assures reseating of the main valve. The pressure drop in the connecting piping between the pilot and the main valve must not be excessive; otherwise, the operation of the main valve will be adversely affected.

The tightness of the main valve portion of these combinations is considerably improved above that of conventional valves by pressure loading the main disk or by the use of soft seats or both.

Despite apparent advantages of pilot-operated valves, users should be aware that they should not be employed in abrasive or dirty service, in applications where coking, polymerization, or corrosion of the wetted pilot parts can occur, or where freezing or condensation of the lading fluid at ambient temperatures is possible.

For all applications the valve Manufacturer should be consulted prior to selecting a valve of this type.

Tightness capability is another factor affecting valve selection, whether spring loaded or pilot operated. It varies somewhat depending on whether metal or resilient seats are specified, and also on such factors as corrosion or temperature. The required tightness and test method should be specified to comply at a pressure no lower than the normal operating pressure of the process. A recommended procedure and acceptance standard is given in API 527. It should also be remembered that any degree of tightness obtained should not be considered permanent. Service operation of a valve almost invariably reduces the degree of tightness.

Application of special designs such as O-rings or resilient seats should be reviewed with the valve Manufacturer.

The anticipated behavior of the valves includes allowance for a plus-or-minus tolerance on set pressure which varies with the pressure level. Installation conditions, such as back pressure, variations, and vibrations, influence selection of special types and an increase in differential pressure.

(c) General Recommendations. The following pressure differentials are recommended unless the safety or safety relief valve has been designed or tested in a specific or similar service and a smaller differential has been recommended by the Manufacturer.

A minimum difference of 5 psi (35 kPa) is recommended for set pressures to 70 psi. In this category, the set pressure tolerance is ±2 psi (±13.8 kPa) [UG-134(d)(1)], and the differential to the leak test pressure is 10% or 5 psi (35 kPa), whichever is greater.

A minimum differential of 10% is recommended for set pressures from 71 psi to 1000 psi (490 kPa to 6900 kPa). In this category, the set pressure tolerance is ±3% and the differential to the leak test pressure is 10%.

A minimum differential of 7% is recommended for set pressures above 1000 psi (6900 kPa). In this category, the set pressure tolerance is (3% and the differential to the leak test pressure should be 5%. Valves having small seat sizes will require additional maintenance when the pressure differential approaches these recommendations.

M-12 INSTALLATION OF SAFETY AND SAFETY RELIEF VALVES

Spring loaded safety and safety relief valves normally should be installed in the upright position with the spindle vertical. Where space or piping configuration preclude such an installation, the valve may be installed in other than the vertical position provided that:

(a) the valve design is satisfactory for such position;

(b) the media is such that material will not accumulate at the inlet of the valve; and

(c) drainage of the discharge side of the valve body and discharge piping is adequate.

M-13 REACTION FORCES AND EXTERNALLY APPLIED LOADS

(a) Reaction Thrust. The discharge of a pressure relief valve imposes reactive flow forces on the valve and associated piping. The design of the installation may require computation of the bending moments and stresses in the piping and vessel nozzle. There are momentum effects and pressure effects at steady state flow as well as transient dynamic loads caused by opening.

(b) External Loads. Mechanical forces may be applied to the valve by discharge piping as a result of thermal expansion, movement away from anchors, and weight of any unsupported piping. The resultant bending moments on a closed pressure relief valve may cause valve leakage and excessive stress in inlet piping. The design of the installation should consider these possibilities.

M-14 SIZING OF PRESSURE RELIEF DEVICES FOR FIRE CONDITIONS

(a) Excessive pressure may develop in pressure vessels by vaporization of the liquid contents and/or expansion of vapor content due to heat influx from the surroundings, particularly from a fire. Pressure relief systems for fire conditions are usually intended to release only the quantity of product necessary to lower the pressure to a predetermined safe level, without releasing an excessive quantity. This control is especially important in situations where release of the contents generates a hazard because of flammability or toxicity. Under fire conditions, consideration must also be given to the possibility that the safe pressure level for the vessel will be reduced due to heating of the vessel material, with a corresponding loss of strength.

(b) Several formulas have evolved over the years for calculating the pressure relief capacity required under fire conditions. The major differences involve heat flux rates. There is no single formula yet developed which takes into account all of the many factors which could be considered in making this determination. When fire conditions are a consideration in the design of a pressure vessel, the following references which provide recommendations for specific installations may be used:

API RP 520, Recommended Practice for the Design and Installation of Pressure-Relieving Systems in Refineries, Part I - Design, 1976, American Petroleum Institute, Washington, DC

API Standard 2000, Venting Atmospheric and Low-Pressure Storage Tanks (nonrefrigerated and refrigerated), 1973, American Petroleum Institute, Washington, DC

AAR Standard M-1002, Specifications for Tank Cars, 1978, Association of American Railroads, Washington, DC

Safety Relief Device Standards: S-1.1, Cylinders for Compressed Gases; S-1.2, Cargo and Portable Tanks; and S-1.3, Compressed Gas Storage Containers, Compressed Gas Association, Arlington, VA

NFPA Code Nos. 30, 59, and 59A, National Fire Protection Association, Boston, MA

Pressure-Relieving Systems for Marine Cargo Bulk Liquid Containers, 1973, National Academy of Sciences, Washington, DC

Bulletin E-2, How to Size Safety Relief Devices, Phillips Petroleum Company, Bartlesville, OK

A Study of Available Fire Test Data as Related to Tank Car Safety Device Relieving Capacity Formulas, 1971, Phillips Petroleum Company, Bartlesville, OK

M-15 PRESSURE INDICATING DEVICE

If a pressure indicating device is provided to determine the vessel pressure at or near the set pressure of the relief device, one should be selected that spans the set pressure of the relief device and is graduated with an upper limit that is neither less than 1.25 times the set pressure of the relief device nor more than twice the maximum allowable working pressure of the vessel. Additional devices may be installed if desired.

NOTES:

APPENDIX 11
CAPACITY CONVERSIONS FOR SAFETY VALVES

11-1

The capacity of a safety or relief valve in terms of a gas or vapor other than the medium for which the valve was officially rated shall be determined by application of the following formulas:[1]

For steam,

$$W_s = 51.5KAP$$

For air,

$$W_a = CKAP\sqrt{\frac{M}{T}}$$

$$C = 356$$

$$M = 28.97$$

T = 520 when W_a is the rated capacity

For any gas or vapor,

$$W_a = CKAP\sqrt{\frac{M}{T}}$$

where

W_s = rated capacity, lb/hr of steam
W_a = rated capacity, converted to lb/hr of air at 60F, inlet temperature
W = flow of any gas or vapor, lb/hr
C = constant for gas or vapor which is function of the ratio of specific heats, k = cp/cv (see Fig. 11-1)
K = coefficient of discharge [see UG-131(d) and (e)]
A = actual discharge area of the safety valve, sq. in.
P = (set pressure x 1.10) plus atmosphere pressure, psia
M = molecular weight
T = absolute temperature at inlet (F + 460)

These formulas may also be used when the required flow of any gas or vapor is known and it is necessary to compute the rated capacity of steam or air.

Molecular weights of some of the common gases and vapors are given in Table 11-1.

For hydrocarbon vapors, where the actual value of k is not known, the conservative value, k = 1.001 has been commonly used and the formula becomes

$$W = 315KAP\sqrt{\frac{M}{T}}$$

When desired, as in the case of light hydrocarbons, the compressibility factor Z may be included in the formulas for gases and vapors as follows:

$$W = CKAP\sqrt{\frac{M}{ZT}}$$

Example 1

GIVEN: A safety valve bears a certified capacity rating of 3020 lb/hr of steam for a pressure setting of 200 psi.
PROBLEM: What is the relieving capacity of that valve in terms of air at 100ºF for the same pressure setting?

SOLUTION:

For steam

$$W_s = 51.5KAP$$

$$3020 = 51.5KAP$$

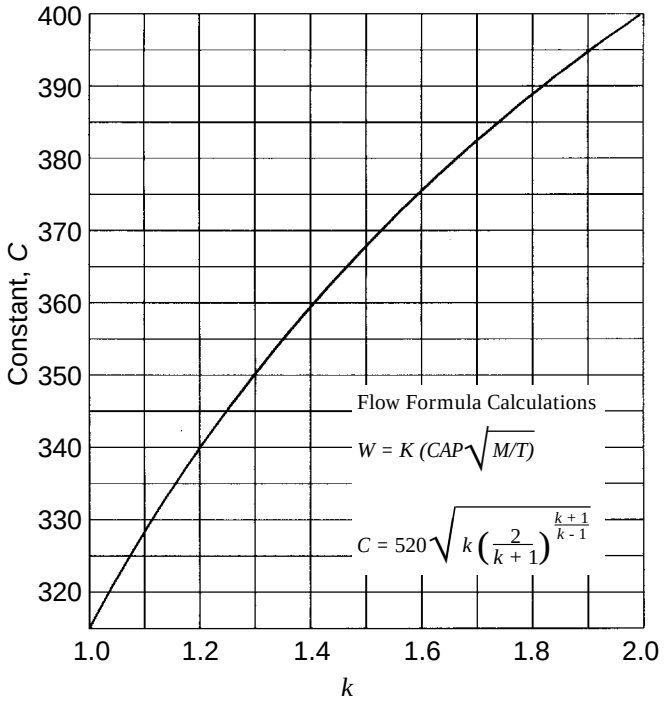
$$KAP = \frac{3020}{51.5} = 58.5$$

[1]Knowing the official rating capacity of a safety valve which is stamped on the valve, it is possible to determine the overall value of KA in either of the following formulas in cases where the value of these individual terms is not known:

Official Rating in Steam: $KA = \frac{Ws}{51.5}$

Official Rating in Air: $KA = \frac{Wa}{CP}\sqrt{\frac{T}{M}}$

This value for KA is then substituted in the above formulas to determine the capacity of the safety valve in terms of the new gas or vapor.



k	Constant C	k	Constant C	k	Constant C
1.00	315	1.26	343	1.52	366
1.02	318	1.28	345	1.54	368
1.04	320	1.30	347	1.56	369
1.06	322	1.32	349	1.58	371
1.08	324	1.34	351	1.60	372
1.10	327	1.36	352	1.62	374
1.12	329	1.38	354	1.64	376
1.14	331	1.40	356	1.66	377
1.16	333	1.42	358	1.68	379
1.18	335	1.44	359	1.70	380
1.20	337	1.46	361	2.00	400
1.22	339	1.48	363	2.20	412
1.24	341	1.50	364	...	...

FIG. 11-1 CONSTANT *C* FOR GAS OR VAPOR RELATED TO RATIO OF SPECIFIC HEATS ($k = c_p/c_v$)

For air

$$W_a = CKAP\sqrt{\frac{M}{T}}$$

$$= 356\ KAP\sqrt{\frac{28.97}{460 + 100}}$$

$$= 356\ (58.5)\sqrt{\frac{28.97}{560}}$$

$$= 4750 \text{ lb/hr}$$

EXAMPLE 2

GIVEN: It is required to relieve 5000 lb/hr of propane from a pressure vessel through a safety valve set to relieve at a pressure of Ps, psi, and with an inlet temperature at 125ºF.

PROBLEM: what total capacity in pounds of steam per hour in safety valves must be furnished?

Solution:

For propane,

$$W = CKAP\sqrt{\frac{M}{T}}$$

The value of *C* is not definitely known. Use the conservative value, *C* = 315.

TABLE 11-1
MOLECULAR WEIGHTS OF GASES AND VAPORS

Air	28.97	Freon 22	86.48
Acetylene	26.04	Freon 114	170.90
Ammonia	17.03	Hydrogen	2.02
Butane	58.12	Hydrogen Sulfide	34.08
Carbon Dioxide	44.01	Methane	16.04
Chlorine	70.91	Methyl Chloride	50.48
Ethane	30.07	Nitrogen	28.02
Ethylene	28.05	Oxygen	32.00
Freon 11	137.371	Propane	44.09
Freon 12	120.9	Sulfur Dioxide	64.06

$$5000 = 315\ KAP\sqrt{\frac{44.09}{460 + 125}}$$

$$KAP = 57.7$$

For steam,

$$W_s = 51.5\ KAP = (51.5)(57.7)$$

$$= 2970 \text{ lb/hr set to relieve at } P_s, \text{ psi}$$

Example 3

GIVEN: It is required to relieve 1000 lb/hr of ammonia from pressure vessel at 150ºF.

PROBLEM: What is the required total capacity in pounds of steam per hour at the same pressure setting?

SOLUTION:

For ammonia

$$W = CKAP\sqrt{\frac{M}{T}}$$

Manufacturer and user agree to use k = 1.33; from Fig. 11-1, C = 350.

$$1000 = 350\,KAP\sqrt{\frac{17.03}{460 + 150}}$$

$$KAP = 17.10$$

For steam,

$$W_s = 51.5\,KAP = 51.5 \times 17.10$$

$$= 880 \text{ lb/hr}$$

Example 4

GIVEN: A safety valve bearing a certified rating of 10,000 cu ft/min of air at 60ºF and 14.7 psia (atmospheric pressure).

PROBLEM: What is the flow capacity of this safety valve in pounds of saturated steam per hour for the same pressure setting?

SOLUTION:

For air: Weight of dry air at 60ºF and 14.7 psia is 0.0766 lb/cu ft.

$$Wa = 10{,}000 \times 0.0766 \times 60 = 45{,}960 \text{ lb/hr}$$

$$45{,}960 = 356\,KAP\sqrt{\frac{28.97}{460 + 60}}$$

$$KAP = 546$$

For steam,

$$W_s = 51.5\,KAP = (51.5)(546)$$

$$= 28{,}200 \text{ lb/hr}$$

NOTE: Before converting the capacity of a safety valve from any gas to steam, the requirements of UG-131(b) must be met.

11-2

(a) Since it is realized that the saturated water capacity is configuration sensitive, the following applies only to those safety valves that have a nozzle type construction (throat to inlet diameter ratio of 0.25 to 0.80 with a continuously contoured change and have exhibited a coefficient K_D in excess of 0.90). No saturated water rating shall apply to other types of construction.

NOTE: The manufacturer, user, and Inspector are all cautioned that for the following rating to apply, the valve shall be continuously subjected to saturated water. If, after initial relief the flow media changes to quality steam, the valve shall be rated as per dry saturated steam. Valves installed on vessels or lines containing steam-water mixture shall be rated dry saturated steam.

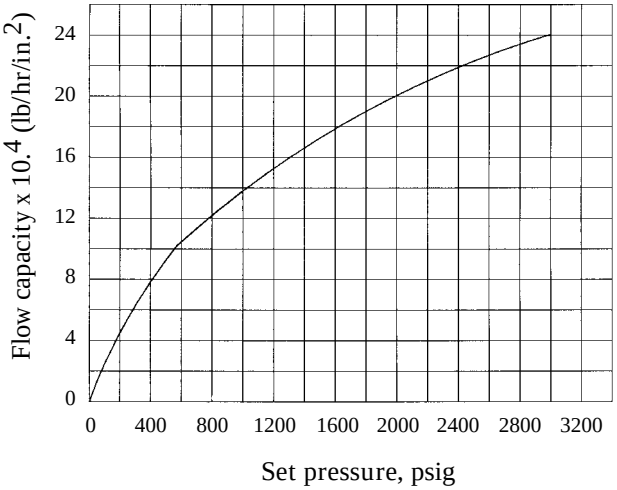


FIG. 11-2 FLOW CAPACITY CURVE FOR RATING NOZZLE TYPE SAFETY VALVES ON SATURATED WATER (BASED ON 10% OVERPRESSURE)

(b) To determine the saturated water capacity of a valve currently rated under UG-131 and meeting the requirements of (a) above, refer to Fig. 11-2. Enter the graph at the set pressure of the valve, move vertically upward to the saturated water line and read horizontally the relieving capacity. This capacity is the theoretical, isentropic value arrived at by assuming equilibrium flow and calculated values for the critical pressure ratio.

NOTES:

NOTES:

STEAM TABLE*

h = Total heat of steam, Btu per pound
v = Specific volume, cubic feet per pound

Pressure psi (gage)	Temperature F° (sat.)		Saturated Liquid	Saturated Vapor	TOTAL TEMPERATURE, °F												
					220	240	260	280	300	320	340	360	380	400	420	440	460
0	212	h	180.1	1150.4	1154.4	1164.2	1173.8	1183.3	1192.8	1202.3	1211.7	1221.1	1230.5	1239.9	1249.3	1258.8	1268.2
		v	0.0167	26.80	27.15	28.00	28.85	29.70	30.53	31.37	32.20	33.03	33.85	34.68	35.50	36.32	37.14
5	228	h	196.2	1156.3		1162.3	1172.2	1182.0	1191.6	1201.2	1210.8	1220.3	1229.7	1239.2	1248.7	1258.2	1267.6
		v	0.0168	20.089		20.48	21.11	21.74	22.36	22.98	23.60	24.21	24.82	25.43	26.04	26.65	27.25
10	240	h	208.4	1160.6			1170.7	1180.6	1190.5	1200.2	1209.8	1219.4	1229.0	1238.5	1248.1	1257.6	1267.1
		v	0.0169	16.303			16.819	17.330	17.836	18.337	18.834	19.329	19.821	20.31	20.80	21.29	21.77
15	250	h	218.8	1164.1			1169.1	1179.3	1189.3	1199.1	1208.9	1218.6	1228.3	1237.9	1247.5	1257.0	1266.6
		v	0.0170	13.746			13.957	14.390	14.816	15.238	15.657	16.072	16.485	16.897	17.306	17.714	18.121
20	259	h	227.9	1167.1			1167.5	1177.9	1188.1	1198.1	1208.0	1217.8	1227.5	1237.2	1246.8	1256A	1266.1
		v	0.0171	11.898			11.911	12.288	12.659	13.025	13.387	13.746	14.103	14.457	14.810	15.162	15.512
25	267	h	236.0	1169.7				1176.5	1186.8	1197.0	1207.0	1216.9	1226.7	1236.5	12462	1255.9	1265.5
		v	0.0171	10.498				10.711	11.040	11.364	11.684	12.001	12.315	12.628	12.938	13.247	13.555
30	274	h	243.4	1172.0				1175.0	1185.6	1195.9	1206.0	1216.0	1225.9	1235.8	1245.6	1255.3	1265.0
		v	0.0172	9.401				9.484	9.781	10.072	10.359	10.643	10.925	11.204	11.482	11.758	120033
40	287	h	256.3	1175.9					1183.0	1193.6	1204.0	1214.3	1224.4	1234.3	1244.3	1254.1	1263.9
		v	0.0173	7.787					7.947	8.192	8.432	8.668	8.902	9.134	9.364	9.592	9.819
50	298	h	267.5	1179.1					1180.3	1191.3	1202.0	1212.5	1222.7	1232.9	1242.9	1252.9	1262.8
		v	0.0174	6.655					6.676	6.889	7.096	7.300	7.501	7.700	7.896	8.091	8.285
60	308	h	277.4	1181.9						1188.9	1199.9	1210.6	1221.1	1231.4	1241.6	1251.7	1261.7
		v	0.0175	5.816						5.9321	6.116	6.296	6.473	6.648	6.820	6.991	7.161
70	316	h	286.4	1184.2						1186.4	1197.7	1208.7	1219.4	1229.9	1240.2	1250.4	1260.6
		v	0.0176	5.168						5.200	5.366	5.528	5.687	5.843	5.997	6.150	6.301
80	324	h	294.6	1186.2							1195.5	1206.7	1217.7	1228.3	1238.8	1249.2	1259.4
		v	0.0177	4.652							4.773	4.921	5.065	5.207	5.347	5.485	5.621
90	331	h	302.1	1188.1							1193.2	1204.7	1215.9	1226.7	1237.4	1247.9	1258.2
		v	0.0178	4.232							4.292	4.429	4.562	4.693	4.821	4.947	5.071
100	338	h	309.1	1189.7							1190.8	1202.7	1214.1	1225.2	1236.0	1246.6	1257.1
		v	0.0178	3.882							3.895	4.022	4.146	4.267	4.385	4.502	4.617
125	353	h	324.8	1193.0								1197.3	1209.4	1211.1	1232.3	1243.3	1254.1
		v	0.0180	3.220								3.258	3.365	3.468	3.569	3.667	3.764
150	366	h	338.5	1195.6									1204.5	1216.7	1228.4	1239.8	1251.0
		v	0.0182	2.752									2.818	2.910	2.998	3.085	3.169
175	378	h	350.8	1197.6									1199.3	1212.2	1224.5	1236.3	1247.8
		v	0.0183	2.404									2.414	2.498	2.577	2.655	2.730
200	388	h	361.9	1199.3										1207.4	1220.3	1232.6	1244.5
		v	0.0185	2.134										2.180	2.253	2.324	2.393
225	397	h	372.1	1200.6										1202.5	1216.0	1228.8	1241.1
		v	0.0186	1.9183										1.9276	1.9964	2.062	2.126
250	406	h	381.6	1201.7											1211.5	1224.9	1237.6
		v	0.0187	1.7422											1.7870	1.8488	1.9081
275	414	h	390.5	1202.6											1206.8	1220.8	1234.0
		v	0.0188	1.5954											1.6130	1.6717	1.7277
300	422	h	398.8	1203.2												1216.5	1230.3
		v	0.0190	1.4711												1.5222	1.5755
350	436	h	414.1	1204.1												1207.5	1222.4
		v	0.0192	1.2720												1.2831	1.3326
400	448	h	428.1	1204.6													1214.0
		v	0.0194	1.1194													1.1468
450	460	h	440.9	1204.6													
		v	0.0196	0.9985													
500	470	h	452.9	1204.2													
		v	0.0198	0.9004													
550	480	h	464.1	1203.7													
		v	0.0200	0.8191													
600	489	h	474.7	1203.0													
		v	0.0202	0.7503													

*Adapted with permission from “Thermodynamic Properties of Steam”, Keenan and Keyes, published by John Wiley & Sons, Inc.

STEAM TABLE*

h = Total heat of steam, Btu per pound
v = Specific volume, cubic feet per pound

TOTAL TEMPERATURE, °F																	Temperature °F (sat.)	Pressure psi (gage)
480	500	520	540	560	580	600	620	640	660	680	700	720	740	750				
1277.6	1287.1	1296.6	1306.2	1315.7	1325.3	1334.8	1344.5	1354.2	1363.8	1373.5	1383.2	1393.0	1402.8	1407.7	h	212	0
37.96	38.78	39.60	40.41	41.23	42.04	42.86	43.68	44.49	45.31	46.12	46.94	47.75	48.56	48.97	v		
1277.1	1286.6	1296.2	1305.7	1315.3	1324.8	1334.4	1344.1	1353.8	1363.5	1373.2	1382.9	1392.7	1402.6	1407.5	h	228	5
27.86	28.46	29.06	29.67	30.27	30.87	31.47	32.07	32.67	33.27	33.87	34.47	35.07	35.67	35.96	v		
1276.6	1286.2	1295.8	1305.3	1314.9	1324.5	1334.1	1343.8	1353.5	1363.2	1372.9	1382.6	1392.5	1402.3	1407.2	h	240	10
22.26	22.74	23.22	23.71	24.19	24.68	25.16	25.64	26.12	26.60	27.08	27.56	28.04	28.52	28.76	v		
1276.2	1285.7	1295.3	1304.9	1314.5	1324.2	1333.8	1343.5	1353.2	1362.9	1372.6	1382.4	1392.3	1402.1	1407.0	h	250	15
18.528	18.933	19.337	19.741	20.144	20.547	20.95	21.35	21.75	22.15	22.56	22.96	23.36	23.76	23.96	v		
1275.7	1285.3	1294.9	1304.5	1314.1	1323.8	1333.5	1343.2	1352.9	1362.6	1372.3	1382.1	1391.9	1401.8	1406.7	h	259	20
15.862	16.210	16.558	16.905	17.251	17.597	17.943	18.288	18.633	18.977	19.322	19.666	20.01	20.35	20.52	v		
1275.2	1284.8	1294.5	1304.1	1313.8	1323.4	1333.1	1342.8	1352.5	1362.3	1372.1	1381.9	1391.7	1401.6	1406.5	h	267	25
13.862	14.168	14.473	14.778	15.082	15.385	15.688	15.990	16.293	16.595	16.896	17.198	17.499	17.8001	7.951	v		
1274.7	1284.4	1294.0	1303.7	1313.4	1323.1	1332.8	1342.5	1352.2	1362.0	1371.8	1381.6	1391.5	1401.4	1406.3	h	274	30
12.307	12.580	12.852	13.123	13.394	13.665	13.935	14.204	14.473	14.742	15.011	15.279	15.547	15.815	15.949	v		
1273.7	1283.4	1293.2	1302.9	1312.6	1322.4	1332.1	1341.9	1351.7	1361.5	1371.3	1381.1	1391.0	1400.9	1405.8	h	287	40
10.044	10.269	10.493	10.717	10.940	11.162	11.384	11.605	11.826	12.047	12.268	12.488	12.708	12.927	13.037	v		
1272.7	1282.5	1292.3	1302.1	1311.9	1321.7	1331.5	1341.3	1351.1	1360.9	1370.8	1380.6	1390.5	1400.4	1405.4	h	298	50
8.478	8.670	8.861	9.051	9.240	9.429	9.618	9.806	9.993	10.181	10.368	10.555	10.741	10.928	11.021	v		
1271.6	1281.5	1291.4	1301.3	1311.1	1321.0	1330.8	1340.6	1350.5	1360.3	1370.2	1380.1	1390.0	1399.9	1404.9	h	308	60
7.329	7.496	7.663	7.829	7.994	8.159	8.323	8.486	8.649	8.812	8.975	9.138	9.300	9.462	9.543	v		
1270.6	1280.6	1290.5	1300.5	1310.4	1320.2	1330.1	1340.0	1349.9	1359.8	1369.7	1379.6	1389.6	1399.5	1404.5	h	316	70
6.450	6.599	6.747	6.894	7.041	7.187	7.332	7.477	7.622	7.766	7.910	8.054	8.198	8.341	8.413	v		
1269.5	1279.6	1289.6	1299.6	1309.6	1319.5	1329.4	1339.4	1349.3	1359.3	1369.2	1379.1	1389.1	1399.0	1404.0	h	324	80
5.756	5.891	6.024	6.156	6.288	6.419	6.550	6.680	6.810	6.940	7.069	7.199	7.327	7.456	7.520	v		
1268.5	1278.6	1288.7	1298.8	1308.8	1318.8	1328.7	1338.7	1348.7	1358.6	1368.6	1378.5	1388.5	1398.5	1403.5	h	331	90
5.195	5.317	5.439	5.559	5.679	5.799	5.918	6.036	6.154	6.272	6.389	6.506	6.623	6.740	6.798	v		
1267.4	1277.7	1287.8	1297.9	1308.0	1318.0	1328.1	1338.1	1348.0	1358.0	1368.0	1378.0	1388.1	1398.1	1403.1	h	338	100
4.730	4.843	4.955	5.066	5.176	5.285	5.394	5.503	5.611	5.719	5.827	5.934	6.041	6.148	6.201	v		
1264.7	1275.2	1285.5	1295.8	1306.0	1316.2	1326.4	1336.5	1346.6	1356.6	1366.7	1376.8	1386.9	1397.0	1402.0	h	353	125
3.860	3.954	4.047	4.140	4.232	4.323	4.413	4.503	4.593	4.683	4.772	4.861	4.949	5.038	5.082	v		
1261.9	1272.6	1283.2	1293.6	1304.0	1314.3	1324.6	1334.8	1345.0	1355.2	1365.3	1375.4	1385.6	1395.8	1400.8	h	366	150
3.252	3.334	3.414	3.494	3.573	3.652	3.730	3.807	3.884	3.960	4.037	4.113	4.188	4.264	4.301	v		
1259.0	1270.0	1280.8	1291.4	1302.0	1312.4	1322.8	1333.2	1343.5	1353.7	1363.9	1374.2	1384.4	1394.6	1399.7	h	378	175
2.804	2.877	2.948	3.019	3.089	3.157	3.226	3.294	3.361	3.429	3.495	3.562	3.628	3.694	3.727	v		
1256.0	1267.3	1278.3	1289.2	1299.9	1310.5	1321.0	1331.4	1341.8	1352.2	1362.5	1372.8	1383.1	1393.3	1398.5	h	388	200
2.460	2.525	2.590	2.653	2.716	2.777	2.839	2.900	2.960	3.019	3.079	3.139	3.198	3.256	3.286	v		
1253.0	1264.5	1275.8	1286.9	1297.8	1308.5	1319.2	1329.8	1340.3	1350.7	1361.1	1371.5	1381.9	1392.2	1397.3	h	397	225
2.187	2.247	2.306	2.364	2.421	2.477	2.533	2.587	2.642	2.696	2.750	2.804	2.857	2.910	2.936	v		
1249.9	1261.7	1273.2	1284.5	1295.6	1306.5	1317.3	1328.0	1338.7	1349.2	1359.7	1370.2	1380.6	1391.0	1396.2	h	406	250
1.9654	2.021	2,076	2.129	2.181	2.233	2.284	2.334	2.384	2.434	2.483	2.532	2.580	2.629	2.653	v		
1246.6	1258.8	1270.6	1282.1	1293.4	1304.5	1315.5	1326.3	1337.0	1347.7	1358.3	1368.8	1379.3	1389.8	1395.0	h	414	275
1.7816	1.8338	1.8846	1.9342	1.9829	2.031	2.078	2.125	2.171	2.217	2.262	2.307	2.352	2.396	2.418	v		
1243.3	1255.8	1267.9	1279.7	1291.2	1302.5	1313.6	1324.5	1335.4	1346.1	1356.8	1367.4	1378.0	1388.6	1393.8	h	422	300
1.6266	1.6759	1.7237	1.7703	1.8159	1.8607	1.9048	1.9483	1.9912	2.034	2.076	2.118	2.159	2.200	2.220	v		
1236.4	1249.6	1262.4	1274.7	1286.6	1298.2	1309.7	1320.9	1332.0	1343.0	1353.9	1364.7	1375.4	1386.1	1391.4	h	436	350
1.3795	1.4243	1.4675	1.5094	1.5501	1.5900	1.6291	1.6676	1.7056	1.7430	1.7801	1.8168	1.8531	1.8892	1.9071	v		
1229.0	1243.2	1256.6	1269.4	1281.8	1293.9	1305.7	1317.2	1328.6	1339.8	1350.9	1361.9	1372.8	1383.6	1389.0	h	448	400
1.1908	1.2325	1.2724	1.3108	1.3480	1.3842	1.4196	1.4544	1.4885	1.5222	1.5554	1.5883	1.6207	1.6529	1.6689	v		
1221.2	1236.3	1250.5	1264.0	1276.9	1289.4	1301.6	1313.5	1325.1	1336.5	1347.8	1359.0	1370.1	1381.1	1386.5	h	460	450
1.0416	1.0811	1.1186	1.1544	1.1889	1.2224	1.2550	1.2868	1.3180	1.3488	1.3789	1.4088	1.4382	1.4675	1.4819	v		
1212.8	1229.0	1244.0	1258.3	1271.8	1284.8	1297.3	1309.6	1321.5	1333.2	1344.7	1356.1	1367.3	1378.4	1384.0	h	470	500
0.9204	0.9584	0.9941	1.0280	1.0604	1.0917	1.1221	1.1516	1.1805	1.2088	1.2367	1.2641	1.2913	1.3180	1.3313	v		
	1221.4	1237.4	1252.4	1266.5	1280.0	1293.0	1305.6	1317.8	1329.8	1341.6	1353.2	1364.6	1375.8	1381.4	h	480	550
	0.8565	0.8909	0.9234	0.9542	0.9838	1.0124	1.0401	1.0671	1.0935	1.1195	1.1449	1.1700	1.1947	1.2070	v		
	1213.2	1230.3	1246.1	1261.0	1275.1	1288.5	1301.5	1314.1	1326.3	1338.3	1350.2	1361.8	1373.2	1378.9	h	489	600
	0.7703	0.8040	0.8353	0.8649	0.8931	0.9203	0.9465	0.9720	0.9968	1.0211	1.0450	1.0684	1.0916	1.1030	v		

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