

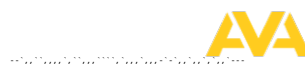
Sizing, Selection, and Installation of Pressure-relieving Devices

Part I—Sizing and Selection

API STANDARD 520
NINTH EDITION, JULY 2014



AMERICAN PETROLEUM INSTITUTE



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Foreword

API Standard 520, *Sizing, Selection, and Installation of Pressure-relieving Devices*, is the result of several years' work by engineers in the petroleum industry. The information in this standard is intended to supplement the information contained in Section VIII—*Pressure Vessels*, of the *ASME Boiler and Pressure Vessel Code*. The recommendations presented in this publication are not intended to supersede applicable laws and regulations.

Users of this standard are reminded that no publication of this type can be complete, nor can any written document be substituted for qualified engineering analysis.

Shall: As used in a standard, “shall” denotes a minimum requirement in order to conform to the specification.

Should: As used in a standard, “should” denotes a recommendation or that which is advised but not required in order to conform to the specification.

The current edition of this standard, published in two parts, has been updated with respect to the practices generally used in the installation of all devices covered in the previous editions; the current edition also contains additional information based on revisions suggested by many individuals and several organizations.

The First Edition of this standard was initially released as a recommended practice in 1955. The Second Edition was published in two parts: Part I, *Design*, in 1960 and Part II, *Installation*, in 1963. The Third Edition of Part I was issued in November 1967 and reaffirmed in 1973. The Fourth Edition was issued in December 1976, the Fifth Edition was issued in July 1990, the Sixth Edition was issued in March 1993, the Seventh Edition was issued in January 2000, and the Eighth Edition was issued in December 2008.

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

Document ID: 1234567890

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Sizing, Selection, and Installation of Pressure-relieving Devices

Part I—Sizing and Selection

1 Scope

This standard applies to the sizing and selection of pressure-relief devices used in refineries, chemical facilities, and related industries for equipment that has a maximum allowable working pressure (MAWP) of 15 psig (103 kPag) or greater. The pressure-relief devices covered in this standard are intended to protect unfired pressure vessels and related equipment against overpressure from operating and fire contingencies.

This standard includes basic definitions and information about the operational characteristics and applications of various pressure-relief devices. It also includes sizing procedures and methods based on steady state flow of Newtonian fluids.

Pressure-relief devices protect a vessel against overpressure only; they do not protect against structural failure when the vessel is exposed to extremely high temperatures such as during a fire. See API 521 for information about appropriate ways of reducing pressure and restricting heat input.

Atmospheric and low-pressure storage tanks covered in API 2000 and pressure vessels used for the transportation of products in bulk or shipping containers are not within the scope of this standard.

The rules for overpressure protection of fired vessels are provided in ASME BPVC, Section I and are not within the scope of this standard.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Standard 520, *Sizing, Selection, and Installation of Pressure-relieving Devices in Refineries, Part II—Installation*

API Standard 521, *Pressure-relieving and Depressuring Systems*

API Standard 526, *Flanged Steel Pressure-relief Valves*

API Standard 527, *Seat Tightness of Pressure-relief Valves*

API Standard 2000, *Venting Atmospheric and Low-pressure Storage Tanks*

ASME Boiler and Pressure Vessel Code (BPVC)¹, *Section I: Power Boilers*

ASME Boiler and Pressure Vessel Code (BPVC), *Section VIII: Pressure Vessels; Division 1*

ASME Boiler and Pressure Vessel Code (BPVC) Code Case 2203², *Omission of Lifting Device Requirements for Pressure Relief Valves on Air, Water Over 140°F, or Steam Service*

ASME B31.1, *Power Piping*

ASME B31.3, *Process Piping*

ASME PTC 25, *Pressure Relief Devices*

¹ ASME International, 3 Park Avenue, New York, New York 10016, www.asme.org.

² Code Cases are temporary in nature and may not be acceptable in all jurisdictions. The user should verify the current applicability of the referenced Code Cases.

3 Terms and Definitions

For the purposes of this document, the following definitions apply. Many of the terms and definitions are taken from ASME PTC 25.

3.1

accumulation

The pressure increase over the MAWP of the vessel, expressed in pressure units or as a percentage of MAWP or design pressure. Maximum allowable accumulations are established by applicable codes for emergency operating and fire contingencies.

3.2

actual discharge area

actual orifice area

The area of a pressure-relief valve (PRV) is the minimum net area that determines the flow through a valve.

3.3

backpressure

The pressure that exists at the outlet of a pressure-relief device as a result of the pressure in the discharge system. Backpressure is the sum of the superimposed and built-up backpressures.

3.4

balanced pressure-relief valve

A spring-loaded pressure-relief valve that incorporates a bellows or other means for minimizing the effect of backpressure on the operational characteristics of the valve.

3.5

blowdown

The difference between the set pressure and the closing pressure of a pressure-relief valve, expressed as a percentage of the set pressure or in pressure units.

3.6

bore area

nozzle area

nozzle throat area

throat area

The minimum cross-sectional flow area of a nozzle in a pressure-relief valve.

3.7

built-up backpressure

The increase in pressure at the outlet of a pressure-relief device that develops as a result of flow after the pressure-relief device opens.

3.8

burst pressure

The value of the upstream static pressure minus the value of the downstream static pressure just prior to when the disk bursts. When the downstream pressure is atmospheric, the burst pressure is the upstream static gauge pressure.

3.9

burst pressure tolerance

The variation around the marked burst pressure at the specified disk temperature in which a rupture disk shall burst.

3.10**capacity**

The rated capacity of steam, air, gas, or water as required by the applicable code.

3.11**chatter**

The opening and closing of a PRV at a very high frequency (on the order of the natural frequency of the valve's spring mass system).

3.12**closing pressure**

The value of decreasing inlet static pressure at which the valve disc reestablishes contact with the seat or at which lift becomes zero as determined by seeing, feeling, or hearing.

3.13**coefficient of discharge**

The ratio of the mass flow rate in a valve to that of an ideal nozzle. The coefficient of discharge is used for calculating flow through a pressure-relief device.

3.14**cold differential test pressure****CDTP**

The pressure at which a pressure-relief valve is adjusted to open on the test stand. The CDTP includes corrections for the service conditions of backpressure or temperature or both.

3.15**conventional pressure-relief valve**

A spring-loaded pressure-relief valve whose operational characteristics are directly affected by changes in the backpressure.

3.16**curtain area**

The area of the cylindrical or conical discharge opening between the seating surfaces above the nozzle seat created by the lift of the disc.

3.17**cycling**

The relatively low frequency (a few cycles per second to a few seconds per cycle) opening and closing of a pressure-relief valve.

3.18**design pressure**

Pressure, together with the design temperature, used to determine the minimum permissible thickness or physical characteristic of each vessel component as determined by the vessel design rules. The design pressure is selected by the user to provide a suitable margin above the most severe pressure expected during normal operation at a coincident temperature. It is the pressure specified on the purchase order. This pressure may be used in place of the MAWP in all cases where the MAWP has not been established. The design pressure is equal to or less than the MAWP.

3.19**effective coefficient of discharge**

A nominal value used with an effective discharge area to calculate the relieving capacity of a pressure-relief valve per the preliminary sizing equations.

3.20**effective discharge area**
effective orifice area

A nominal area used with an effective discharge coefficient to calculate the relieving capacity of a pressure-relief valve per the preliminary sizing equations. API 526 provides effective discharge areas for a range of sizes in terms of letter designations, "D" through "T."

3.21**flutter**

The abnormal, rapid reciprocating motion of the moveable parts of the PRV. During the fluttering, the disk does not contact the seat or the upper stop.

3.22**huddling chamber**

An annular chamber located downstream of the seat of a pressure-relief valve for the purpose of assisting the valve to achieve lift.

3.23**inlet size**

The nominal pipe size (NPS) of the device at the inlet connection, unless otherwise designated.

3.24**leak test pressure**

The specified inlet static pressure at which a seat leak test is performed.

3.25**lift**

The actual travel of the disc from the closed position when a valve is relieving.

3.26**lot of rupture disks**

Disks manufactured at the same time and of the same size, material, thickness, type, heat, and manufacturing process, including heat treatment.

3.27**manufacturing design range**

The pressure range in which the rupture disk shall be marked. Manufacturing design ranges are usually catalogued by the manufacturer as a percentage of the specified burst pressure. Catalogued manufacturing design ranges may be modified by agreement between the user and the manufacturer.

3.28**marked burst pressure**
rated burst pressure

The burst pressure established by tests for the specified temperature and marked on the disk tag by the manufacturer. The marked burst pressure may be any pressure within the manufacturing design range unless otherwise specified by the customer. The marked burst pressure is applied to all of the rupture disks of the same lot.

3.29**maximum allowable working pressure**
MAWP

The maximum gauge pressure permissible at the top of a completed vessel in its normal operating position at the designated coincident temperature specified for that pressure. The pressure is the least of the values for the internal or external pressure as determined by the vessel design rules for each element of the vessel using actual nominal thickness, exclusive of additional metal thickness allowed for corrosion and loadings



other than pressure. The MAWP is the basis for the pressure setting of the pressure-relief devices that protect the vessel. The MAWP is normally greater than the design pressure but can be equal to the design pressure when the design rules are used only to calculate the minimum thickness for each element and calculations are not made to determine the value of the MAWP.

3.30

maximum operating pressure

The maximum pressure expected during normal system operation.

3.31

minimum net flow area

The calculated net area after a complete burst of a rupture disk with appropriate allowance for any structural members that may reduce the net flow area through the rupture disk device.

3.32

modulating pressure-relief valve

A pressure-relief valve that opens and flows in proportion to the inlet pressure for some or all parts of the valve's operating range from set pressure to overpressure at full lift.

3.33

nonfragmenting rupture disk

A rupture disk designed and manufactured to be installed upstream of other piping components. Nonfragmenting rupture disks do not impair the function of pressure-relief valves when the disk ruptures.

3.34

nonreclosing pressure-relief device

A pressure-relief device which remains open after operation. A manual resetting means may be provided.

3.35

opening pressure

The value of increasing inlet static pressure at which there is a measurable lift of the disc or at which discharge of the fluid becomes continuous, as determined by seeing, feeling, or hearing.

3.36

operating ratio of a pressure-relief valve

The ratio of maximum system operating pressure to the set pressure.

3.37

operating ratio of a rupture disk

The ratio of the maximum system operating pressure to a pressure associated with a rupture disk (see Figure 26 and Figure 28). For marked burst pressures above 40 psi, the operating ratio is the ratio of maximum system operating pressure to the disk marked burst pressure. For marked burst pressures between 15 psi and 40 psi, the operating ratio is the ratio of maximum system operating pressure to the marked burst pressure minus 2 psi. For marked burst pressures less than 15 psi, the operating ratio should be determined by consulting the manufacturer.

3.38

outlet size

The NPS of the device at the discharge connection, unless otherwise designated.

3.39

overpressure

The pressure increase over the set pressure of the relieving device. Overpressure is expressed in pressure units or as a percentage of set pressure. Overpressure is the same as accumulation only when the relieving device is set to open at the MAWP of the vessel.

3.40**pilot-operated pressure-relief valve**

A pressure-relief valve in which the major relieving device or main valve is combined with and controlled by a self-actuated auxiliary pressure-relief valve (pilot).

3.41**pin-actuated device**

A nonreclosing pressure-relief device actuated by static pressure and designed to function by buckling or breaking a pin which holds a piston or a plug in place. Upon buckling or breaking of the pin, the piston or plug instantly moves to the full open position.

3.42**pressure-relief device****PRD**

A device actuated by inlet static pressure and designed to open during emergency or abnormal conditions to prevent a rise of internal fluid pressure in excess of a specified design value. The device also may be designed to prevent excessive internal vacuum. The device may be a pressure-relief valve, a nonreclosing pressure-relief device, or a vacuum relief valve.

3.43**pressure-relief valve****PRV**

A pressure-relief device designed to open and relieve excess pressure and to reclose and prevent the further flow of fluid after normal conditions have been restored.

3.44**rated coefficient of discharge**

A value used with the actual discharge area to calculate the rated flow capacity of a pressure-relief valve. The rated coefficient of discharge of a pressure-relief valve is determined in accordance with the applicable code or regulation.

3.45**rated relieving capacity**

The basis for the application of a pressure-relief device. This capacity is determined in accordance with the applicable code or regulation and is provided by the manufacturer.

3.46**relief valve**

A spring-loaded pressure-relief valve actuated by the static pressure upstream of the valve. The valve opens normally in proportion to the pressure increase over the opening pressure. A relief valve is used primarily with incompressible fluids.

3.47**relieving conditions**

The inlet pressure and temperature on a pressure-relief device during an overpressure condition. The relieving pressure is equal to the valve set pressure (or rupture disk burst pressure) plus the overpressure. The temperature of the flowing fluid at relieving conditions may be higher or lower than the operating temperature.

3.48**rupture disk**

A pressure-containing, pressure- and temperature-sensitive element of a rupture disk device.



3.49**rupture disk device**

A nonreclosing pressure-relief device actuated by static differential pressure between the inlet and outlet of the device and designed to function by the bursting of a rupture disk. A rupture disk device includes a rupture disk and a rupture disk holder.

3.50**rupture disk holder**

The structure that encloses and clamps the rupture disk in position. Some disks are designed to be installed between standard flanges without holders.

3.51**safety relief valve**

A spring-loaded pressure-relief valve that may be used as either a safety or relief valve depending on the application.

3.52**safety valve**

A spring-loaded pressure-relief valve actuated by the static pressure upstream of the valve and characterized by rapid opening or pop action. A safety valve is normally used with compressible fluids.

3.53**set pressure**

The inlet gauge pressure at which the pressure-relief device is set to open under service conditions.

3.54**simmer**

The audible or visible escape of compressible fluid between the seat and disc of a pressure-relief valve that may occur at an inlet static pressure below the set pressure prior to opening.

3.55**specified burst pressure**

The burst pressure specified by the user. The marked burst pressure may be greater than or less than the specified burst pressure but shall be within the manufacturing design range. The user is cautioned to consider manufacturing design range, superimposed backpressure, and specified temperature when determining a specified burst pressure.

3.56**specified disk temperature**

The temperature of the disk when the disk is expected to burst. The specified disk temperature is the temperature the manufacturer uses to establish the marked burst pressure. The specified disk temperature is rarely ever the design temperature of the vessel and may not even be the operating temperature or relief temperature, depending on the relief system configuration.

3.57**superimposed backpressure**

The static pressure that exists at the outlet of a pressure-relief device at the time the device is required to operate. Superimposed backpressure is the result of pressure in the discharge system coming from other sources and may be constant or variable.

4 Pressure-relief Devices

4.1 General

This section describes the basic principles, operational characteristics, applications, and selection of pressure-relief devices used independently or in combination. These devices include spring-loaded and pilot-operated pressure-relief valves (PRVs), rupture disk devices, and other pressure-relief devices. These devices are described in the text and illustrated in Figure 1 through Figure 29.

4.2 Pressure-relief Valves (PRVs)

4.2.1 Spring-loaded PRVs

4.2.1.1 Conventional PRVs

4.2.1.1.1 A conventional PRV (see Figure 1 and Figure 4) is a self-actuated spring-loaded PRV that is designed to open at a predetermined pressure and protect a vessel or system from excess pressure by removing or relieving fluid from that vessel or system. The valve shown in Figure 4 is available in small sizes, commonly used for thermal relief valve applications. The basic elements of a spring-loaded PRV include an inlet nozzle connected to the vessel or system to be protected, a movable disc that controls flow through the nozzle, and a spring that controls the position of the disc. Under normal system operating conditions, the pressure at the inlet is below the set pressure and the disc is seated on the nozzle preventing flow through the nozzle.

4.2.1.1.2 Spring-loaded PRVs are referred to by a variety of terms, such as safety valves, relief valves, and safety relief valves. These terms have been traditionally applied to valves for gas/vapor service, liquid service, or multiservice applications, respectively. The more generic term, PRV, is used in the text and is applicable to all three.

4.2.1.1.3 The operation of a conventional spring-loaded PRV is based on a force balance (see Figure 5). The spring load is preset to equal the force exerted on the closed disc by the inlet fluid when the system pressure is at the set pressure of the valve. When the inlet pressure is below the set pressure, the disc remains seated on the nozzle in the closed position. When the inlet pressure exceeds set pressure, the pressure force on the disc overcomes the spring force and the valve opens. When the inlet pressure is reduced to the closing pressure, the valve recloses.

4.2.1.1.4 When the valve is closed during normal operation (see Figure 5, Item A) the system or vessel pressure acting against the disc surface (area A) is resisted by the spring force. As the system pressure approaches the set pressure of the valve, the seating force between the disc and the nozzle approaches zero.

4.2.1.1.5 In vapor or gas service, the valve may “simmer” before it will “pop.” When the vessel pressure closely approaches the set pressure, fluid will audibly move past the seating surfaces into the huddling chamber B. As a result of the restriction of flow between the disc holder and the adjusting ring, pressure builds up in the huddling chamber B (see Figure 5, Item B). Since pressure now acts over a larger area, an additional force, commonly referred to as the expansive force, is available to overcome the spring force. By changing the position of the adjusting ring, the opening in the annular orifice can be altered, thus controlling the pressure buildup in the huddling chamber B. This controlled pressure buildup in the huddling chamber will overcome the spring force causing the disc to move away from the nozzle seat, and the valve will pop open.

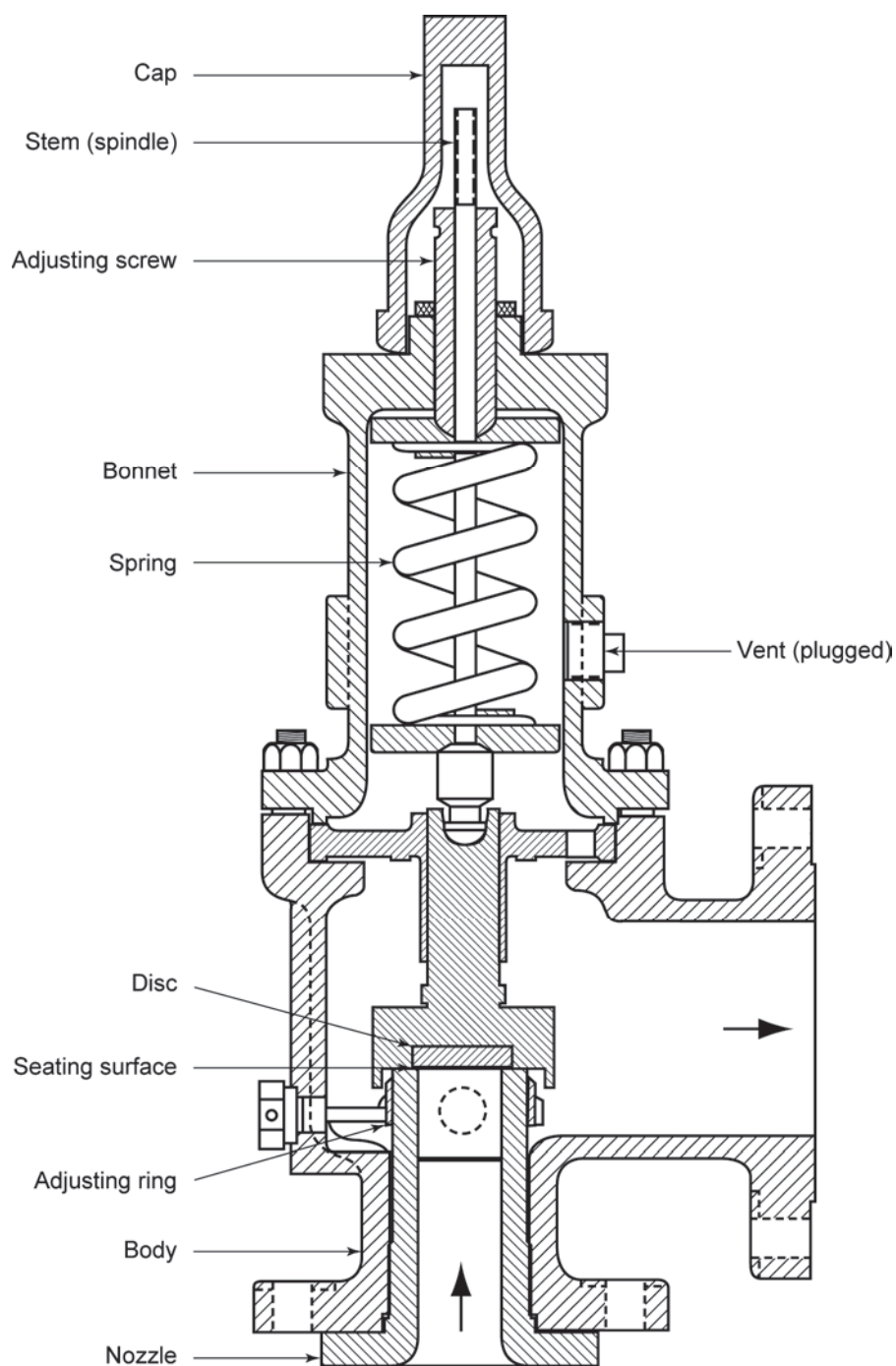


Figure 1—Conventional PRV with a Single Adjusting Ring for Blowdown Control

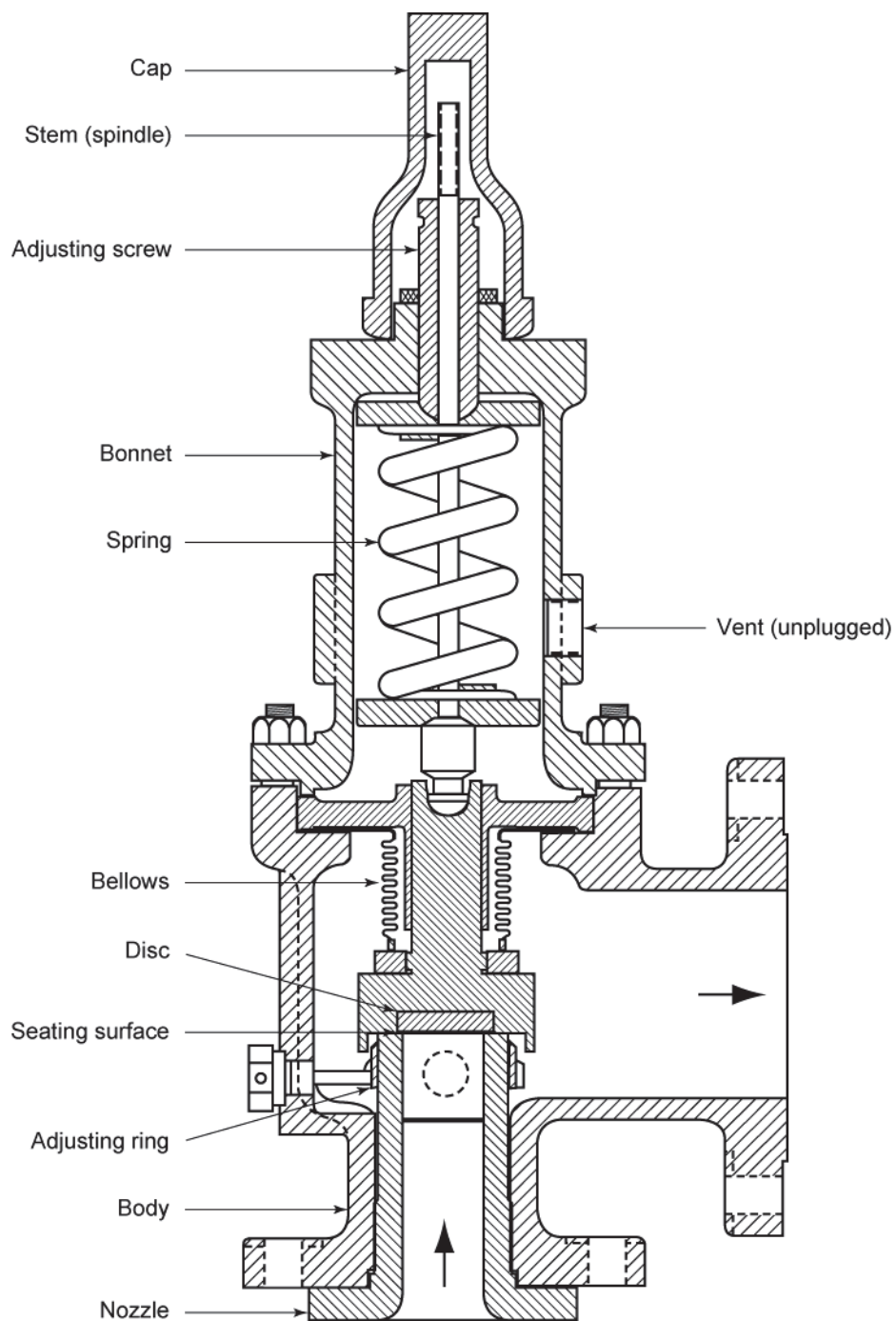


Figure 2—Balanced-bellows PRV

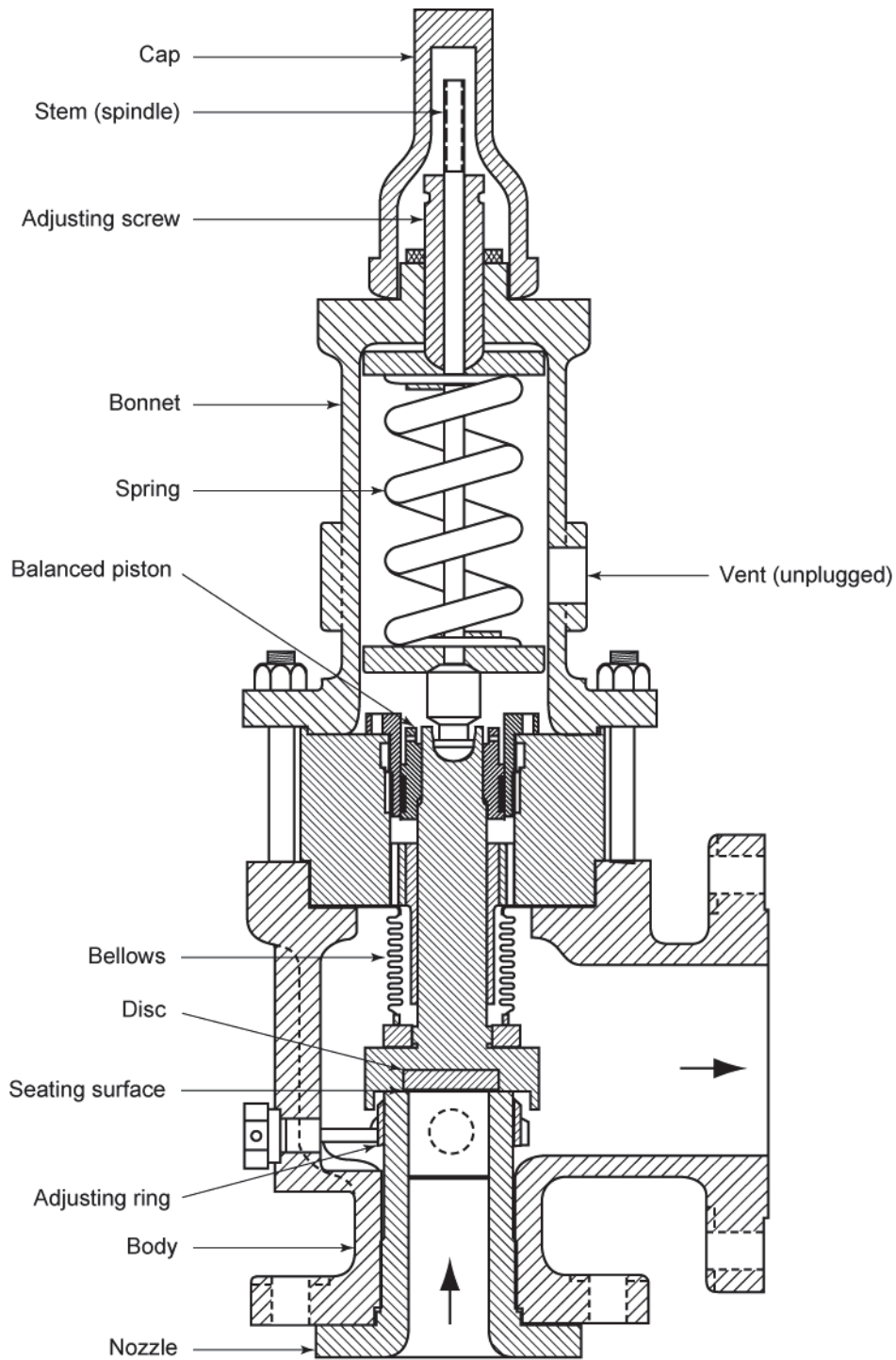


Figure 3—Balanced-bellows PRV with an Auxiliary Balanced Piston

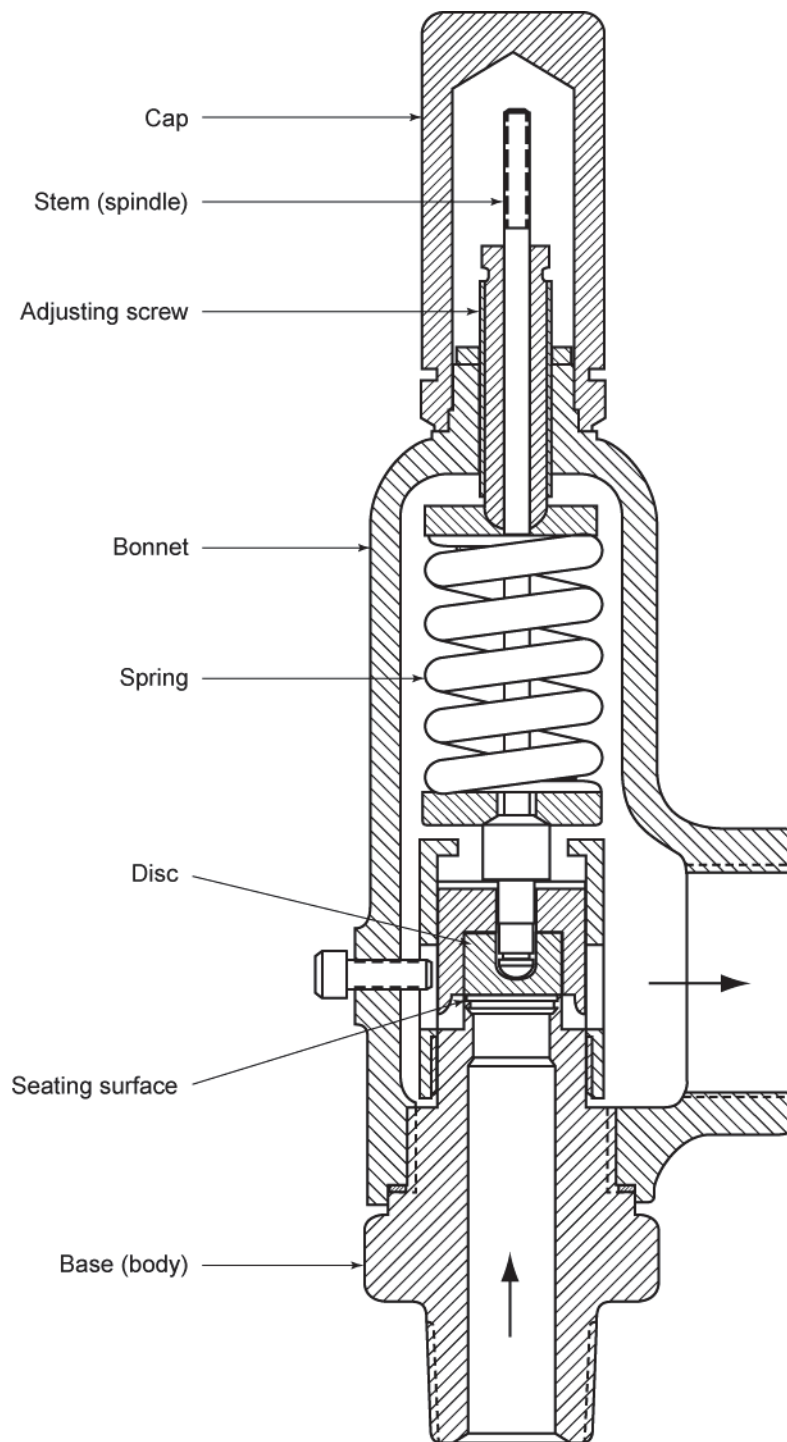


Figure 4—Conventional PRV with Threaded Connections

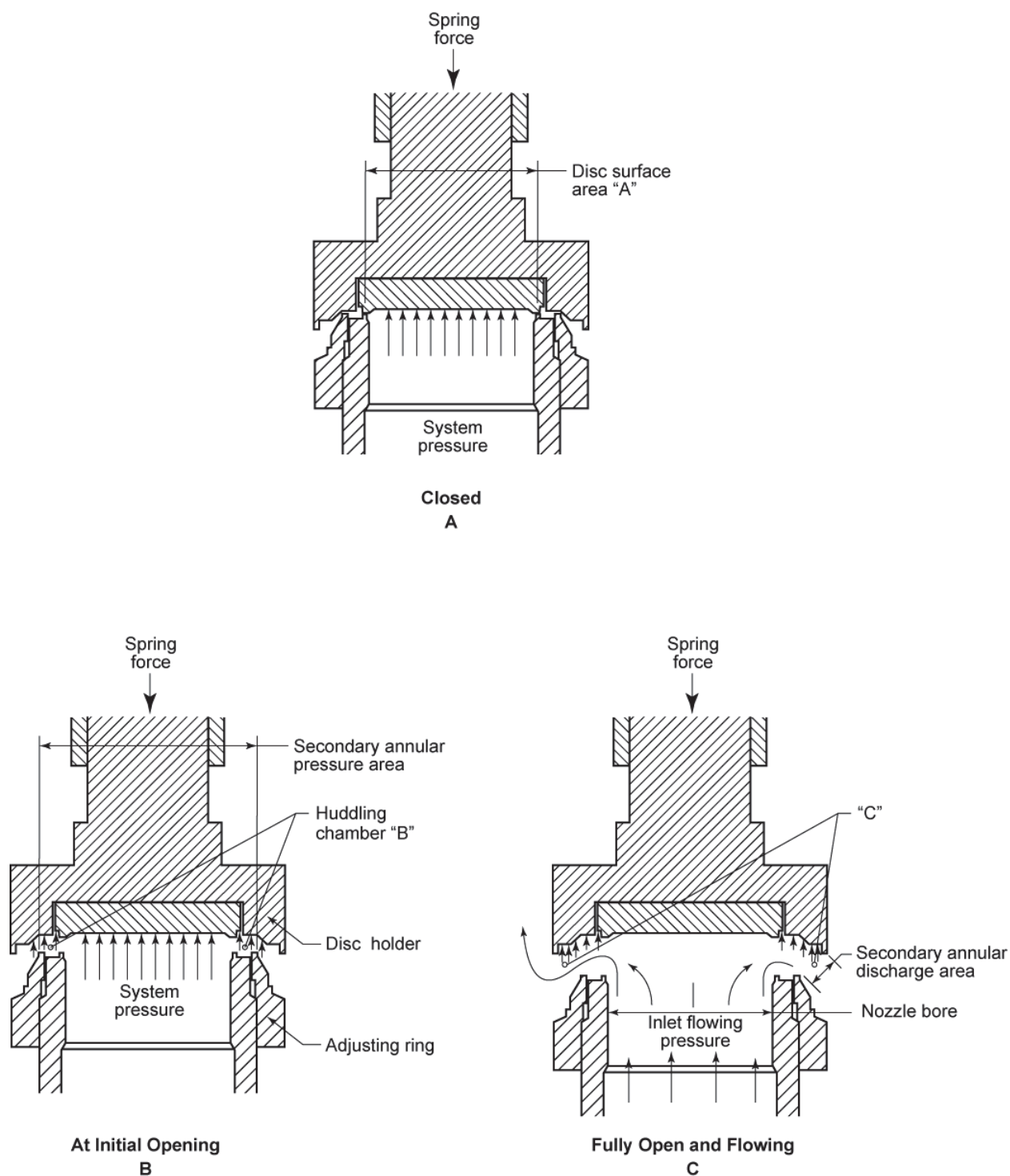


Figure 5—PRV Operation—Vapor/Gas Service

4.2.1.1.6 Once the valve has opened, an additional pressure buildup at C occurs (see Figure 5, Item C). This is due to the sudden flow increase and the restriction to flow through another annular orifice formed between the inner edge of the disc holder skirt and the outside diameter of the adjusting ring. These additional forces at C cause the disc to lift substantially at pop.

4.2.1.1.7 Flow is restricted by the opening between the nozzle and the disc until the disc has been lifted from the nozzle seat approximately one quarter of the nozzle diameter. After the disc has attained this degree of lift, flow is then controlled by the bore area rather than by the area between the seating surfaces.

4.2.1.1.8 The valve closes when the inlet pressure has dropped sufficiently below the set pressure to allow the spring force to overcome the summation of forces at A, B, and C. The pressure at which the valve reseats is the closing pressure. The difference between the set pressure and the closing pressure is blowdown.

4.2.1.1.9 Figure 6 shows the disc travel from the set pressure, A, to the maximum relieving pressure, B, during the overpressure incident and to the closing pressure, C, during the blowdown.

4.2.1.2 Spring-loaded PRVs Designed for Liquid Service Applications

4.2.1.2.1 Liquid service valves do not pop in the same manner as vapor service valves (see Figure 7), since the expansive forces produced by vapor are not present in liquid flow. Liquid service valves typically rely on reactive forces to achieve lift.

4.2.1.2.2 When the valve is closed, the forces acting on the valve disc are the same as those applied by vapor until a force balance is reached and the net force holding the seat closed approaches zero. From this point on, the force relationship is totally different.

4.2.1.2.3 At initial opening, the escaping liquid forms a very thin sheet of fluid, as seen in Figure 7, Item A, expanding radially between the seating surfaces. The liquid strikes the reaction surface of the disc holder and is deflected downward, creating a reactive (turbine) force tending to move the disc and holder upward. These forces typically build very slowly during the first 2 % to 4 % of overpressure.

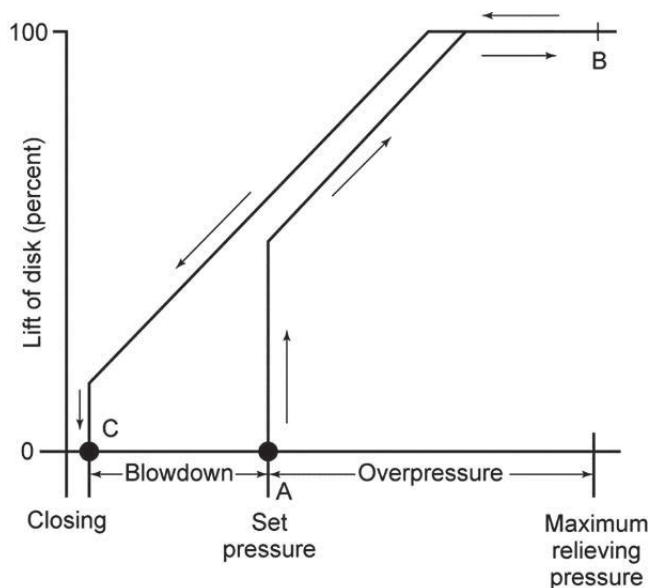


Figure 6—Typical Relationship Between Lift of Disk in a PRV and Vessel Pressure

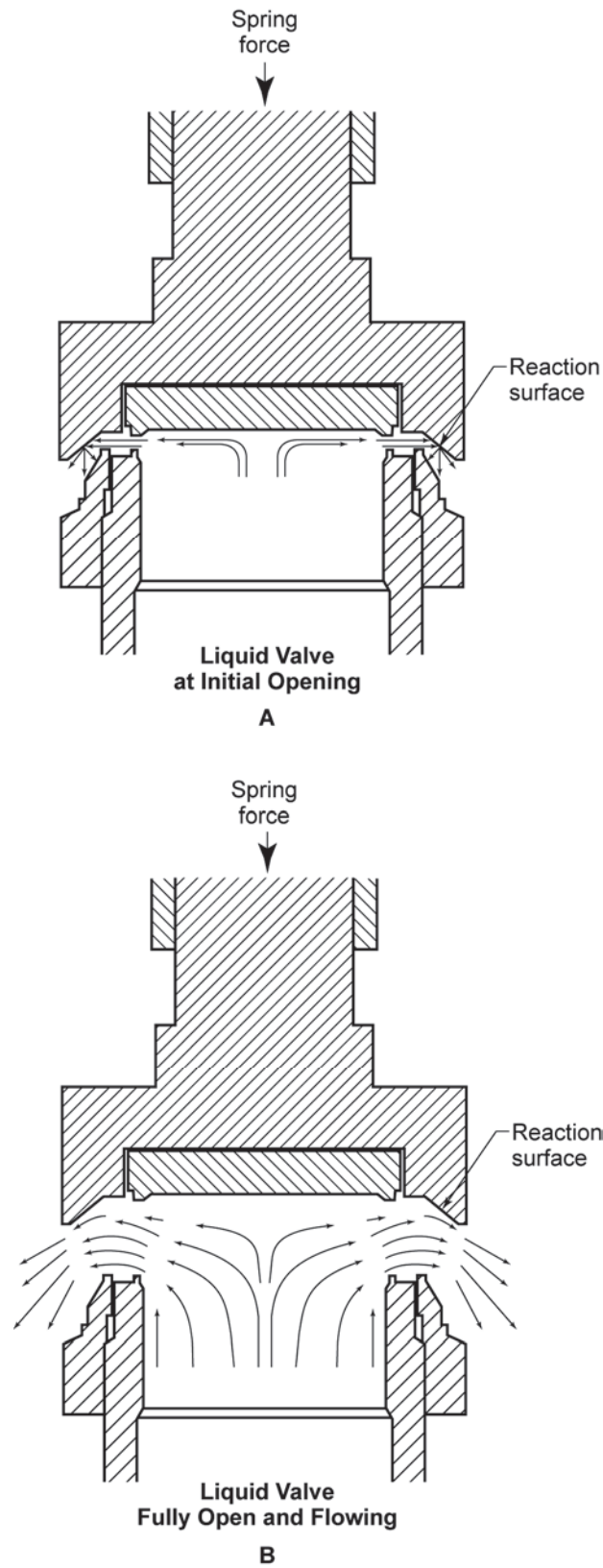


Figure 7—PRV Operation—Liquid Service

4.2.1.2.4 As the flow gradually increases, the velocity head of the liquid moving through the nozzle also increases. These momentum forces, combined with the reactive forces of the radially discharging liquid as it is deflected downward from the reaction surface (see Figure 7, Item B), are substantial enough to cause the valve to go into lift. Typically, the valve will suddenly surge to 50 % to 100 % lift at 2 % to 6 % overpressure. As the overpressure increases, these forces continue to grow, driving the valve into full lift. Liquid service valves, capacity certified in accordance with the ASME Code, are required to reach full rated capacity at 10 % or less overpressure.

4.2.1.2.5 In the closing cycle, as the overpressure decreases, momentum and reactive forces decrease, allowing the spring force to move the disc back into contact with the seat.

4.2.1.2.6 Historically, many PRVs used in liquid applications were safety relief or relief valves designed for compressible (vapor) service. Many of these valves, when used in liquid service, required high overpressure (25 %) to achieve full lift and stable operation, since liquids do not provide the expansive forces that vapors do. Where liquid PRVs were required to operate within the accumulation limit of 10 %, a conservative factor of 0.6 was applied to the valve capacity when sizing the valves. Consequently, many installations were oversized and instability often resulted. The criteria used for sizing this type of valve may be found in 5.9.

4.2.1.2.7 Rules have been incorporated into the ASME Code, as well as other international standards that address performance of liquid service valves at 10 % overpressure and require a capacity certification. PRVs designed for liquid service have been developed that achieve full lift, stable operation, and rated capacity at 10 % overpressure in compliance with the requirements. Blowdown is adjustable in some designs. Some valves are designed so that they operate on liquid and gas. Such valves may, however, exhibit different operational characteristics, depending on whether the flow stream is liquid, gas, or a combination of the two. Many PRVs designed for liquid service, for example, will have a much longer blowdown (typically 20 %) on gas than on liquid service. Additionally, some variation in set pressure may occur if the valve is set on liquid and required to operate on gas or vice versa.

4.2.1.2.8 The rules for sizing PRVs designed for liquid service are given in 5.8. If a capacity on gas service is required, 5.6.3 or 5.6.4 should be used for the preliminary sizing calculation. Capacity certification data for sizing on liquid and gas service should be obtained from the manufacturer for use in final sizing and application of the valve.

4.2.1.2.9 Spring-loaded PRVs designed for liquid (or liquid and gas) applications and that are balanced to minimize the effects of backpressure are recommended for two-phase applications when the fluid being relieved may be liquid, gas, or a multiphase mixture. Many manufacturers recommend that valves designed for liquid or liquid-and-gas service be used if the mass percentage of the two-phase mixture at the valve inlet is 50 % vapor or less. In addition, if the ratio of liquid to gas in the flow stream is not certain, a valve specifically designed for liquid service or for service on liquid and gas should be used.

4.2.1.2.10 PRVs designed for liquid and gas service should be specified for the fluid to which the valve is normally exposed. For example, if a liquid and gas service valve is located in the vapor region of a vessel containing a liquid level, the valve should be specified for gas service. The valve capacity stamped on the nameplate will be in SCFM of air. If a liquid and gas service valve is located on the liquid side of a heat exchanger, then the valve should be specified in liquid service. This valve will have a capacity stamped in gallons per minute of water.

4.2.1.2.11 In some applications, the valve may be required to relieve a liquid or a gas depending on the condition causing the overpressure (e.g. heat exchanger tube rupture). In this application, a valve designed for liquid service or one designed for liquid and gas service is recommended.

4.2.1.2.12 The user is cautioned that vapor certified relief valves relieving liquid are more prone to chatter than liquid certified relief valves relieving liquid. It has been observed on PRV test stands that vapor certified PRVs relieving liquid at very low overpressures (where flow rate is about 5 % of PRV capacity) will flow without much flutter, but at higher overpressures the PRV disk may lift abruptly resulting in unstable valve

operation. Vapor certified valves relieving liquid may exhibit stable flow where overpressure is high (20 % or higher) or where the valve lift is mechanically limited. Liquid certified valves were designed to solve the observed instability problems with liquid relief.

4.2.1.3 Balanced PRVs

4.2.1.3.1 A balanced PRV is a spring-loaded PRV that incorporates a bellows or other means of balancing the valve disc to minimize the effects of backpressure on the performance characteristics of the valve (see Figure 2 and Figure 3).

4.2.1.3.2 When a superimposed backpressure is applied to the outlet of a conventional spring-loaded PRV, a pressure force is applied to the valve disc that is additive to the spring force. This added force increases the pressure at which an unbalanced PRV will open. If the superimposed backpressure is variable, then the pressure at which the valve will open will vary (see Figure 8).

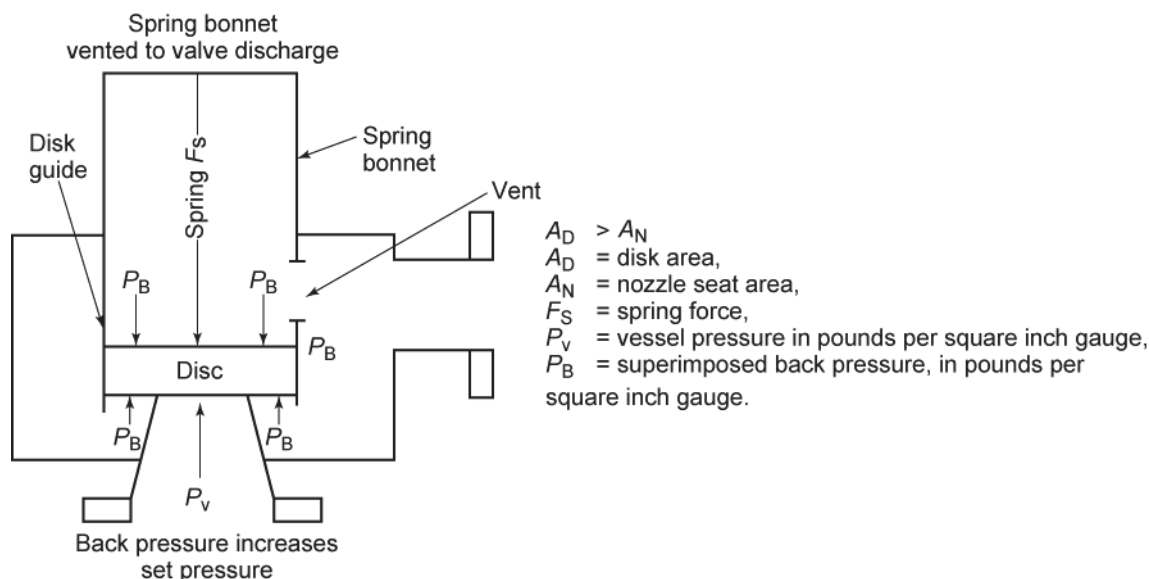


Figure 8—Typical Effects of Superimposed Backpressure on the Opening Pressure of Conventional PRVs

4.2.1.3.3 In a balanced-bellows PRV, a bellows is attached to the disc holder with an effective bellows area, A_B , approximately equal to or greater than the seating area of the disc, A_N (see Figure 9). This isolates an area on the disc, approximately equal to the disc seat area, from the backpressure. If the bellows area, A_B , were identical to the area of the disc, A_N , the variable backpressure would not affect the PRV opening pressure. However, considerations concerning the bellows manufacturing tolerances and the possible variations of opening pressure with backpressure lead to the use of bellows with minimum effective bellows area A_B greater than or equal to A_N . This ensures that backpressure does not increase the opening pressure of the balanced PRV. With the addition of a bellows, therefore, the opening pressure of the PRV will remain constant or decrease with increases in backpressure. This change in opening pressure corresponds to the variation within the bellows manufacturing tolerance. The magnitude of this effect is normally acceptable. Where opening pressures are reduced due to backpressures, the closing pressures will also be reduced resulting in longer blowdown. Consult the manufacturer when there are concerns about backpressure effects on opening pressure.

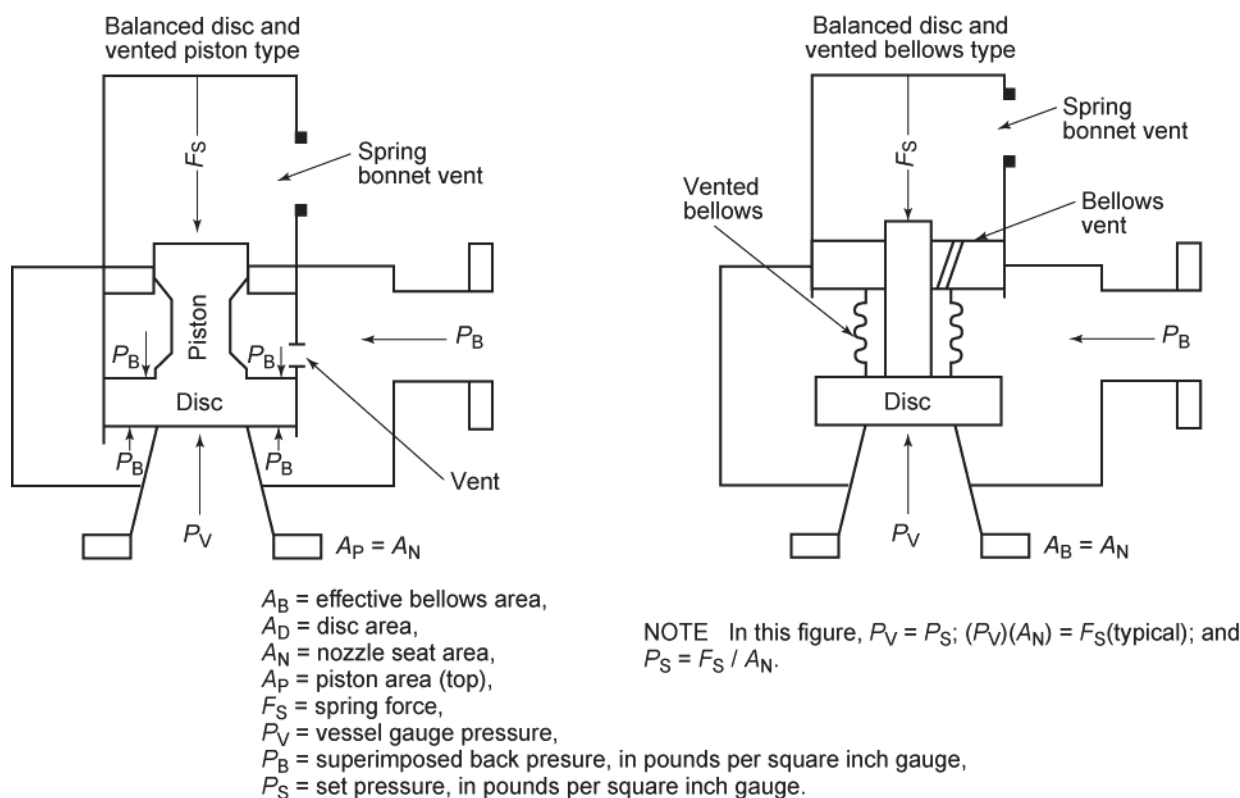


Figure 9—Typical Effects of Backpressure on the Set Pressure of Balanced PRVs

4.2.1.3.4 The internal area of the bellows in a balanced-bellows spring-loaded PRV is referenced to atmospheric pressure in the valve bonnet. It is important that the bonnet of a balanced PRV be vented to the atmosphere for the bellows to perform properly. If the valve is located where atmospheric venting would present a hazard or is not permitted by regulations, the vent shall be piped to a safe location that is free of backpressure that may affect the PRV opening pressure.

4.2.1.3.5 Other means of balancing a spring-loaded PRV such as a sealed piston are used in some valve designs. These designs perform in a manner similar to the balanced bellows design.

4.2.1.3.6 When the superimposed backpressure is constant, the spring load can be reduced to compensate for the effect of backpressure on set pressure, and a balanced valve is not required. There are cases where superimposed backpressure is not always constant and such cases shall be evaluated carefully.

4.2.1.3.7 Balanced PRVs should be considered where the built-up backpressure (backpressure caused by flow through the downstream piping after the PRV lifts) is too high for a conventional pressure-relief (see 5.3.3.1). A detailed discussion of backpressure and its effects on PRV performance and flow capacity can be found in 5.3.

4.2.1.3.8 Balanced PRVs may also be used as a means to isolate the guide, spring, bonnet, and other top works parts within the valve from the relieving fluid. This may be important if there is concern that the fluid will cause corrosive damage to these parts.

4.2.1.3.9 It is important to remember that the bonnet of a balanced PRV shall be vented to atmosphere at all times. The user should be cautioned of the potential for freezing of atmospheric moisture inside the bonnet in cold service due to autorefrigeration or cold ambient temperatures.

4.2.2 Pilot-operated PRVs

4.2.2.1 General

4.2.2.1.1 A pilot-operated PRV consists of the main valve, which normally encloses a floating unbalanced piston assembly, and an external pilot (see Figure 10 through Figure 14). The piston is designed to have a larger area on the top than on the bottom. Up to the set pressure, the top and bottom areas are exposed to the same inlet operating pressure. Because of the larger area on the top of the piston, the net force holds the piston tightly against the main valve nozzle. As the operating pressure increases, the net seating force increases and tends to make the valve tighter. This feature allows most pilot-operated valves to be used where the maximum expected operating pressure is higher than the percentage shown in Figure 15. At the set pressure, the pilot vents the pressure from the top of the piston; the resulting net force is now upward causing the piston to lift, and process flow is established through the main valve. After the overpressure incident, the pilot will close the vent from the top of the piston, thereby reestablishing pressure, and the net force will cause the piston to reseat.

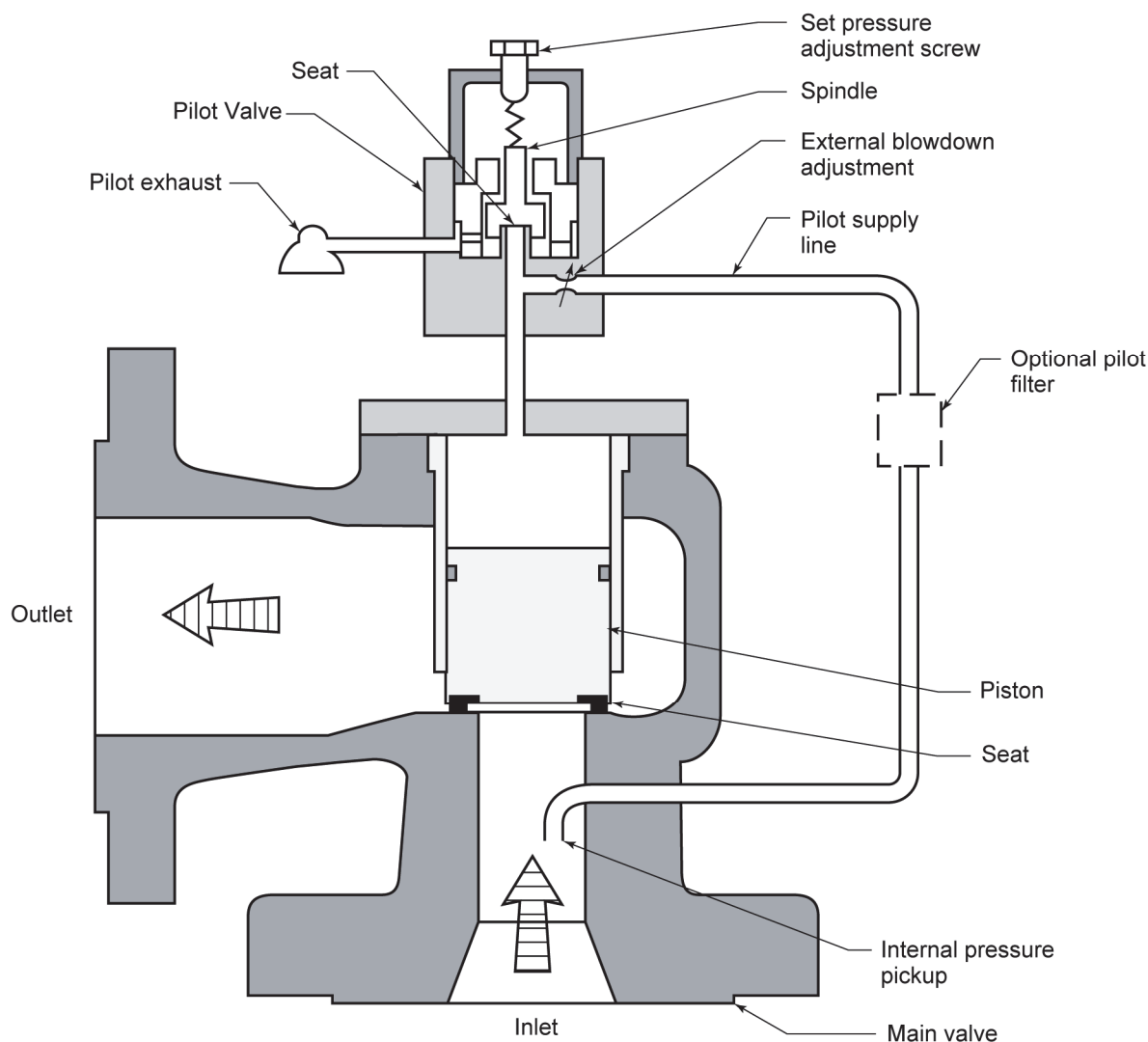


Figure 10—Pop-action Pilot-operated Valve (Flowing Type)

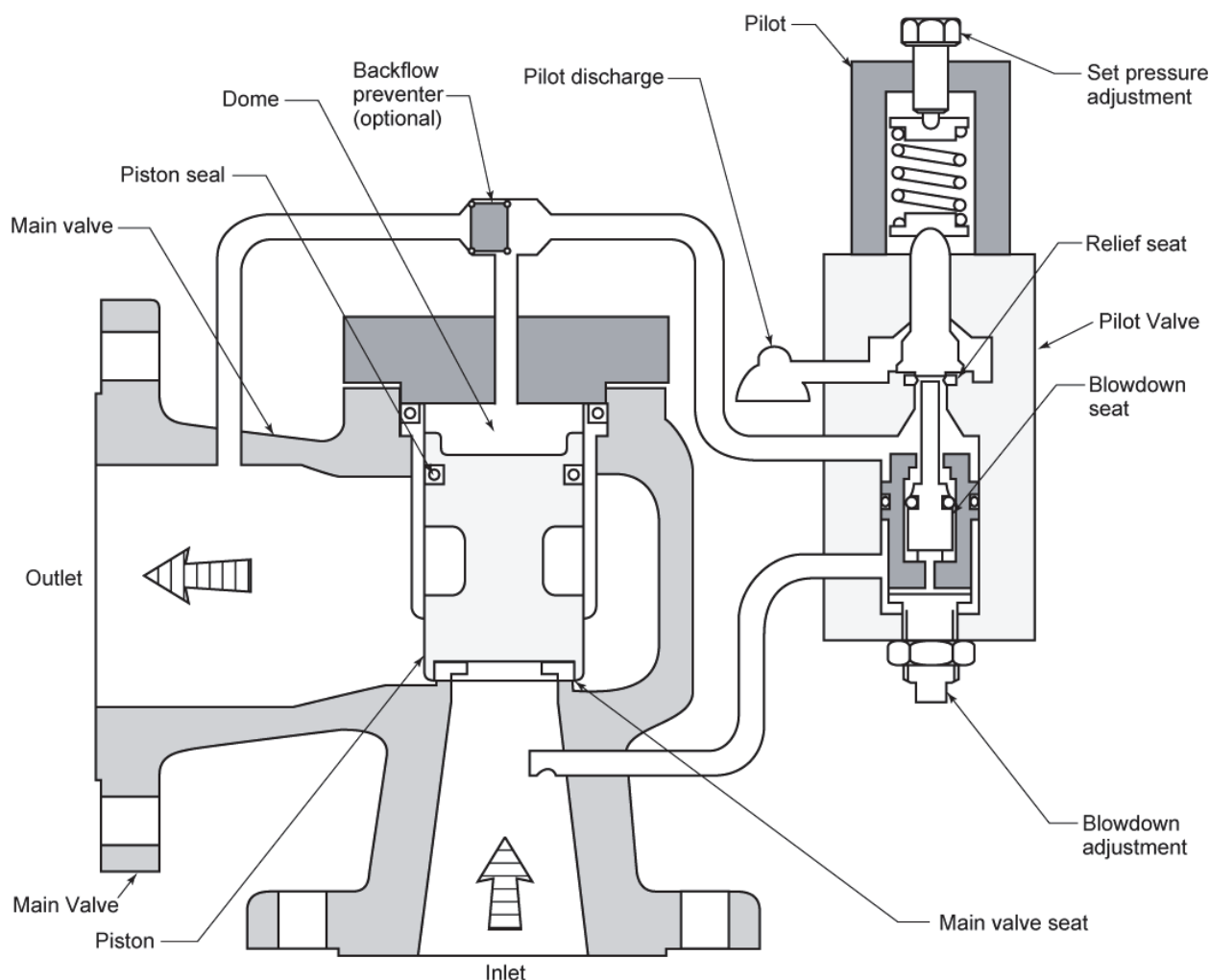


Figure 11—Pop-action Pilot-operated Valve (Nonflowing Type)

4.2.2.1.2 The main valve of the pilot-operated PRV can use a diaphragm in lieu of a piston to provide the unbalanced moving component of the valve. A disc, which normally closes the main valve inlet, is integral with a flexible diaphragm (see Figure 14). The external pilot serves the same function to sense process pressure, vent the top of the diaphragm at set pressure, and reload the diaphragm once the process pressure is reduced. As with the piston valve, the seating force increases proportionally with the operating pressure because of the differential exposed area of the diaphragm.

4.2.2.1.3 The lift of the main valve piston or diaphragm, unlike a conventional or balanced spring-loaded valve, is not affected by built-up backpressure. This allows for even higher pressures in the relief discharge manifolds.

4.2.2.1.4 The pilot vent can be either directly exhausted to atmosphere or to the main valve outlet depending upon the pilot's design and user's requirement. Only a balanced type of pilot, where set pressure is unaffected by backpressure, should be installed with its exhaust connected to a location with varying pressure (such as to the main valve outlet). Slight variations in backpressure may be acceptable for unbalanced pilots (see 5.3.3.1).

4.2.2.2 Backflow Prevention

A backflow preventer is required when the possibility exists of developing a pressure on the discharge side of the valve that exceeds the inlet pressure of the valve. The higher discharge pressure can cause sufficient upward force on the diaphragm or piston to open the valve and cause flow reversal. The backflow preventer

allows the discharge pressure to provide a net downward force on the diaphragm or piston to keep the valve closed (see Figure 11). The proper operation of the backflow preventer is critical to further insuring no flow reversal occurs in the valve. The selection of the material and seals in the backflow preventer should be consistent with the pilot-operated PRV.

4.2.2.3 Pilot Types

4.2.2.3.1 The pilot that operates the main valve can be either a pop-action or modulating action pilot. The pop-action pilot, as shown in Figure 16, causes the main valve to lift fully at set pressure without overpressure. This immediate release of pressure provides extremely high opening and closing forces on the main valve seat. This opening action is typically not recommended for liquid services to avoid valve instability.

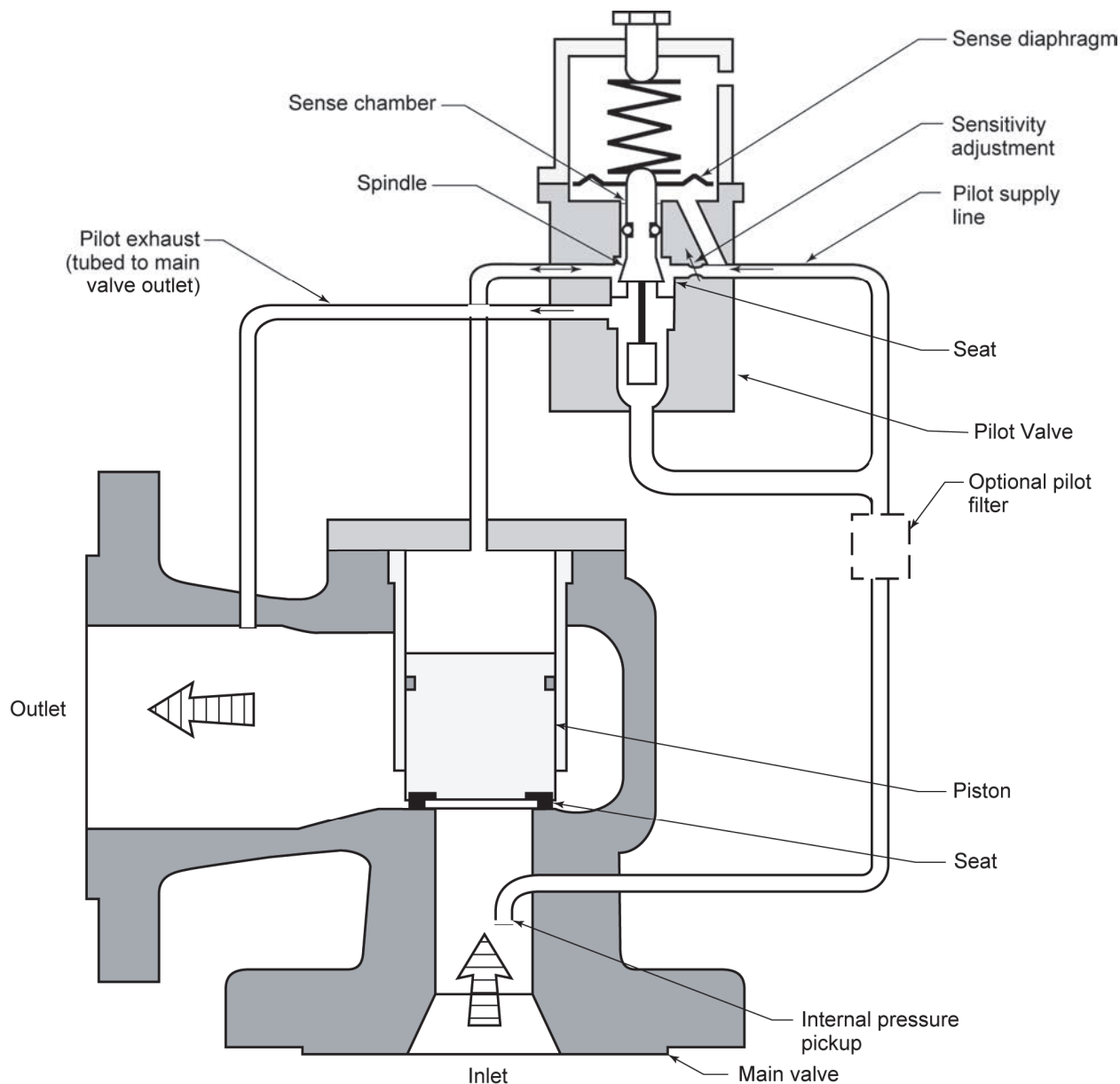


Figure 12—Modulating Pilot-operated Valve (Flowing Type)

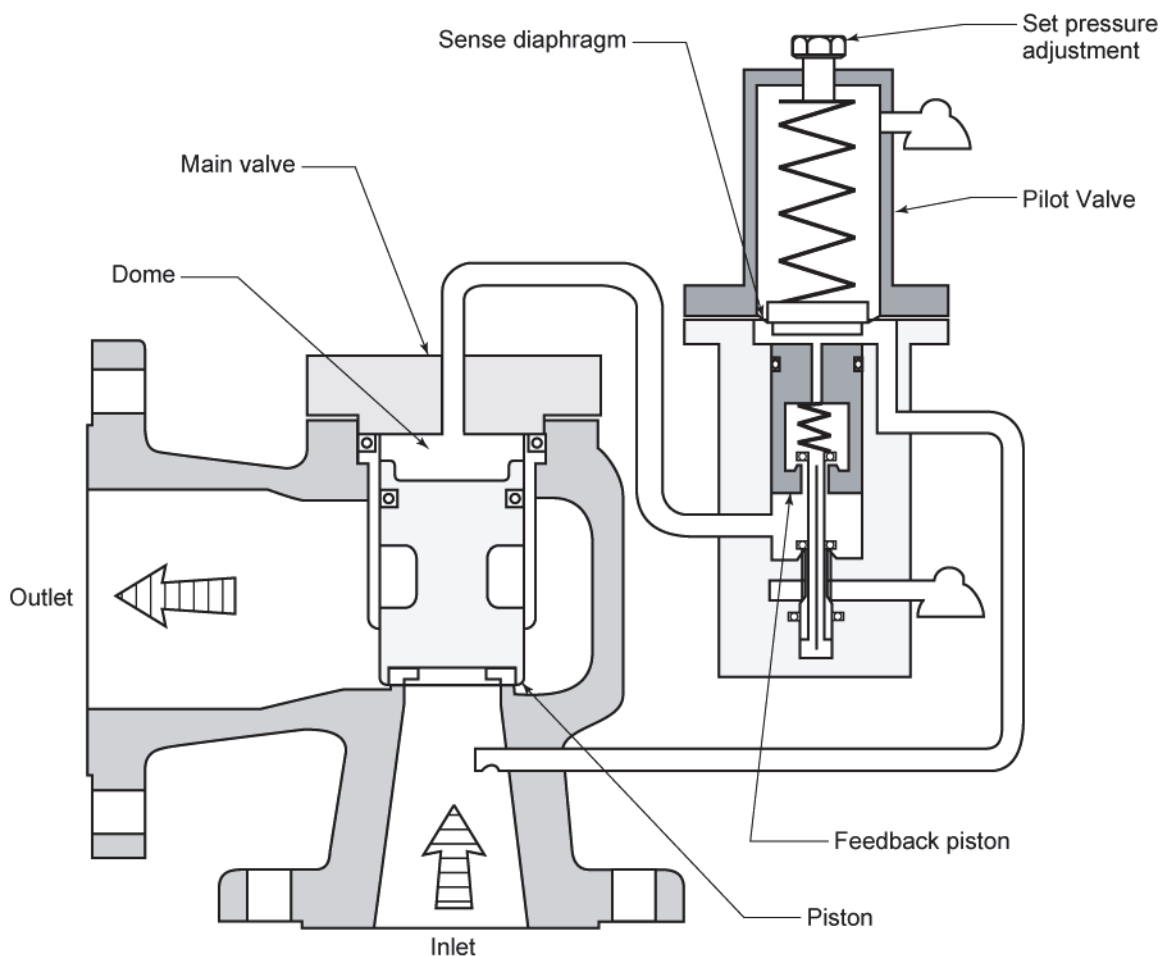


Figure 13—Pilot-operated Relief Valve with a Nonflowing Modulating Pilot Valve

4.2.2.3.2 The modulating pilot, as shown in Figure 17, opens the main valve only enough to satisfy the required relieving capacity and can be used in gas, liquid, or two-phase flow applications. A modulating pilot-operated valve, in contrast to a pop action valve, limits the amount of relieving fluid to only the amount required to prevent the pressure from exceeding the allowable accumulation. Since a modulating pilot only releases the required relieving rate, the calculation of built-up backpressure may be based on the required relieving rate instead of the rated relieving capacity of the valve. The modulating pilot valve also can reduce interaction with other pressure control equipment in the system during an upset condition, reduce unwanted atmospheric emissions, and reduce the noise level associated with discharge to the atmosphere.

4.2.2.3.3 The pilots may be either a flowing or nonflowing type. The flowing type allows process fluid to continuously flow through the pilot when the main valve is open; the nonflowing type does not. The nonflowing pilot type is generally recommended for most services to reduce the possibility of hydrate formation (icing) or solids in the lading fluid affecting the pilot's performance.

4.2.2.4 Application and Limitations of Pilot-operated PRVs

4.2.2.4.1 Pilot-operated PRVs are available for use in liquid and vapor services. Operating characteristics of some pilot-operated PRVs are unaffected by the state of fluid (liquid or gas), and these types are recommended for two-phase flow applications.

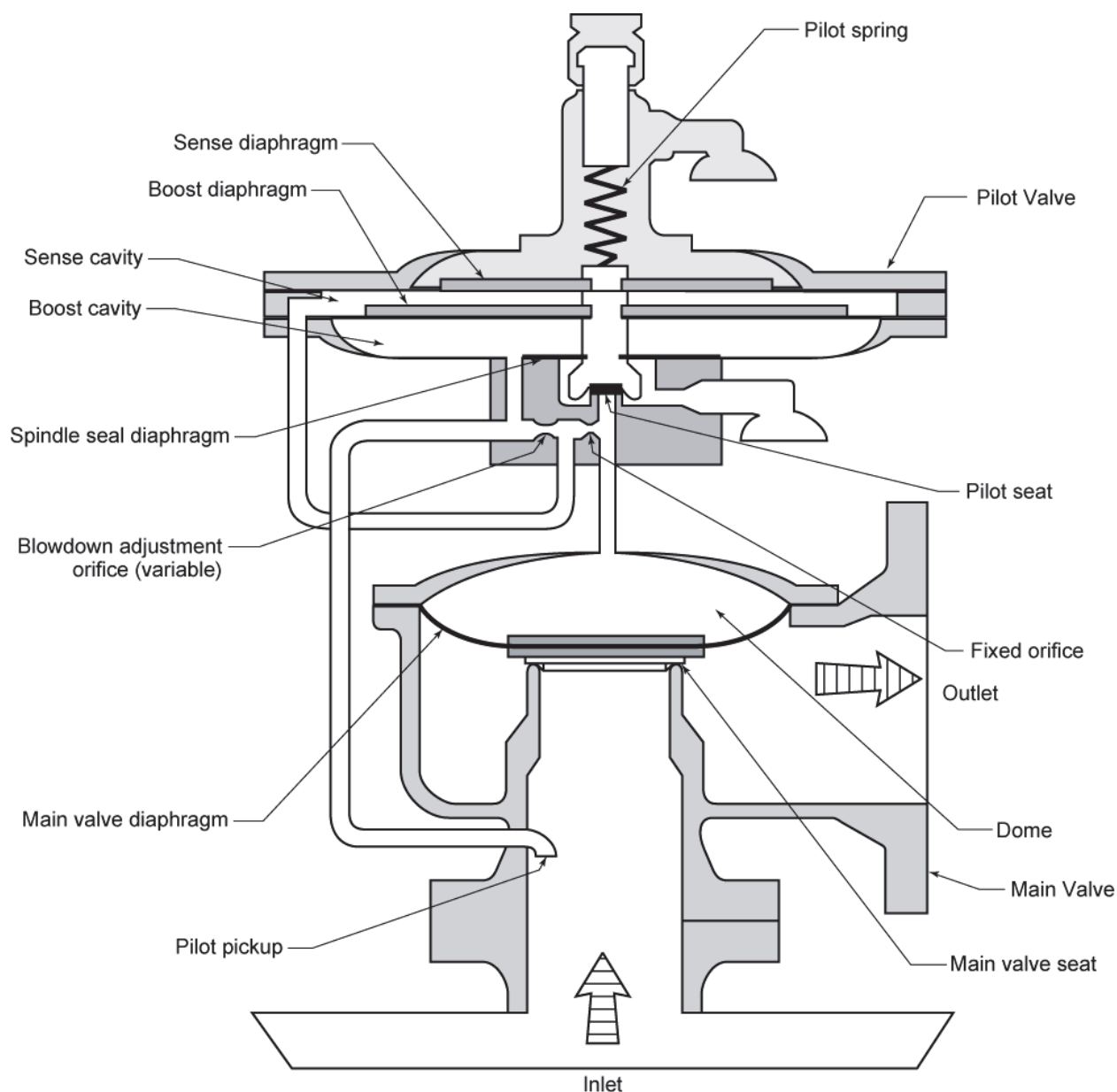


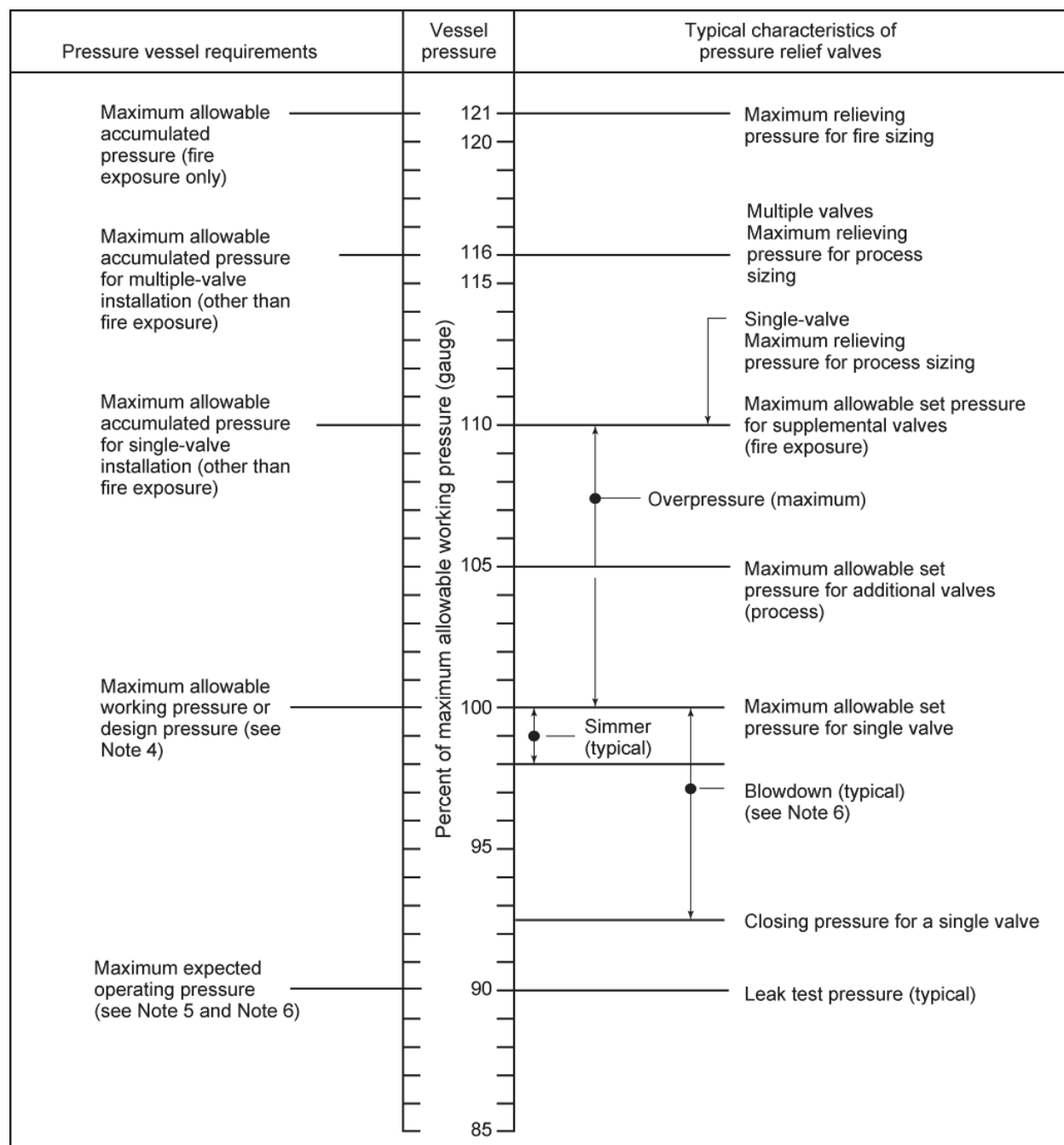
Figure 14—Low-pressure Pilot-operated Valve (Diaphragm Type)

4.2.2.4.2 Similar to soft seated spring-loaded valves, most main valves and their pilots contain nonmetallic components, and process temperature and fluid compatibility can limit their use. In addition, as with all pressure-relief devices, fluid characteristics such as susceptibility to polymerization or fouling, viscosity, the presence of solids, and corrosiveness should be considered. The manufacturer should be consulted to ensure that the proposed application is compatible with available valves.

4.2.2.5 Pilot-operated PRV Accessories

4.2.2.5.1 General

A variety of accessories and options are available for pilot-operated PRVs to provide additional functions. The following is a list of some of the more common accessories. The manufacturer should be contacted to determine availability.



NOTE 1 This figure conforms with the requirements of Section VIII of the ASME *Boiler and Pressure Vessel Code* for MAWPs greater than 30 psig.

NOTE 2 The pressure conditions shown are for pressure relief valves installed on a pressure vessel.

NOTE 3 Allowable set-pressure tolerances will be in accordance with the applicable codes.

NOTE 4 The maximum allowable working pressure is equal to or greater than the design pressure for a coincident design temperature.

NOTE 5 The operating pressure may be higher or lower than 90 %.

NOTE 6 Section VIII, Division 1, Appendix M of the ASME *Code* should be referred to for guidance on blowdown and pressure differentials.

Figure 15—Pressure Level Relationships for PRVs

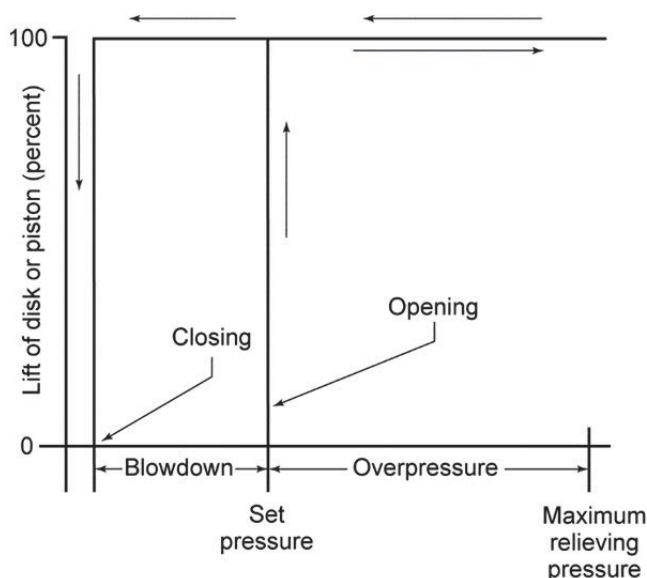


Figure 16—Typical Relationship Between Lift of Disk or Piston and Vessel Pressure in a Pop-action Pilot-operated PRV

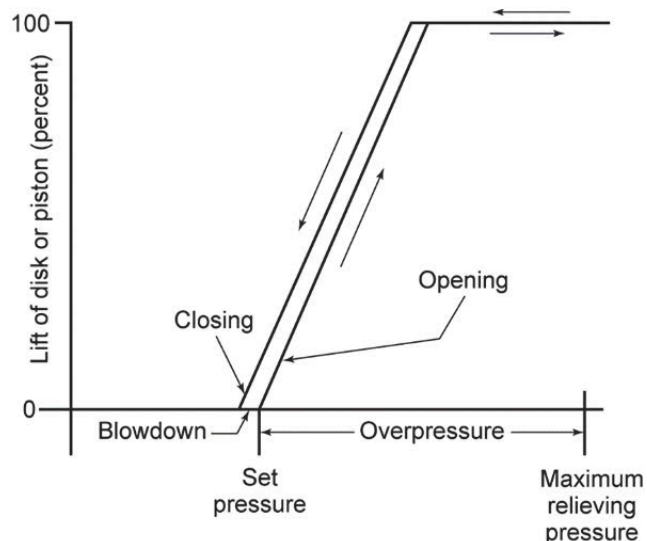


Figure 17—Typical Relationship Between Lift of Disk or Piston and Vessel Pressure in a Modulating-action Pilot-operated PRV

4.2.2.5.2 Field Test Connection

Pilot-operated PRVs may be readily tested for verification of set pressure during normal system operation with this accessory. This field test is typically done via pressure from an independent source such as a nitrogen bottle, where the source gas is slowly admitted through a metering valve. The pilot and main valve dome are pressurized simulating an increased system pressure. The field test pressure will actuate the pilot and may or may not actuate the main valve. The valve manufacturer should be contacted for details.

4.2.2.5.3 Backflow Preventer

This accessory, sometimes called a “vacuum block,” prevents a pilot-operated valve from reverse flow when the pressure at the outlet flange (superimposed backpressure) is greater than the current system pressure. Reverse flow can occur with any standard type or design of pilot-operated PRV when sufficient reverse differential pressure exists. A backflow preventer permits the introduction of outlet pressure into the dome of

the main valve, thereby holding the piston firmly on the nozzle, overcoming the effect of a reverse differential pressure. A backflow preventer should be specified whenever any of the following situations apply:

- the protected equipment can be depressured and isolated (e.g. to prepare for maintenance) while lined up to an active flare header;
- a vacuum may be present at the inlet connection due to unusual operating conditions or during start-up;
- the valve is connected to a downstream pressure vessel where pressure may vary from time to time in excess of the pressure in the upstream system;
- the discharge of multiple PRVs is combined into a single manifold or vent system, creating superimposed backpressure in excess of the current upstream system pressure.

4.2.2.5.4 Pilot Supply Filter

A pilot supply filter protects the pilot from particulate matter in the flow stream. This accessory, installed in the pilot supply line has expanded the service applications for pilot-operated PRVs. The user is cautioned that in services prone to plugging, frequent maintenance of the filter may be required to achieve the benefits. For applications with excessive particulate matter, other methods such as the addition of a purge system may be required.

4.2.2.5.5 Pressure Spike Snubber

A pressure spike snubber is recommended for use on compressible or incompressible lading fluid installations where instantaneous pressure spikes or pulsations approach or exceed the simmer or set pressure and may cause inadvertent valve wear and actuation (e.g. downstream of positive displacement rotating equipment). The device dampens these transient pressure rises before they reach the sensing chambers of the pilot without affecting the valve's set pressure.

4.2.2.5.6 Remote Pressure Sense Connection

This optional feature permits the pilot to sense system pressure at a location that most accurately reflects the actual operating pressure of the protected system. It can also be used to eliminate the false system pressure indication that will occur during relieving conditions due to pressure losses in the inlet piping. The addition of a remote pilot sense line allows the pilot to correctly sense system pressure and to keep the valve from rapid cycling or chattering due to high inlet piping pressure losses. Relieving capacity will be proportionately reduced whenever there is inlet pressure loss to the valve.

4.2.2.5.7 Manual or Remote Unloader

An unloader permits the main valve to be opened either manually or remotely to depressurize the system. Its use has no effect on the sealed pressure settings. Either a manual, pneumatic, or solenoid operated valve is connected to the main valve dome. Opening this valve vents the dome pressure faster than it can be recharged by the pilot supply allowing the piston to lift. When permitted by code, the manual unloader may be substituted for a mechanical lift lever.

4.2.2.5.8 Pilot Lift Lever

This accessory is provided for those applications where the mechanical lifting of the pilot is required for verification of valve operation. Lifting of the pilot spindle will permit the main valve to lift when the system pressure is at least equal to or greater than 75 % of the set pressure. The ASME Code requires the use of this device or a manual unloader for air, hot water over 140 °F (60 °C), and steam applications, unless ASME Code Case 2203 has been used to eliminate the need for a lifting lever.

4.2.2.5.9 Pilot Valve Isolation

There are several designs that use an inert fluid to isolate all or part of the pilot valve portion of the pilot-operated PRV from the service conditions. This may allow the pilot-operated PRV to be considered in applications where plugging and fouling might otherwise be a concern (e.g. where there is a potential for polymerization, high viscosity fluids, presence of solids, or corrosiveness). These isolation systems should be designed to provide the inert fluid to protect the critical parts of the pilot valve during normal operating conditions and also when the pilot valve operates during an over pressure event. The user should contact the manufacturer to discuss the various isolation options available with a particular pilot design and what isolation options would be suitable for the specific service condition. The user should advise the manufacturer of any local codes or regulations that affect the application and the suitability of a particular pilot valve isolation system.

4.2.3 Cold Differential Test Pressure (CDTP)

4.2.3.1 The actual service conditions under which a PRV is required to open may be different from the conditions at which the PRV is set to operate on a test stand. To compensate for this effect, a CDTP is specified for adjusting the set pressure of the valve on the test stand. The CDTP may include a correction for actual service conditions of backpressure and/or temperature.

4.2.3.2 A temperature correction factor may be applied when the pressure-relief valve temperature is significantly different from the ambient temperature. The magnitude of the correction factor and the minimum temperature at which it may be applied is dependent on the pressure-relief valve model. The correction factor shall be obtained from the pressure-relief valve manufacturer and is often available in their Installation, Operation and Maintenance manuals. The correction factor is normally provided as a multiplier to the set pressure.

4.2.3.3 The temperature used for the correction factor should be based on the temperature at the inlet to the relief valve at its normal service (nonrelieving) conditions. The temperature at the valve may not be equal to the operating temperature of the process due to valve's physical location, collection of noncondensable vapors below the valve inlet, isolation from the process by a rupture disk, or heat tracing of the valve. The factor compensates for variations in spring load due to thermal growth in valve components as well as changes in the spring material properties. Compensation may also be required for service below -75°F (-60°C). A conventional PRV, operating with a constant superimposed backpressure, normally requires a correction factor to compensate for the backpressure. In this case the required set pressure minus the superimposed backpressure is equal to the CDTP. This change accounts for the additional closing force exerted on the valve disk by the backpressure. In the case of a balanced spring-loaded PRV, the change in closing force due to the superimposed backpressure is negligible and no correction is required.

4.2.3.4 When the CDTP is to include a correction for backpressure and temperature, the differential pressure is calculated and then multiplied by the temperature correction to determine the CDTP.

4.2.3.5 Pilot-operated PRVs (see 4.2.2) may require a CDTP when used in high temperature or backpressure service. The valve manufacturer should be consulted regarding backpressure and temperature limits, and required correction factor.

4.3 Rupture Disk Devices

4.3.1 General

4.3.1.1 Rupture disk devices are nonreclosing pressure-relief devices used to protect vessels, piping, and other pressure-containing components from excessive pressure and/or vacuum. Rupture disks are used in single and multiple relief device installations. They are also used as redundant pressure-relief devices.

4.3.1.2 With no moving parts, rupture disks are simple, reliable, and faster acting than other pressure-relief devices. Rupture disks react quickly enough to relieve some types of pressure spikes. Because of their light

weight, rupture disks can be made from high alloy and corrosion resistant materials that are not practical in PRVs.

4.3.1.3 Rupture disks can be specified for systems with vapor (gas) or liquid pressure-relief requirements. Also, rupture disk designs are available for highly viscous fluids. The use of rupture disk devices in liquid service should be carefully evaluated to ensure that the design of the disk is suitable for liquid service. The user should consult the manufacturer for information regarding liquid service applications.

4.3.1.4 The rupture disk is also a temperature sensitive device. Burst pressures can vary significantly with the temperature of the rupture disk device. This temperature may be different from the normal fluid operating temperature. As the temperature at the disk increases, the burst pressure usually decreases. Since the effect of temperature depends on the rupture disk design and material, the manufacturer should be consulted for specific applications. For these reasons, the rupture disk shall be specified at the pressure and temperature the disk is expected to burst.

4.3.1.5 Care shall be taken during installation to avoid damaging the disk and to ensure that the disk and holder are properly oriented relative to the flow. A damaged or improperly oriented disk may burst considerably higher than its marked burst pressure, depending on the style of the disk. Contact the manufacturer for information about the effects of damage or improper orientation for a specific style of disk.

4.3.1.6 Care shall also be taken to follow the manufacturer's bolt torque and tightening procedures during installation. Improper torque can also affect the disk's burst pressure.

4.3.2 Application of Rupture Disks

4.3.2.1 Single, Multiple, and Fire Applications

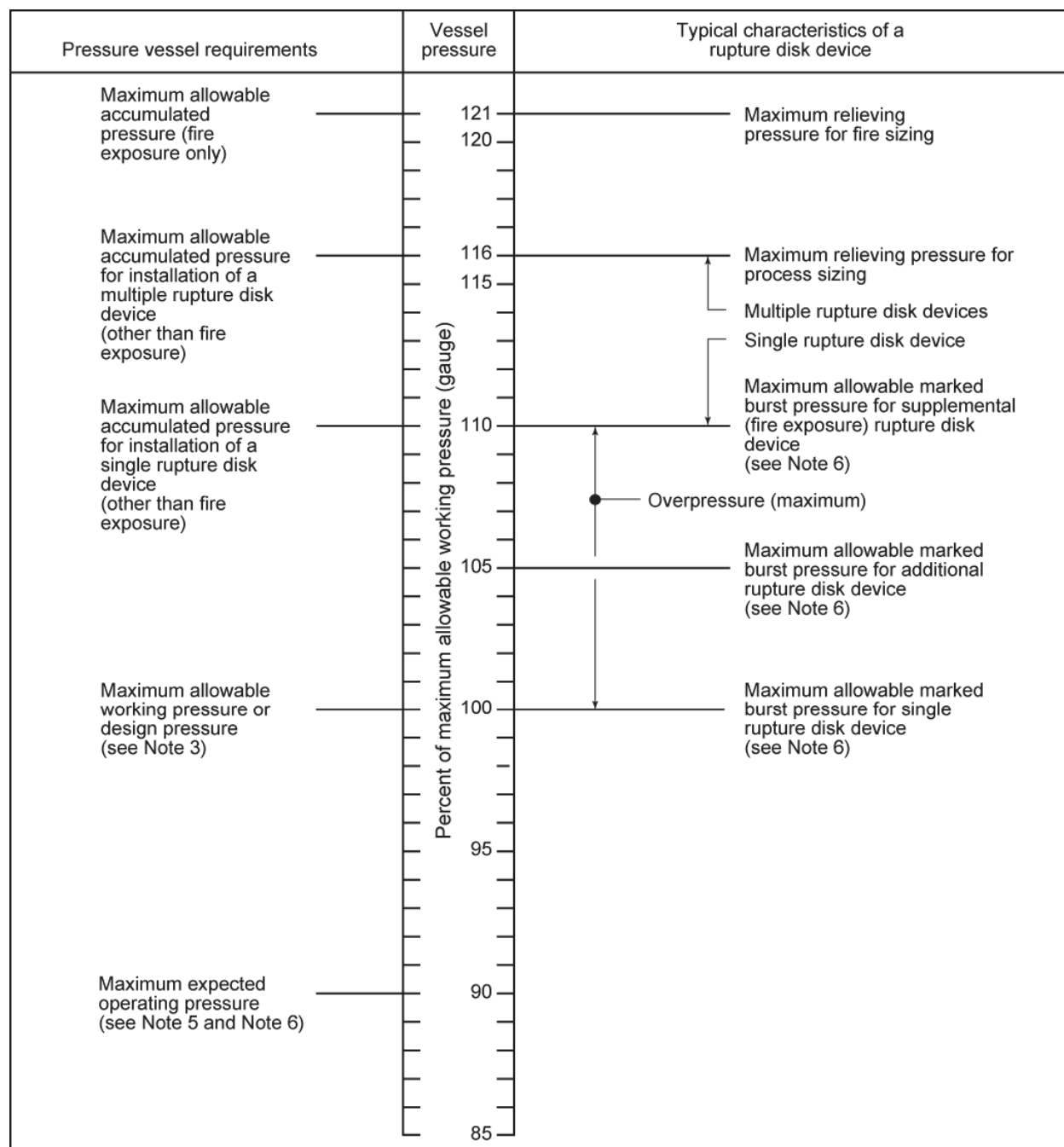
Rupture disks can be used in any application requiring overpressure protection where a nonreclosing device is suitable. This includes single, multiple, and fire applications as specified in UG-134 of the ASME Code. Figure 18 provides the pressure level relationships between rupture disks and the protected equipment in accordance with the ASME Code.

4.3.2.2 Rupture Disk Device at the Inlet of a PRV

4.3.2.2.1 The ASME Code also allows for the use of rupture disks in combination with PRVs (see Figure 19). Rupture disks are used upstream of PRVs to seal the system to meet emissions standards, to provide corrosion protection for the valve, and to reduce valve maintenance.

4.3.2.2.2 When a rupture disk device is installed at the inlet of a PRV, the devices are considered to be close coupled, and the specified burst pressure and set pressure should be the same nominal value. When installed in liquid service it is especially important for the disk and valve to be close coupled to reduce shock loading on the valve.

4.3.2.2.3 The space between the rupture disk and the PRV shall have a free vent, pressure gauge, trycock, or suitable telltale indicator as required in UG-127 of the ASME Code. A nonvented space with a pressure gauge without alarms or other devices is not recommended as a suitable telltale indicator. Users are warned that a rupture disk will not burst in tolerance if backpressure builds up in a nonvented space between the disk and the PRV, which will occur should leakage develop in the rupture disk due to corrosion or other cause.



NOTE 1 This figure conforms with the requirements of Section VIII of the ASME *Boiler and Pressure Vessel Code* for MAWPs greater than 30 psig.

NOTE 2 The pressure conditions shown are for rupture disk devices installed on a pressure vessel.

NOTE 3 The margin between the maximum allowable working pressure and the operating pressure must be considered in the selection of a rupture disk.

NOTE 4 The allowable burst-pressure tolerance will be in accordance with the applicable code.

NOTE 5 The operating pressure may be higher or lower than 90 % depending on the rupture disk design.

NOTE 6 The marked burst pressure of the rupture disk may be any pressure at or below the maximum allowable marked burst pressure.

Figure 18—Pressure Level Relationships for Rupture Disk Devices

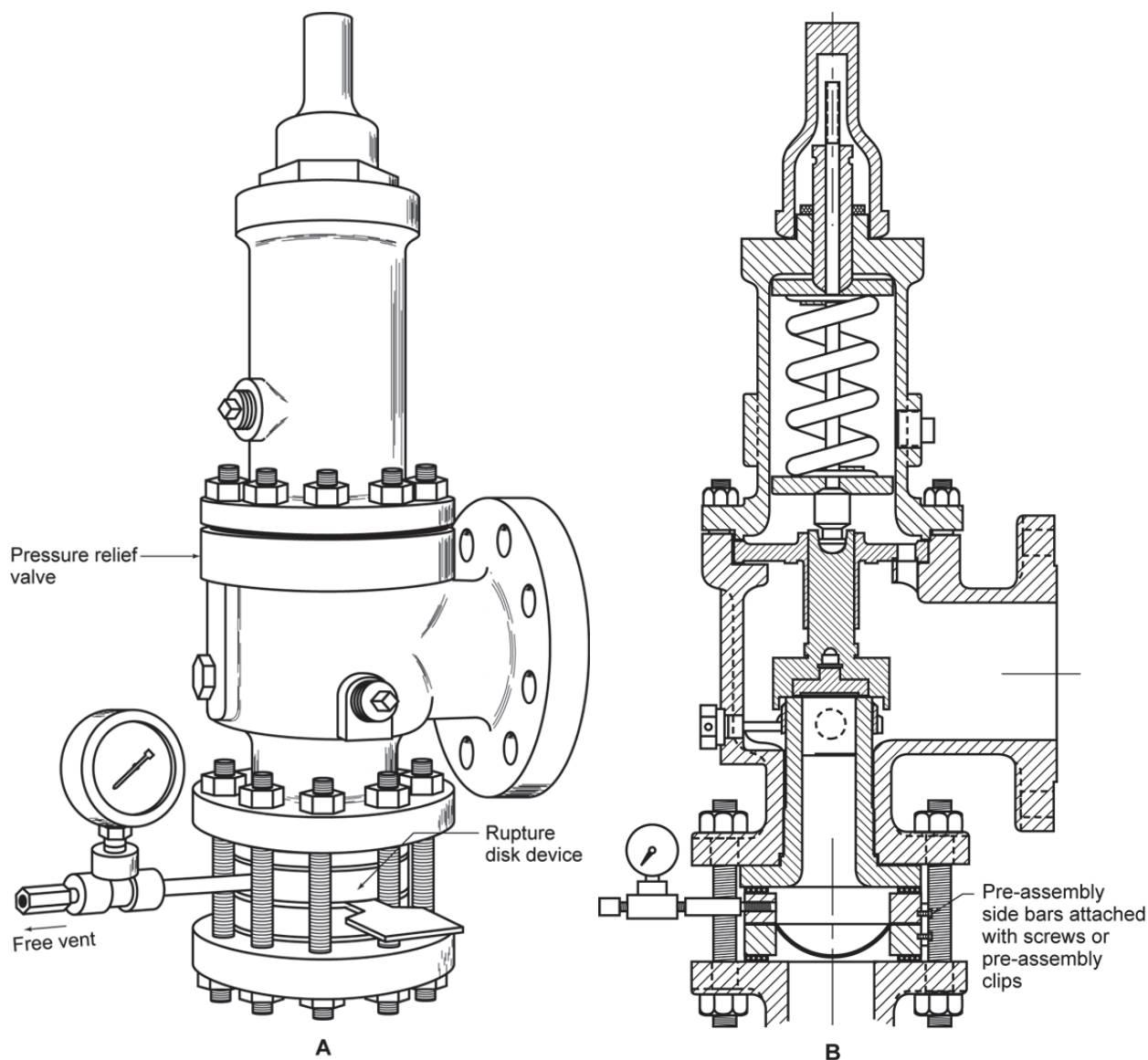


Figure 19—Rupture Disk Device in Combination with a PRV

4.3.2.3 Rupture Disk Device at the Outlet of a PRV

A rupture disk device may be installed on the outlet of a PRV to protect the valve from atmospheric or downstream fluids. Consideration should be given to the valve design so that it will open at its proper pressure setting regardless of any backpressure that may accumulate between the valve and rupture disk. See UG-127 of the ASME Code for other requirements and considerations.

4.3.2.4 Highly Corrosive Applications

In highly corrosive applications, two rupture disks are often used together. A double disk assembly consists of two rupture disks mounted in a special holder with a vapor space between them. If the first disk develops a leak due to corrosion the second disk will contain the fluid. The vapor space between the disks should have a free vent, pressure gauge, trycock, or suitable telltale indicator for monitoring of pressure buildup. This gives the user an indication that replacement of the rupture disk is required.

4.3.2.5 Highly Viscous Applications

Rupture disk designs are available for processes with high viscosity fluid, including nonabrasive slurries, where fluid flow is directed across the rupture disk inlet to prevent product buildup that may otherwise adversely affect rupture disk performance. The disk manufacturer should be consulted for details in these applications.

4.3.3 Types of Rupture Disks

4.3.3.1 General

There are three major rupture disk types:

- forward-acting, tension loaded;
- reverse-acting, compression loaded;
- graphite, shear loaded.

4.3.3.2 Forward-acting Solid Metal Rupture Disks

A forward-acting rupture disk is a formed (domed), solid metal disk designed to burst at a rated pressure applied to the concave side (see Figure 20). This rupture disk typically has an angular seat design and provides a satisfactory service life when operating pressures are up to 70 % of the marked burst pressure of the disk (70 % operating ratio). Consult the manufacturer for the actual recommended operating ratio for the specific disk under consideration. If vacuum or backpressure conditions are present, the disk can be furnished with a support to prevent reverse flexing. These disks have a random opening pattern and are considered fragmenting designs that are not suitable for installation upstream of a PRV.

4.3.3.3 Forward-acting Scored Rupture Disks

The scored forward-acting rupture disk is a formed (domed) disk designed to burst along scored lines at a rated pressure applied to the concave side (see Figure 21). Some designs provide satisfactory service life when operating pressures are up to 85 % to 90 % of the marked burst pressure of the disk (85 % to 90 % operating ratio). Consult the manufacturer for the actual recommended operating ratio for the specific disk under consideration. Most designs withstand vacuum conditions without a vacuum support. If backpressure conditions are present, the disk can be furnished with a support to prevent reverse flexing. Because the score lines control the opening pattern, this type of disk can be manufactured to be nonfragmenting and is acceptable for installation upstream of a PRV. The scored, forward-acting rupture disk is manufactured from thicker material than nonscored designs with the same burst pressure, and it provides additional resistance to mechanical damage.

4.3.3.4 Forward-acting Composite Rupture Disks

4.3.3.4.1 A forward-acting composite rupture disk is a flat or domed multipiece construction disk (see Figure 22). The domed composite rupture disk is designed to burst at a rated pressure applied to the concave side. The flat composite rupture disk may be designed to burst at a rated pressure in either or both directions. Some designs are nonfragmenting and acceptable for use upstream of a PRV.

4.3.3.4.2 The domed composite rupture disk is available in flat seat or angular seat design. The burst pressure is controlled by the combination of slits and tabs in the top section and a metallic or nonmetallic seal member under the top section. Composite rupture disks are generally available in burst pressures lower than those of forward acting, nonscored rupture disks. Composite rupture disks may offer a longer service life as a result of the corrosion resistant properties of the seal material selected.

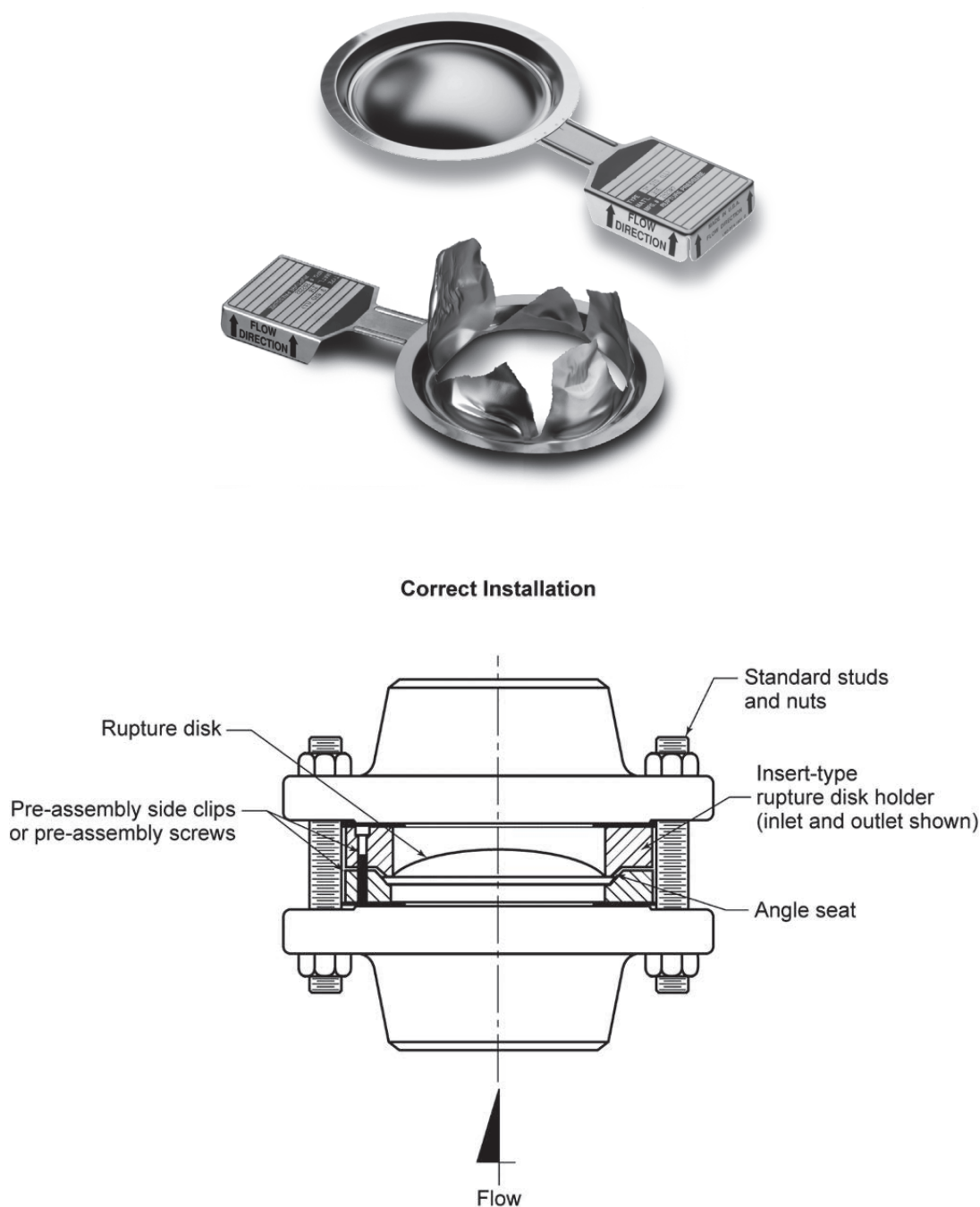


Figure 20—Forward-acting Solid Metal Rupture Disk

4.3.3.4.3 The slits and tabs in the top section provide a predetermined opening pattern for the rupture disk. If vacuum or backpressure conditions are present, composite disks can be furnished with a support to prevent reverse flexing (see Figure 22). A domed, composite rupture disk generally provides satisfactory service life when the operating pressure is 80 % or less of the marked burst pressure (80 % operating ratio). Consult the manufacturer for the actual recommended operating ratio for the specific disk under consideration.

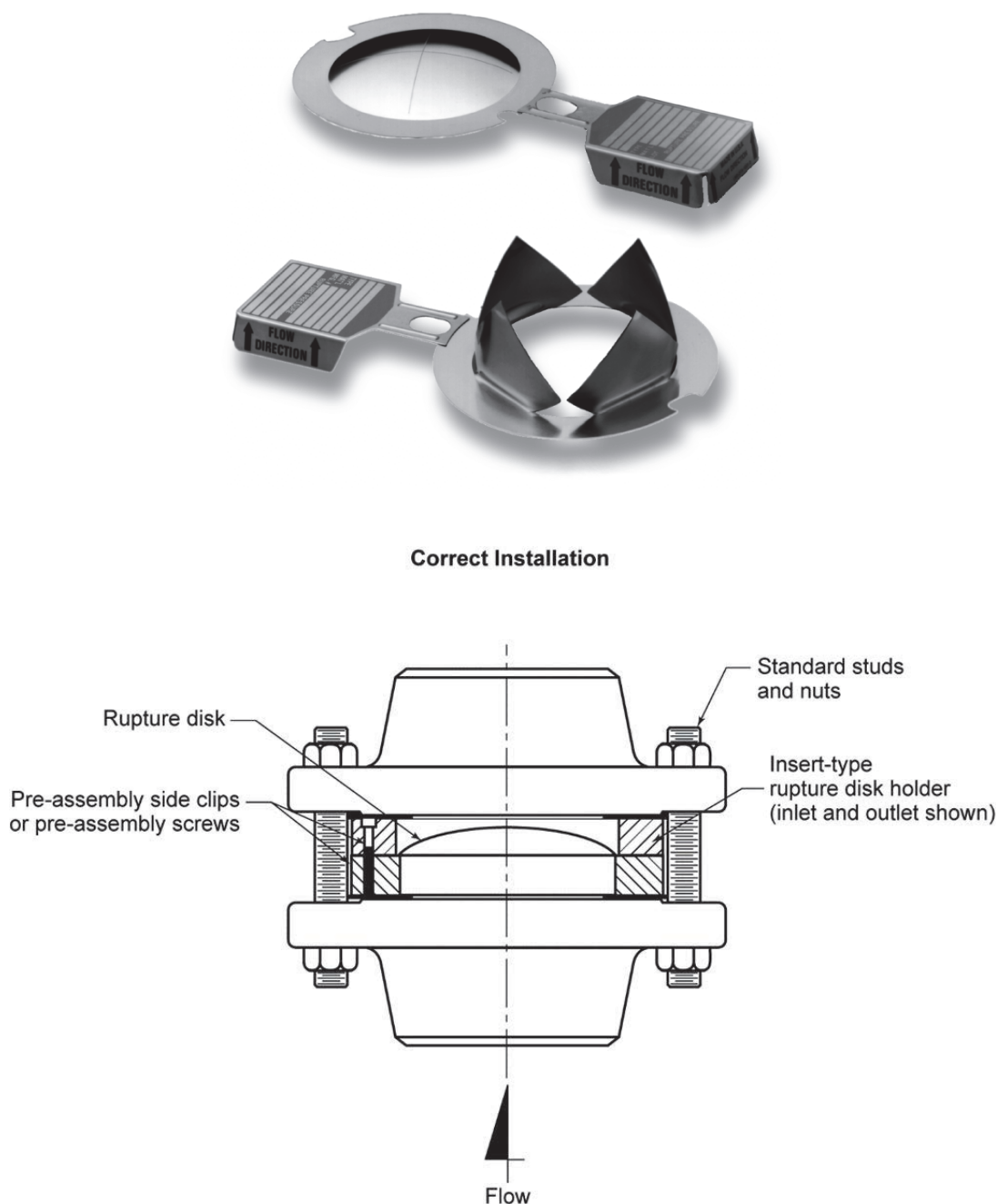


Figure 21—Forward-acting Scored Rupture Disk

4.3.3.4.4 A flat composite rupture disk is available for the protection of low-pressure vessels or the isolation of equipment such as exhaust headers or the outlet side of a PRV. This disk usually comes complete with gaskets and is designed to be installed between companion flanges rather than within a specific rupture disk holder. Flat composite rupture disks generally provide satisfactory service life when operating pressures are 50 % or less of the marked burst pressure (50 % operating ratio). Consult the manufacturer for the actual recommended operating ratio for the specific disk under consideration.

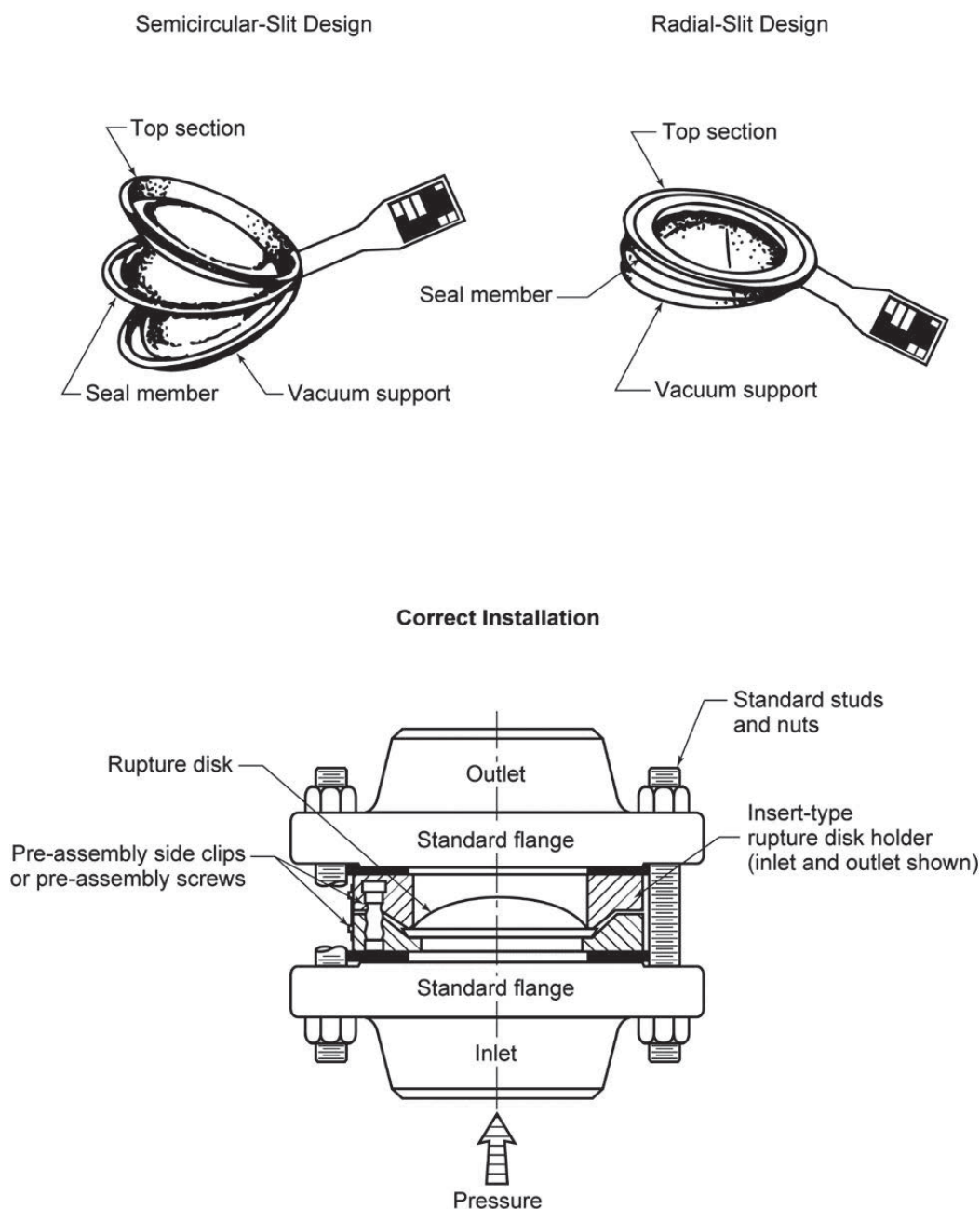


Figure 22—Forward-acting Composite Rupture Disk

4.3.3.5 Reverse-acting Rupture Disks

4.3.3.5.1 A reverse-acting rupture disk typically is a formed (domed) solid metal disk designed to reverse and burst at a rated pressure applied on the convex side. Reverse-acting rupture disks are designed to open by such methods as shear knife blades, tooth rings, or scored lines (see Figure 23 and Figure 24).

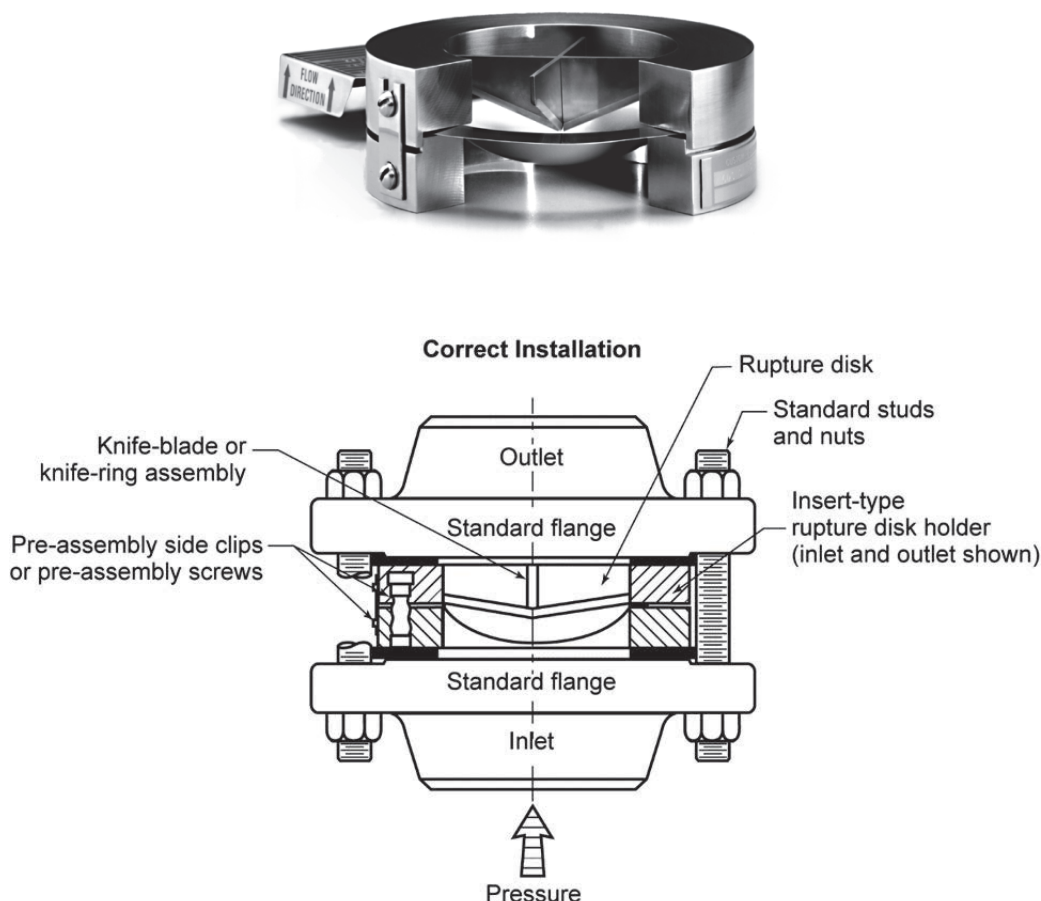


Figure 23—Reverse-acting Rupture Disk with Knife Blades

4.3.3.5.2 Reverse-acting rupture disks may be manufactured as nonfragmenting and are suitable for installation upstream of PRVs. These disks provide satisfactory service life when operating pressures are 90 % or less of marked burst pressure (90 % operating ratio). Some types of reverse-buckling disks are designed to be exposed to pressures up to 95 % of the marked burst pressure. Consult the manufacturer for the actual recommended operating ratio for the specific disk under consideration. Because a reverse-acting rupture disk is operated with pressure applied on the convex side, thicker disk materials may be used, thereby lessening the effects of corrosion, eliminating the need for vacuum support, and providing longer service life under pressure/vacuum cycling conditions and pressure fluctuations.

4.3.3.5.3 Knife blades installed in holders should be constructed of corrosion resistant material and should be inspected periodically to ensure sufficient sharpness to open the disk. Dull or damaged knife blades may prevent proper opening of the disk.

4.3.3.6 Graphite Rupture Disks

4.3.3.6.1 Graphite rupture disks are typically machined from a bar of fine graphite that has been impregnated with a sealing compound to seal the porosity of the graphite matrix (see Figure 25). The disk operates on a pressure differential across the center diaphragm or web portion of the disk. Graphite rupture disks provide a satisfactory service life when operating pressures are up to 80 % of the marked burst pressure (80 % operating ratio) and can be used in both liquid and vapor service. Consult the manufacturer for the actual recommended operating ratio for the specific disk under consideration.



Correct Installation

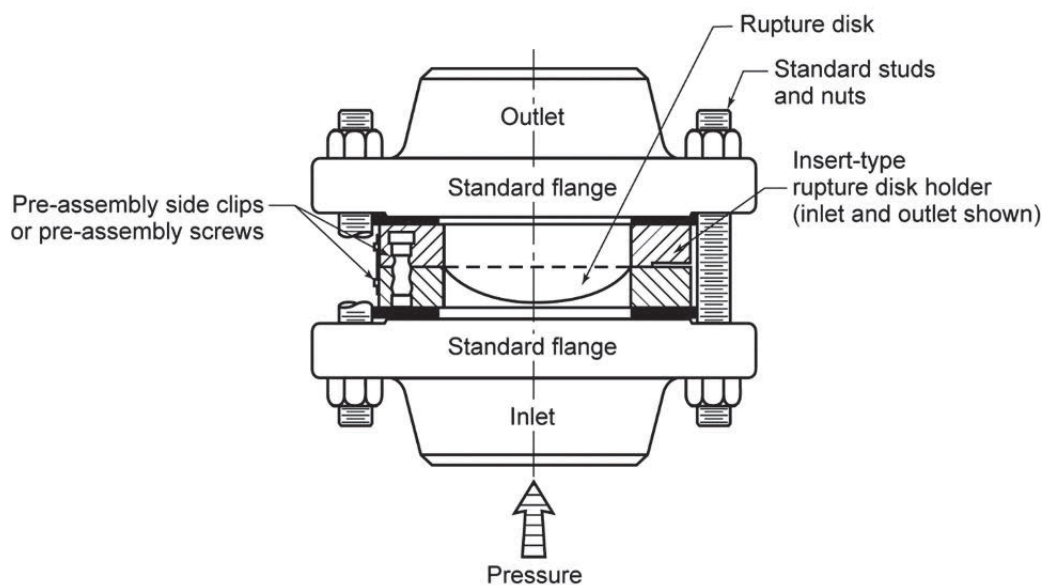


Figure 24—Reverse-acting Scored Rupture Disk

4.3.3.6.2 If vacuum or backpressure conditions are present, the disk can be furnished with a support to prevent reverse flexing. These disks have a random opening pattern and are considered fragmenting designs that are not suitable for installation upstream of a PRV. A metallic ring called armoring is often added to the outside diameter of the disk to help support uneven piping loads and minimize the potential for cracking of the outer graphite ring and blowout of process fluid.

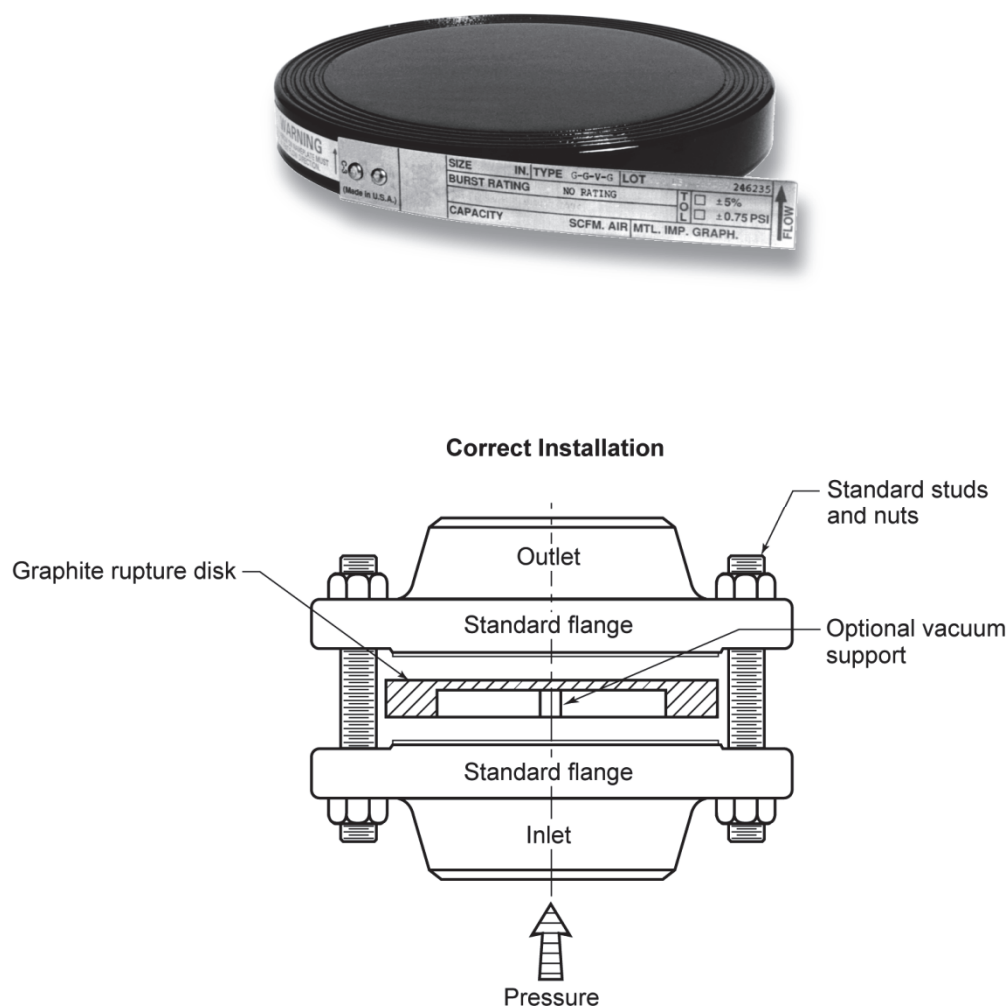


Figure 25—Graphite Rupture Disk

4.3.4 Rupture Disk Holders

Rupture disk holders are used to clamp the rupture disk in place and effect a leak-tight, metal-to-metal seal. The seating area of the holders is typically unique to specific manufacturers and styles of rupture disks. Rupture disk holders are available in a variety of configurations including full bolting, weldneck, threaded, etc. The most common configuration is the insert type that fits between standard pipe flanges, and the outside diameter of the holder fits inside the flange studs. Rupture disk holders are available in a variety of materials and coatings.

4.3.5 Rupture Disk Accessories

A variety of accessories are available for use with rupture disks in various applications. The following provides a brief description of some of these components and their application.

- Rupture Indicators and Sensors**—These devices typically provide an electrical or mechanical signal which can indicate the opening and/or leakage of a rupture disk or PRV.
- Alarm Monitors**—Alarm monitors are available to monitor rupture disk indicators or sensors. Alarm monitors are available with intrinsically safe circuits.

- c) *Heat Shields*—Heat shields are generally installed upstream of the rupture disk in high temperature processes to reduce the temperature at the rupture disk.
- d) *Baffle Plates*—When venting to atmosphere, baffle plates can be used to deflect process discharge away from personnel and equipment. Baffle plates are also commonly used to assist in absorbing the recoil forces of an activating rupture disk.

4.3.6 Rupture Disk Selection and Specification

4.3.6.1 General

4.3.6.1.1 Rupture disk selection is based on the operating parameters of the system in which it is installed. These parameters should be specified by the purchaser when purchasing rupture disks. These parameters include, but are not limited to:

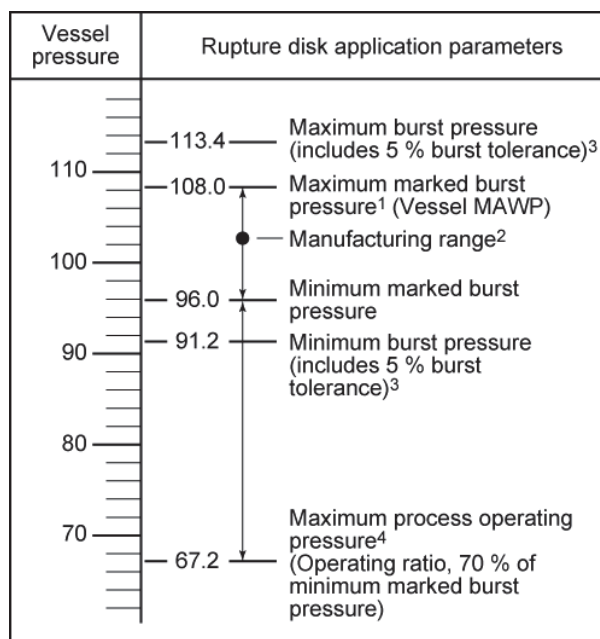
- MAWP of vessel or piping;
- fluid state (vapor, liquid, or multiphase);
- range of operating pressures and operating temperature;
- cyclic or pulsating service;
- required relieving capacity or maximum resistance coefficient;
- corrosiveness of upstream and downstream environment;
- vacuum or backpressure conditions;
- location upstream or downstream of a PRV;
- single or multiple devices.

4.3.6.1.2 The following rupture disk parameters are selected or determined based on the above system operating parameters:

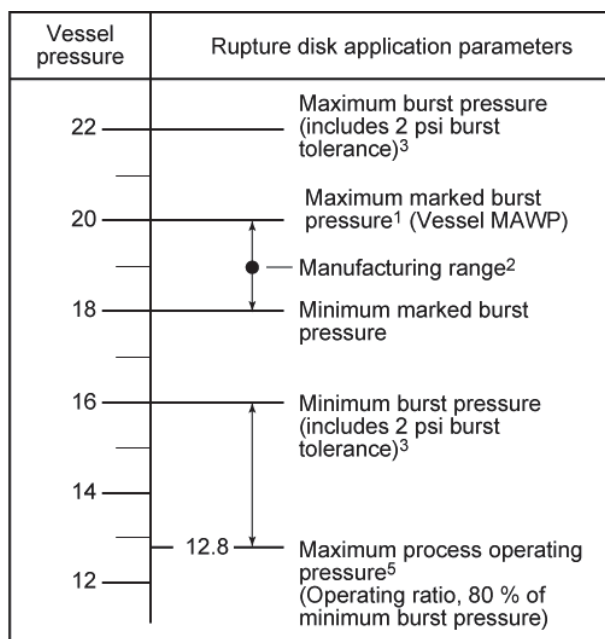
- burst pressure and temperature (see Figure 26);
- operating ratio, manufacturing design range and burst tolerance (see Figure 27);
- disk type, material, and construction;
- disk and holder size (based on required flow per 5.11).

4.3.6.2 Rupture Disk Selection

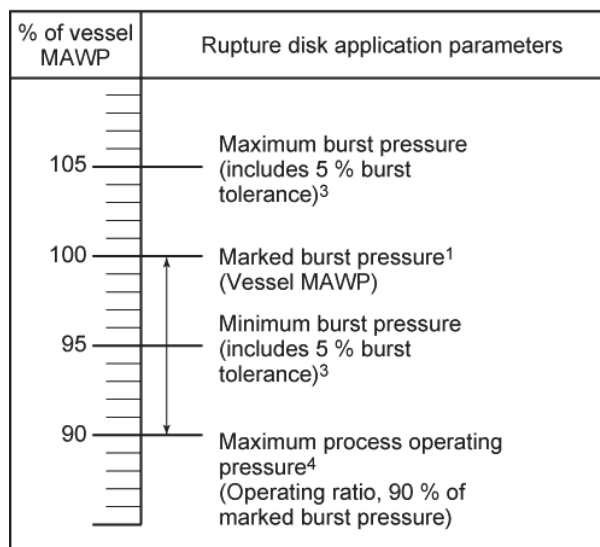
4.3.6.2.1 Rupture disk types and basic performance characteristics are described in 4.3.3 and may be used as a basis for selection. The relationship between system pressures and the operating characteristics of a rupture disk device are shown in Figure 26. Since the marked burst pressure of a rupture disk can be anywhere within its manufacturing design range, the user is cautioned to make sure that the upper limit of the manufacturing design range does not exceed the MAWP of the equipment being protected. As shown in Figure 27, when the disk has a positive manufacturing design range, the marked burst pressure of the disk can actually be greater than the specified pressure.



A. Example of a rupture disk with a specified burst pressure of 100 psig, manufacturing range of +8/-4 %, burst tolerance of ± 5 %, and a 70 % operating ratio.



C. Example of a rupture disk with a specified burst pressure of 20 psig, manufacturing range of +0/-10 %, burst tolerance of ± 2 psig, and an 80 % operating ratio.



B. Example of a rupture disk with a specified burst pressure of 100 psig, zero manufacturing range, burst tolerance of ± 5 %, and a 90 % operating ratio.

- NOTE 1 See Figure 18 for limits on marked burst pressure.
- NOTE 2 Marked burst pressure may be any pressure within the manufacturing range, see Figure 27.
- NOTE 3 For marked burst pressures above 40 psig, the burst tolerance is ± 5 %. For marked burst pressures at 40 psig and below, the burst tolerance is ± 2 psi.
- NOTE 4 For marked burst pressures above 40 psig, the maximum process operating pressure is calculated by multiplying the minimum marked burst pressure by the operating ratio.
- NOTE 5 For marked burst pressures at 40 psig and below, the maximum process operating pressure is calculated by subtracting the burst tolerance from the minimum marked burst pressure, then multiplying the difference by the operating ratio.

Figure 26—Rupture Disk Application Parameters Assuming No Superimposed Backpressure