Inspection of Pressure-relieving Devices

API RECOMMENDED PRACTICE 576
THIRD EDITION, NOVEMBER 2009

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Inspection of Pressure-relieving Devices

Downstream Segment

API RECOMMENDED PRACTICE 576
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Inspection of Pressure-relieving Devices

1 Scope

This recommended practice (RP) describes the inspection and repair practices for automatic pressure-relieving devices commonly used in the oil and petrochemical industries. As a guide to the inspection and repair of these devices in the user's plant, it is intended to ensure their proper performance. This publication covers such automatic devices as pressure-relief valves, pilot-operated pressure-relief valves, rupture disks, and weight-loaded pressure-vacuum vents.

The scope of this RP includes the inspection and repair of automatic pressure-relieving devices commonly used in the oil and petrochemical industry.

The recommendations in this publication are not intended to supersede requirements established by regulatory bodies. This publication does not cover weak seams or sections in tanks, explosion doors, fusible plugs, control valves, and other devices that either depend on an external source of power for operation or are manually operated. Inspections and tests made at manufacturers' plants, which are usually covered by codes or purchase specifications, are not covered by this publication.

This publication does not cover training requirements for mechanics involved in the inspection and repair of pressure-relieving devices. Those seeking these requirements should see API 510, which gives the requirements for a quality control system and specifies that the repair organization maintain and document a training program ensuring that personnel are qualified.

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 510, *Pressure Vessel Inspection Code: In-service Inspection, Rating, Repair, and Alteratio*n

API Standard 520 (All Parts), *Sizing, Selection, and Installation of Pressure-relieving Devices in Refineries*

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 Recommended Practice 580, *Risk-Based Inspection*

API Recommended Practice 581, *Risk-Based Inspection Technology*

API Standard 620, *Design and Construction of Large, Welded, Low-pressure Storage Tanks*

API Standard 2000, *Venting Atmospheric and Low-pressure Storage Tanks (Nonrefrigerated and Refrigerated)*

ASME PTC 25 [1], *Pressure Relief Devices*

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

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[1] ASME International, Three Park Avenue, New York, New York, 10016-5990, www.asme.org.

ASME *Boiler and Pressure Vessel Code* (*BPVC*), *Section IV: Heating Boilers*

ASME *Boiler and Pressure Vessel Code* (*BPVC*), *Section VI: Recommended Rules for the Care and Operation of Heating Boilers*

ASME *Boiler and Pressure Vessel Code* (*BPVC*), *Section VII: Recommended Guidelines for the Care of Power Boilers*

ASME Boiler and Pressure Vessel Code (*BPVC*), *Section VIII: Pressure Vessels; Division 1, Division 2 and Division 3*

ISO 4126-6 [2], *Safety devices for protection against excessive pressure—Part 6: Application, selection and installation of bursting disc safety devices*

NACE MR 0175 [3], *Petroleum and Natural Gas Industries—Materials for Use in* H_2S*-Containing Environments in Oil and Gas Production*

NACE MR 0103, *Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments*

NB-18 [4], *Pressure-relief Device Certifications*

NB-23:2004, *National Board Inspection Code*

3 Terms and Definitions

3.1 General

For the purposes of this document, the following terms and definitions apply.

3.1.1
car seal
A locking seal that when placed in position and closed, locks and must be cut or physically broken to be removed.

3.1.2
galling
A condition whereby excessive friction between high spots results in localized welding with subsequent splitting and a further roughening of rubbing surfaces of one or both of two mating parts.

3.1.3
non-reclosing pressure-relief device
A pressure-relief device, which remains open after operation. A manual resetting means may be provided.

3.1.4
pin-actuated device
A non-reclosing 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.

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2 International Organization for Standardization, 1, ch. de la Voie-Cruese, Case postale 56, CH-1211, Geneva, Switzerland, www.iso.org.
3 NACE International, (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, Houston, Texas 77218-8340, www.nace.org.
4 The National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, Ohio 43229, www.nationalboard.org.

3.2 Dimensional Characteristics of Pressure-relief Valves

3.2.1
effective discharge area
A nominal or computed area used with an effective discharge coefficient to calculate the minimum required relieving capacity for a pressure-relief valve per the preliminary sizing equations contained in API 520. Refer to API 520-1 for the preliminary sizing equations. API 526 provides effective discharge areas for a range of sizes in terms of letter designations, “D” through “T.”

3.2.2
huddling chamber
An annular pressure chamber located downstream of the seat of a pressure-relief valve, for the purpose of assisting the valve to achieve lift.

3.2.3
inlet size
The nominal pipe size (NPS) of the relief device at the inlet connection, unless otherwise designated.

3.2.4
lift
The actual travel of the disk away from the closed position when a pressure-relief valve is relieving.

3.2.5
outlet size
The nominal pipe size (NPS) of the relief device at the discharge connection, unless otherwise designated.

3.3 Operational Characteristics—System Pressures

3.3.1
accumulation
The pressure increase over the MAWP of the vessel allowed during discharge through the pressure-relief device, 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.

3.3.2
design pressure
The design pressure of the vessel along with the design temperature is 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.

3.3.3
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.

3.3.4
maximum operating pressure
The maximum pressure expected during normal system operation.

3.3.5
overpressure
The pressure increase over the set pressure of a pressure relief of a relieving device allowed to achieve rated flow. Overpressure is expressed in pressure units or as a percentage of set pressure. It is the same as accumulation only when the relieving device is set to open at the MAWP of the vessel.

3.3.6
rated relieving capacity
The relieving capacity used as 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.

NOTE The capacity marked on the device is the rated capacity on steam, air, gas, or water as required by the applicable code.

3.3.7
stamped relieving capacity
The rated relieving capacity that appears on the device nameplate and based on the rated relieving capacity determined at the specified set pressure or burst pressure plus the allowable overpressure.

3.4 Operational Characteristics—Device Pressures

3.4.1
backpressure
The pressure that exists at the outlet of a pressure-relief device as a result of the pressure in the discharge system. It is the sum of the superimposed and built-up backpressures.

3.4.2
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.

3.4.3
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.

3.4.4
burst pressure
The burst pressure of a rupture disk at the specified temperature is 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.

3.4.5
burst-pressure tolerance
The variation around the marked burst pressure at the specified disk temperature in which a rupture disk will burst.

3.4.6
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.

3.4.7
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 temperatures or both.

3.4.8
leak-test pressure
The specified inlet static pressure at which a seat leak test is performed.

3.4.9
manufacturing design range
The pressure range at 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 ranges may be modified by agreement between the user and the manufacturer.

3.4.10
marked burst pressure or **rated burst pressure**
The marked burst pressure or rated burst pressure of a rupture disk is 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 the rupture disks of the same lot.

3.4.11
opening pressure
The value of increasing inlet static pressure whereby there is a measurable lift of the disk or at which discharge of the fluid becomes continuous, as determined by seeing, feeling or hearing.

3.4.12
set pressure
The inlet gauge pressure at which a pressure-relief valve is set to open under service conditions.

3.4.13
simmer
The audible or visible escape of compressible fluid between the seat and disc, which may occur at an inlet static pressure below the set pressure prior to opening.

3.4.14
specified burst pressure
The specified burst pressure of a rupture disk is 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 range, superimposed backpressure and specified temperature when determining a specified burst pressure.

3.4.15
superimposed backpressure
The static pressure that exists at the outlet of a pressure-relief device at the time the device is required to operate. It is the result of pressure in the discharge system coming from other sources and may be constant or variable.

4 Pressure-relieving Devices

4.1 General

Pressure-relieving devices protect equipment and personnel by automatically opening at predetermined pressures and preventing the adverse consequences of excessive pressures in process systems and storage vessels.

A pressure-relief device is 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 may also be designed to prevent excessive internal vacuum. The device may be a pressure-relief valve, a non-reclosing pressure-relief device, or a vacuum-relief valve.

Common examples include direct spring-loaded pressure-relief valves, pilot-operated pressure-relief valves, rupture disks, weight-loaded devices, and pressure- and/or vacuum-vent valves.

4.2 Pressure-relief Valve

A pressure-relief valve is designed to open for the relief of excess pressure and reclose thereby preventing further flow of fluid after normal conditions have been restored. A pressure-relief valve opens when its upstream pressure reaches the opening pressure. It then allows fluid to flow until its upstream pressure falls to the closing pressure. It then closes, preventing further flow. Examples of specific types of pressure-relief valves include: safety valve, relief valve, conventional safety-relief valve, balanced safety-relief valve, and pilot-operated pressure-relief valve.

4.3 Safety Valve

4.3.1 General

A safety valve is a direct spring-loaded pressure-relief valve that is actuated by the static pressure upstream of the valve and characterized by rapid opening or pop action.

When the static inlet pressure reaches the set pressure, it will increase the pressure upstream of the disk and overcome the spring force on the disk. Fluid will then enter the huddling chamber, providing additional opening force. This will cause the disk to lift and provide full opening at minimal overpressure. The closing pressure will be less than the set pressure and will be reached after the blowdown phase is completed.

The spring of a safety valve is usually fully exposed outside of the valve bonnet to protect it from degradation due to the temperature of the relieving medium. A typical safety valve has a lifting lever for manual opening to ensure the freedom of the working parts. Open bonnet safety valves are not pressure tight on the downstream side. Figure 1 illustrates a full-nozzle, top-guided safety valve.

4.3.2 Applications

A safety valve is normally used with compressible fluids. Safety valves are used on steam boiler drums and super-heaters. They are also used for general air and steam services in refinery and petrochemical plants. Safety valve discharge piping may contain a vented drip pan elbow or a short piping stack routed to the atmosphere.

4.3.3 Limitations

Safety valves should not be used:

- in corrosive services (unless isolated from the process by a rupture disk),
- in installations that impose any backpressure unless the effects of the backpressure have been accounted for in the installation,
- where the escape of process fluid around blowing valves is not desirable,
- in liquid service,
- as pressure control or bypass valves.

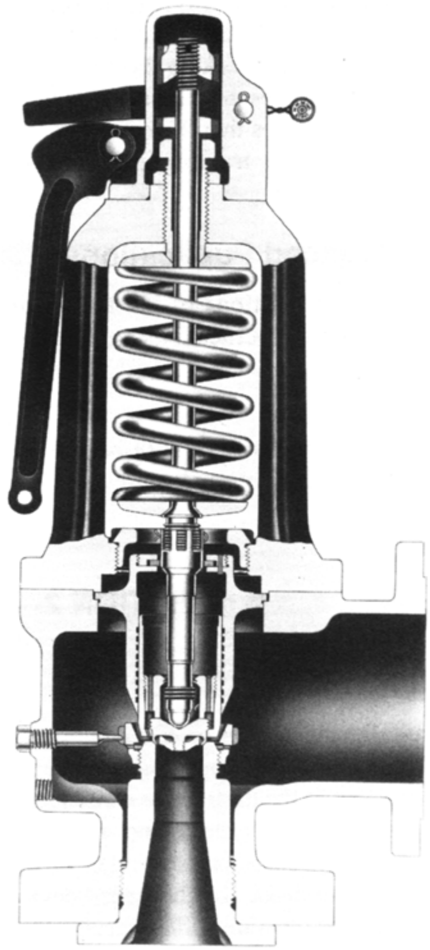


Figure 1—Full-nozzled, Top-guided Safety Valve

4.4 Relief Valve

4.4.1 General

A relief valve is a direct 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 begins to open when the static inlet pressure reaches its set pressure. When the static inlet pressure overcomes the spring force, the disk begins to lift off the seat, allowing flow of the liquid. The value of the closing pressure is lower than the set pressure and will be reached after the blowdown phase is complete. Relief valves usually reach full lift at either 10 % or 25 % overpressure, depending on the type of valve and trim.

These valves have closed bonnets to prevent the release of corrosive, toxic, flammable, or expensive fluids. They can be supplied with lifting levers, balancing bellows, and soft seats as needed. Figure 2 illustrates one type of relief valve. The ASME *BPVC* requires that liquid service relief valves installed after January 1, 1986 have their capacity certified and stamped on the nameplate.

Some relief valves are manufactured with resilient O-rings or other types of soft seats to supplement or replace the conventional metal-to-metal valve seating surfaces. Usually, the valves are similar in most respects to the other pressure-relief valves, with the exception that the disks are designed to accommodate some type of resilient seal ring to promote a degree of tightness exceeding that of the usual commercial tightness of conventional metal seats. Figure 3 illustrates one type of O-ring seat seal as installed in a safety-relief valve.

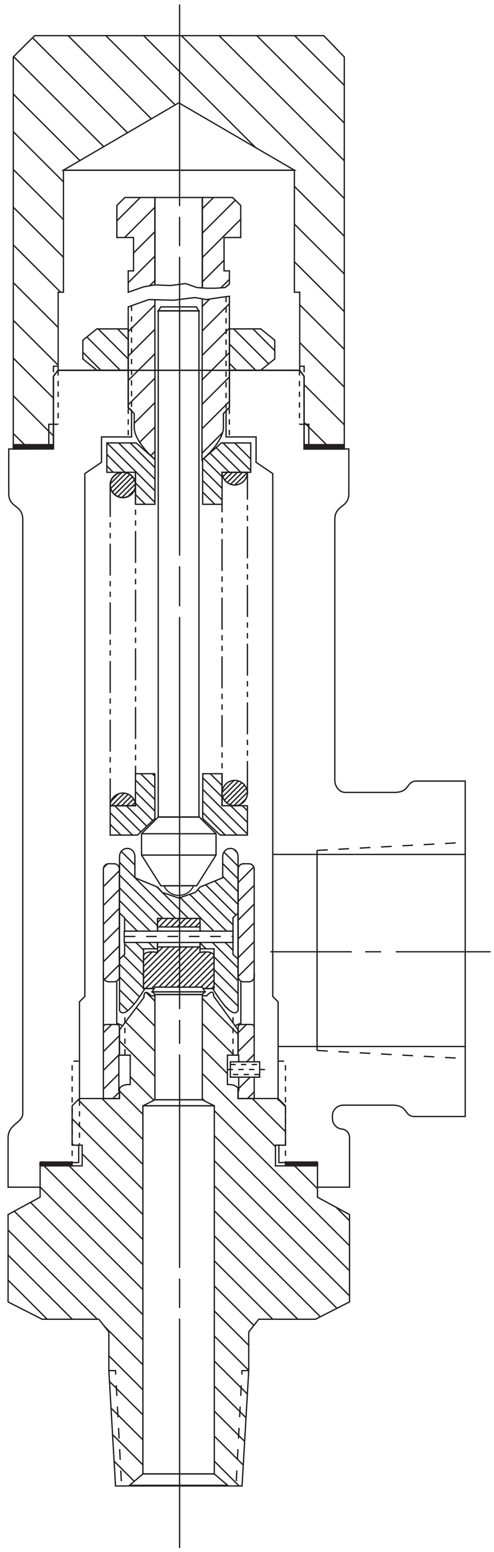


Figure 2—Relief Valve

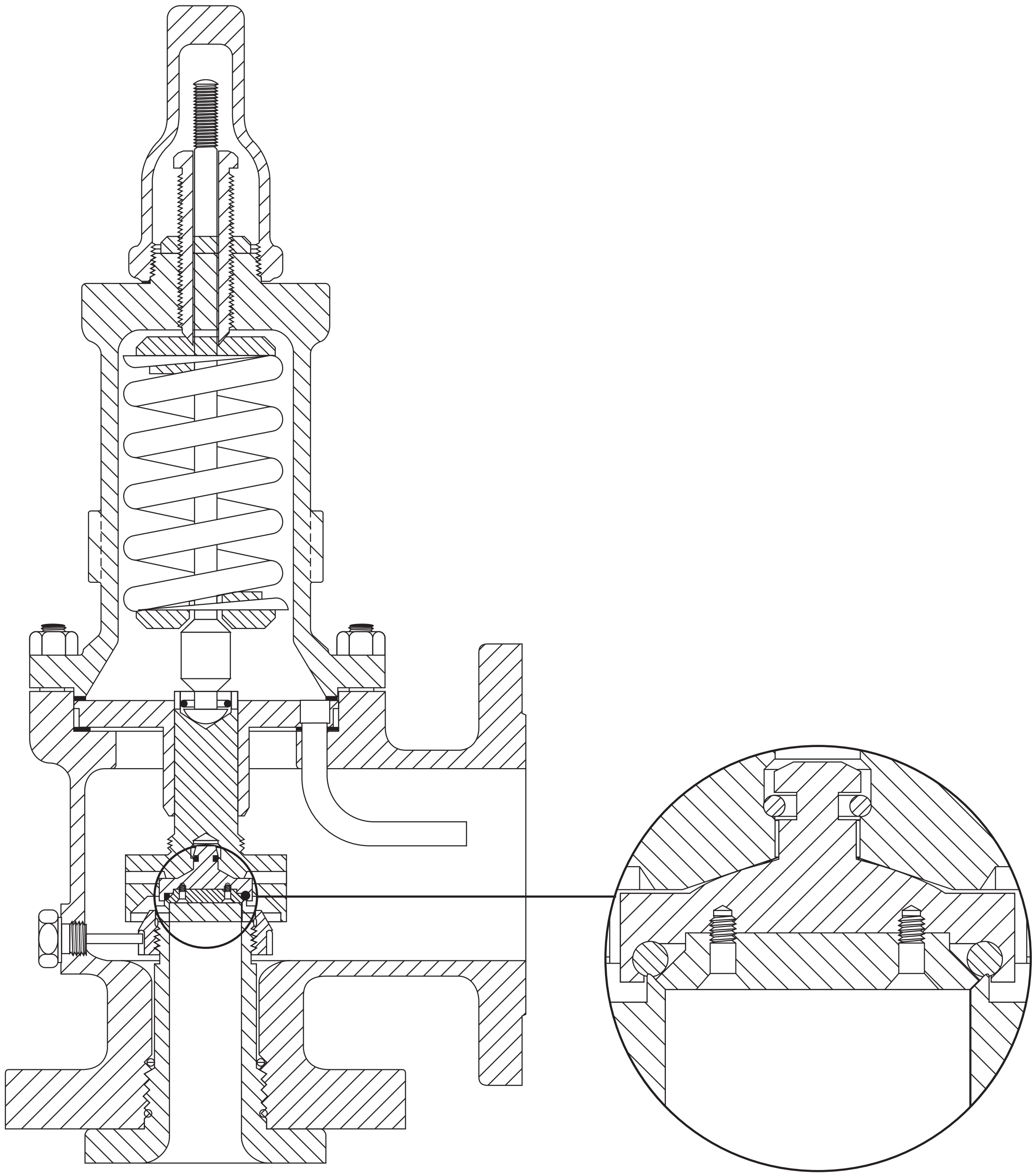


Figure 3—Safety-relief Valve with O-ring Seal

4.4.2 Applications

Relief valves are normally used for incompressible fluids (see API 520, Part 1).

4.4.3 Limitations

Relief valves should not be used:

— in steam, air, gas, or other vapor services;

— in installations that impose any backpressure unless the effects of the backpressure have been accounted for;

— as pressure control or bypass valves.

4.5 Safety-relief Valve

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

A safety-relief valve is normally fully open at 10 % overpressure when in gas or vapor service. When installed in liquid service, full lift will be achieved at approximately 10 % or 25 % overpressure, depending on trim type.

4.6 Conventional Safety-relief Valve

4.6.1 General

A conventional safety-relief valve is a direct spring-loaded pressure-relief valve whose operational characteristics (opening pressure, closing pressure, and relieving capacity) are directly affected by changes in the backpressure (see Figure 4).

A conventional safety-relief valve has a bonnet that encloses the spring and forms a pressure-tight cavity. The bonnet cavity is vented to the discharge side of the valve.

4.6.2 Applications

Conventional safety-relief valves can be used in refinery and petrochemical processes that handle flammable, hot, or toxic material. The effect of temperature and backpressure on the set pressure is considered when specifying conventional safety-relief valves.

4.6.3 Limitations

Conventional safety-relief valves should not be used in the following applications:

a) where the total built-up backpressure exceeds the allowable overpressure;

b) where the cold differential test pressure (CDTP) cannot be reduced to account for the effects of variable backpressure (see API 520, Part 1);

c) on ASME *BPVC* Section I steam boiler drums or ASME *BPVC* Section I superheaters;

d) as pressure control or bypass valves.

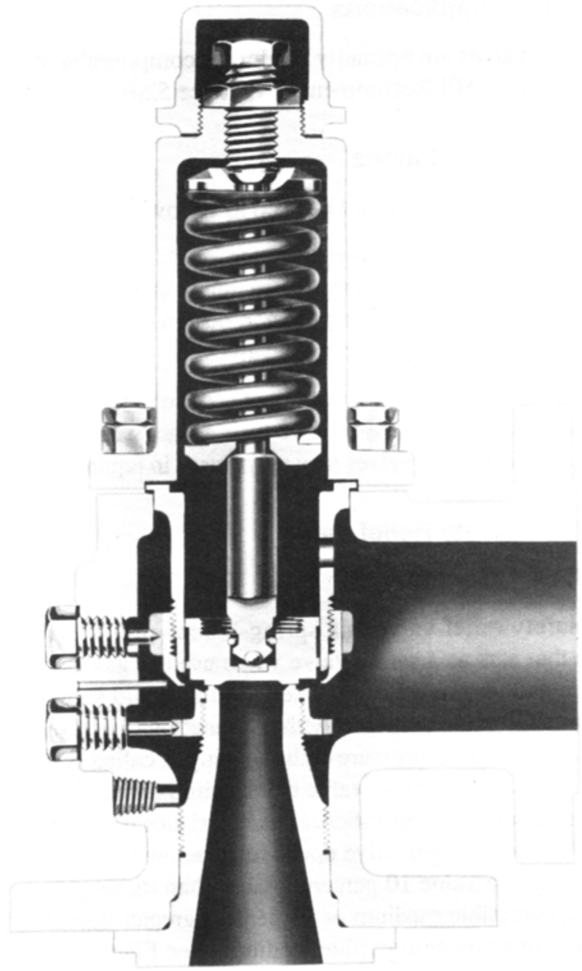


Figure 4—Conventional Safety-relief Valve

4.7 Balanced Safety-relief Valve

4.7.1 General

A balanced safety-relief valve is a direct 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. Whether it is pressure tight on its downstream side depends on its design. See Figure 5 and Figure 6.

4.7.2 Applications

Balanced safety-relief valves are normally used in refinery and petrochemical process industries that handle flammable, hot, or toxic material, where high backpressures are present at the valve discharge. This typically occurs where material from the valve is routed to a collection system. They are used:

— in gas, vapor, steam, air, or liquid services;

— in corrosive service to isolate the spring and the bonnet cavity of the valve from process material;

— when the discharge from the valves is piped to remote locations.

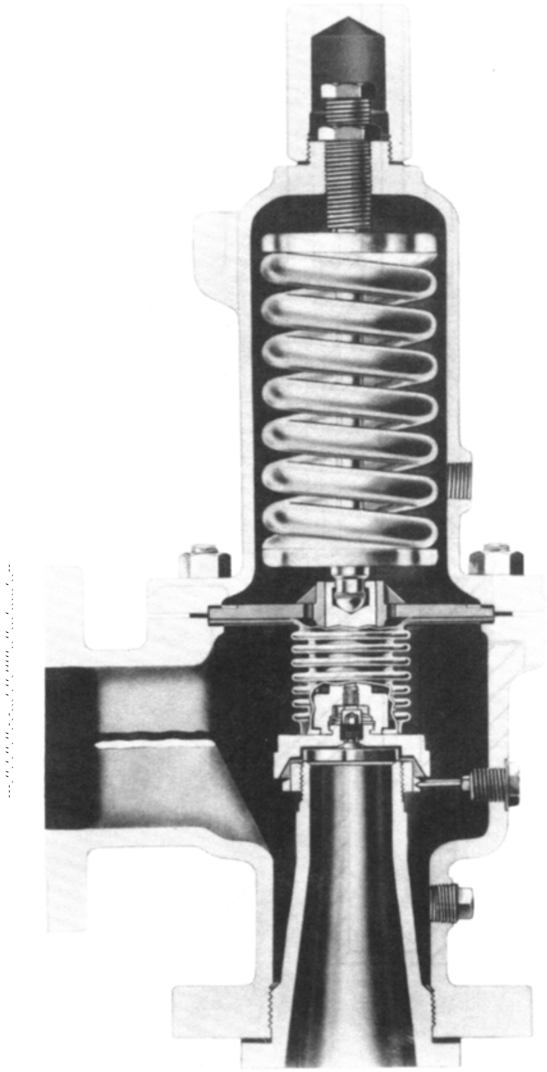


Figure 5—Balanced Bellows Safety-relief Valve

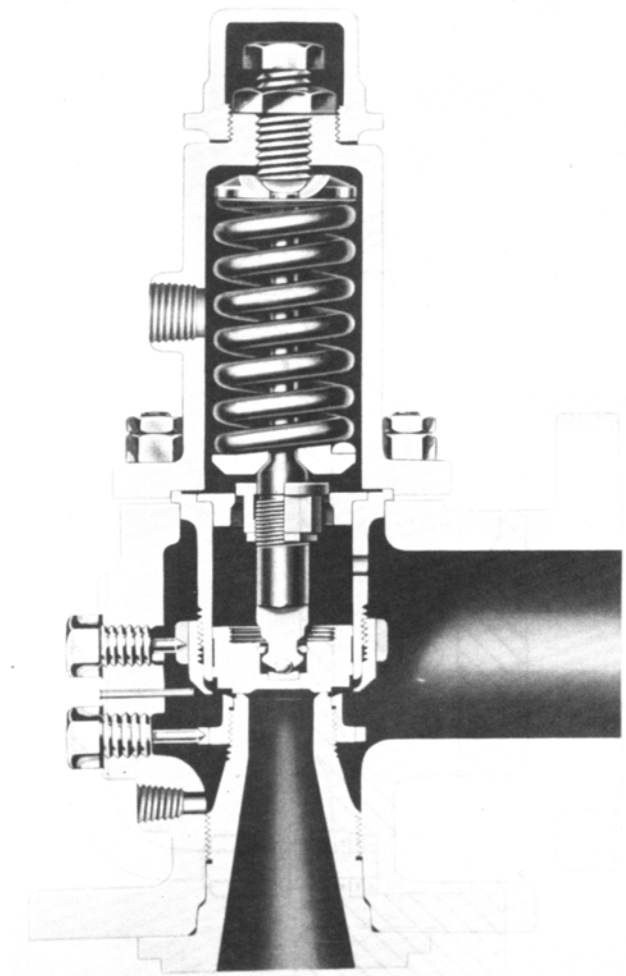


Figure 6—Balanced Bellows Safety-relief Valve with Auxiliary Balancing Piston

4.7.3 Limitations

Balanced safety-relief valves should not be used:

— on ASME *BPVC* Section I steam boiler drums or ASME *BPVC* Section I superheaters, and

— as pressure control or bypass valves.

Balanced type valves require vented bonnets. A bellows failure allows process media from the discharge side of the valve to discharge from the bonnet vent. Consider the nature of the process media (e.g. liquid/vapor, toxicity, and flammability) when evaluating the bonnet vent disposition. Bonnet vents are typically routed to a drain or atmosphere depending on the process media involved.

The internal area of the bellows in a balanced-bellows spring-loaded pressure-relief valve is referenced to atmospheric pressure in the valve bonnet. The bonnet of a balanced pressure-relief valve shall be vented to the atmosphere at all times for the bellows to perform properly. In the case of a bellows failure, the absence of the vent (i.e. if the bonnet were closed), will allow the bonnet pressure to rise to the valve discharge pressure, defeating the balanced design of the valve, and effectively converting it to a conventional valve. The bonnet vent ensures nearly-balanced performance even in the event of a bellows failure, and therefore shall be kept open. If the valve is located where atmospheric venting would present a hazard or is not permitted by environmental regulations, the vent should be piped to a safe location that is free of backpressure that may affect the pressure-relief valve set pressure.

Balanced safety-relief valves may have a backpressure limitation based on the mechanical strength of the bellows. Consult the individual valve manufacturer to assure the allowable backpressure is not exceeded.

4.8 Pilot-operated Pressure-relief Valve

4.8.1 General

A pilot-operated safety-relief valve is 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).

Depending on the design, the pilot valve (control unit) and the main valve may be mounted on either the same connection or separately. The pilot is a spring-loaded valve that operates when its inlet static pressure exceeds its set pressure. This causes the main valve to open and close according to the pressure. Process pressure is either vented off by the pilot valve to open the main valve or applied to the top of the unbalanced piston, diaphragm, or bellows of the main valve to close it. Figure 7 illustrates a low-pressure diaphragm-type pilot-operated valve. Figure 8 and Figure 9 show a high-pressure pilot-operated valve that uses an unbalanced piston with an integrally-mounted pilot. Figure 9 also illustrates optional remote pressure sensing from the vessel and optional dual outlets to equalize thrust.

4.8.2 Applications

Pilot-operated safety-relief valves are generally used:

a) where a large relief area and/or high set pressures are required, since pilot-operated valves can usually be set to the full rating of the inlet flange;

b) where a low differential exists between the normal vessel operating pressure and the set pressure of the valves;

c) on large low-pressure storage tanks (see API 620);

d) where very short blowdown is required;

e) where backpressure is very high and balanced design is required, since pilot-operated valves with the pilots either vented to the atmosphere or internally balanced are inherently balanced by design;

f) where process conditions require sensing of pressure at one location and relief of fluid at another location;

g) where inlet or outlet piping frictional pressure losses are high;

h) where in-situ, in service, set pressure verification is desired.

4.8.3 Limitations

Pilot-operated safety-relief valves are not generally used as follows:

a) in service where fluid is dirty, or where there is a potential for fouling or solidification (e.g. hydrates, wax, or ice) in the pilot or sensing line unless special provisions are taken (such as filters, sense line purging, etc.);

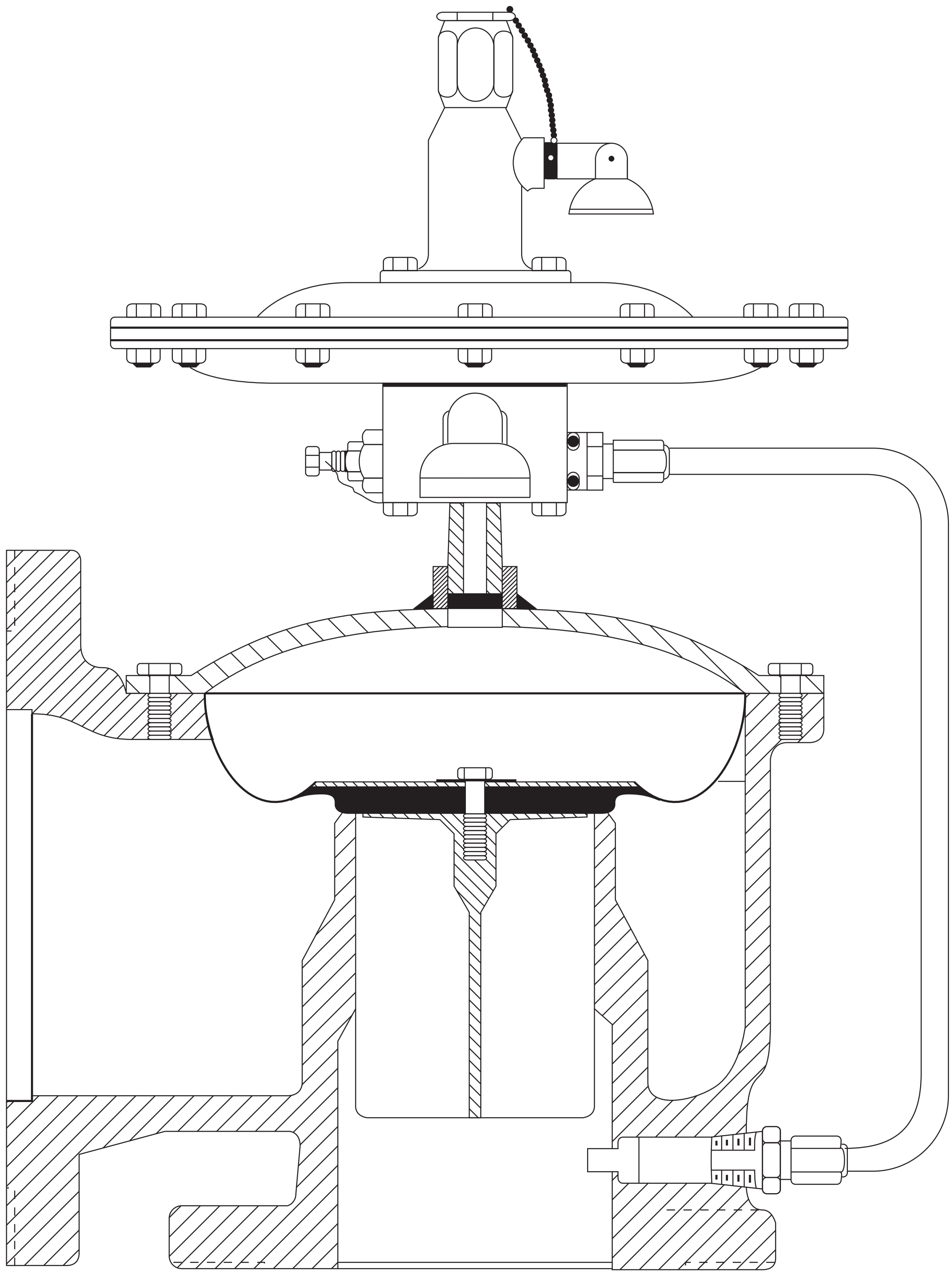


Figure 7—Low-pressure Diaphragm-type Pilot-operated Valve

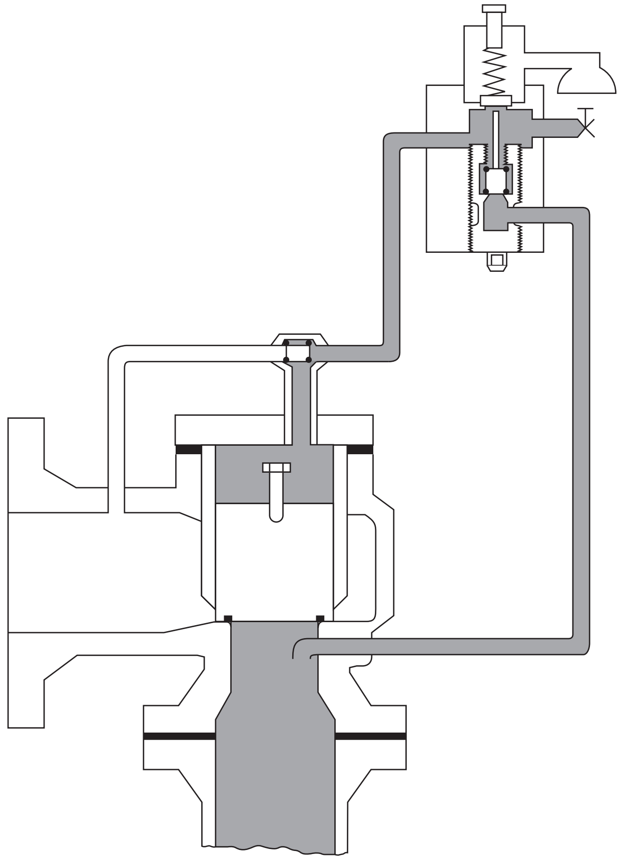


Figure 8—High-pressure Pilot-operated Valve

b) in viscous liquid service, as pilot-operated valve operating times will increase markedly due to flow of viscous liquids through relatively small passages within the pilot;

c) with vapors that will polymerize in the valves;

d) in services where the temperature exceeds the safe limits for the diaphragms, seals, or O-rings selected;

e) where chemical compatibility of the loading fluid with the diaphragms, seals, or O-rings of the valves is questionable;

f) where corrosion buildup can impede the actuation of the pilot.

4.9 Pressure- and/or Vacuum-vent Valve

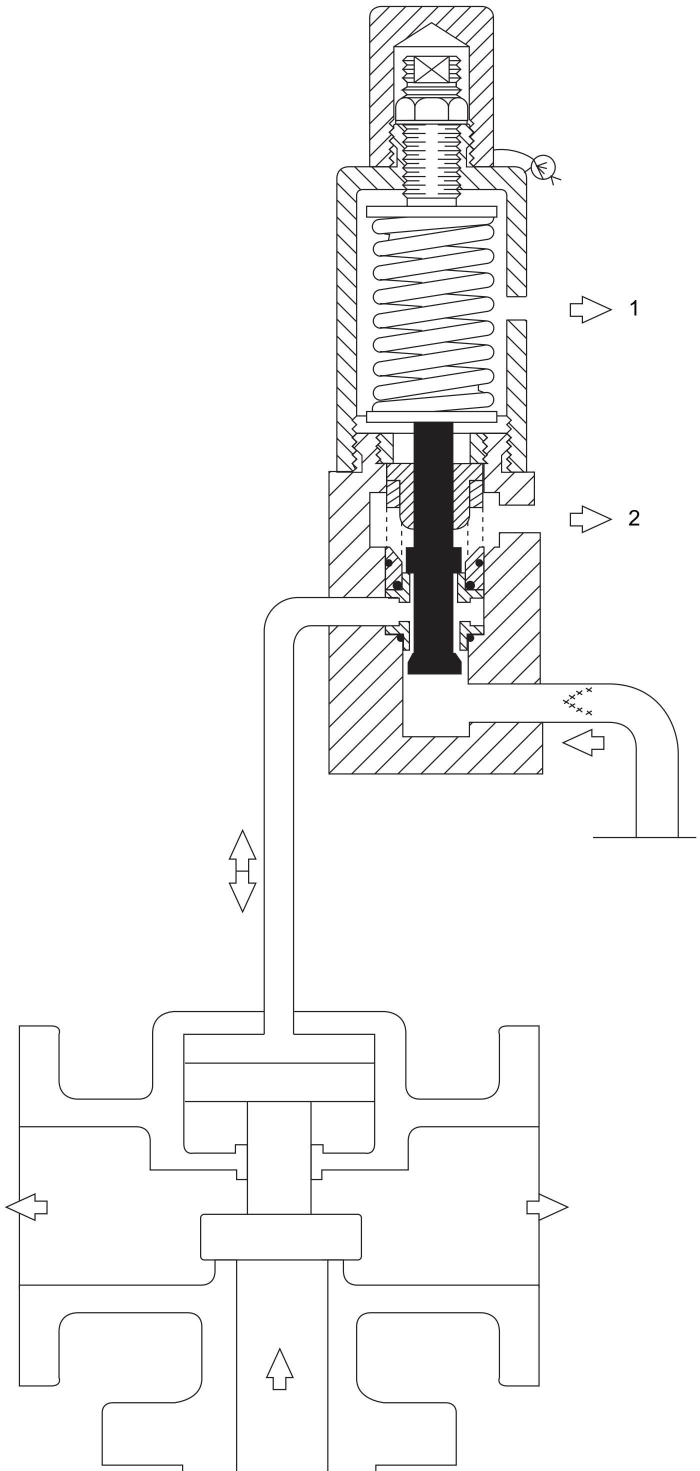
4.9.1 General

A pressure- and/or vacuum-vent valve (also known as a pressure- and/or vacuum-relief valve) is an automatic pressure- or vacuum-relieving device actuated by the pressure or vacuum in the protected equipment. A pressure- and/or vacuum-vent valve falls into one of three basic categories:

— weight-loaded pallet-vent valve, as shown in Figure 10;

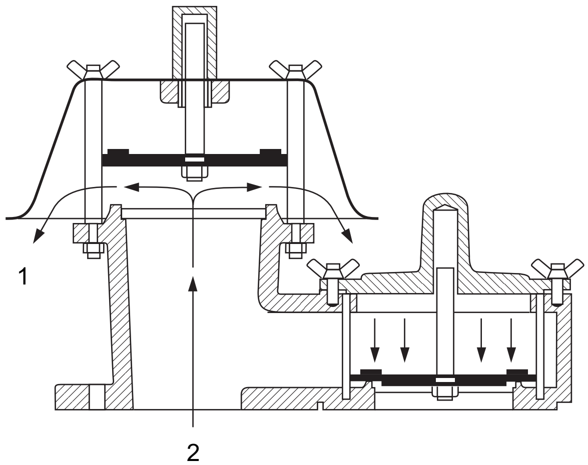
— pilot-operated vent valve, as shown in Figure 7;

— spring- and weight-loaded vent valve, as shown in Figure 11.

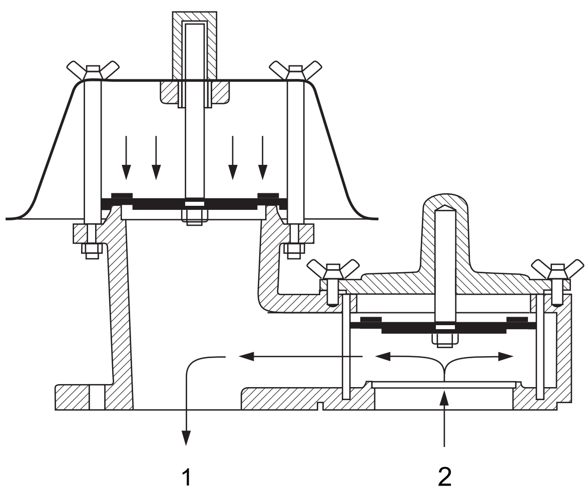


Key
1 vent
2 exhaust

Figure 9—High-pressure Pilot-operated Valve with Optional Dual Outlets



Key
1 atmosphere
2 tank pressure



Key
1 tank vacuum
2 atmosphere

Figure 10—Weight-loaded Pallet Vent Valve

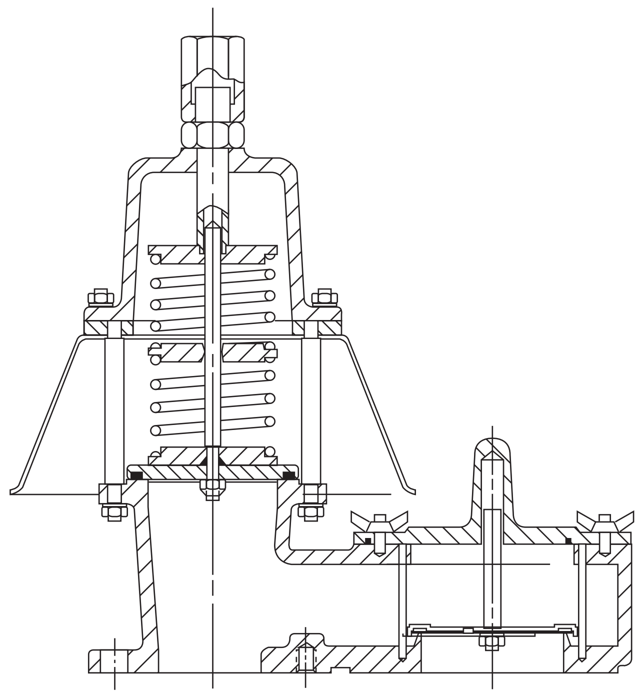


Figure 11—Spring and Weight-loaded Vent Valve

4.9.2 Applications

Pressure- and/or vacuum-vent valves are normally used to protect atmospheric and low-pressure storage tanks against a pressure large enough to damage the tank. Single units composed of both pressure-vent valves and vacuum-vent valves are also known as conservation-vent valves, and are normally used on atmospheric storage tanks containing materials with a flash point below 100 °F (38 °C). However, they may also be used on tanks storing heavier oils (see API 2000).

4.9.3 Limitations

Pressure- and/or vacuum-vent valves are generally not used for applications requiring a set pressure greater than 15 lbf/in.^{2} (103 kPa).

4.10 Rupture Disk Device

4.10.1 General

A rupture disk device is a non-reclosing pressure-relief device actuated by the 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 (see Figure 12).

a) A rupture disk is a pressure containing, pressure and temperature sensitive element of a rupture disk device. Rupture disks may be designed in several configurations, such as flat, domed (prebulged), or reverse-acting. The rupture disk holder secures the disk in place.

b) A nonfragmenting rupture disk is a rupture disk designed and manufactured to be installed upstream of other piping components, such as pressure-relief valves, and will not impair the function of those components when the disk ruptures.

c) A rupture disk holder is the structure which encloses and clamps the rupture disk in position.

Rupture disks normally require a rupture disk holder although some disk designs can be installed between standard flanges without holders.

4.10.2 Types of Rupture Disk Devices

4.10.2.1 Conventional Rupture Disk

A conventional domed rupture disk is a prebulged solid metal disk designed to burst when it is overpressured on the concave side (see Figure 13).

The conventional domed rupture disk of flat-seat or angular-seat design generally provides a satisfactory service life when operating conditions are 70 % or less of the rated burst pressure of the disk and when limited pressure cycling and temperature variations are present. If vacuum or backpressure conditions are present, the disk must be furnished with a vacuum support to prevent reverse flexing or implosion. Vacuum supports are designed for continuous service at full vacuum or less. Special designs are available for backpressure conditions that exceed 15 lbf/in.^{2} (103 kPa). The conventional domed rupture disk will fragment upon burst.

4.10.2.2 Scored Tension-loaded Rupture Disk

The scored tension-loaded rupture disk is designed to open along scored lines (see Figure 14). This type of disk is designed to allow a higher ratio (generally 80 % to 90 %) of system operating pressure to disk burst pressure. Because the score lines control the opening pattern, this type of disk is normally nonfragmenting. The scored tension-loaded rupture disk is manufactured from thicker material than is used for unscored disks for the same burst pressure. The disk is mechanically scored to control the burst pressure and burst pattern. The increased material thickness of the disk provides additional resistance to mechanical damage; in most cases, the disk will withstand full vacuum without the addition of a separate vacuum support.

4.10.2.3 Composite Rupture Disk

A composite rupture disk is a flat or domed metallic or nonmetallic multipiece construction disk. The domed composite rupture disk is designed to burst when it is overpressured on the concave side. The flat composite rupture disk is designed to burst when it is overpressured on the side designated by the manufacturer.

The domed composite rupture disk, available in flat-seat or angular-seat design, permits typical operation to 80 % of the rated burst pressure under limited pressure cycling and temperature variations. The burst pressure is controlled by the combination of a slit-top section and a metallic or nonmetallic seal member under the top section. Composite

Figure 12—Rupture Disk Device—Rupture Disk in a Typical Holder

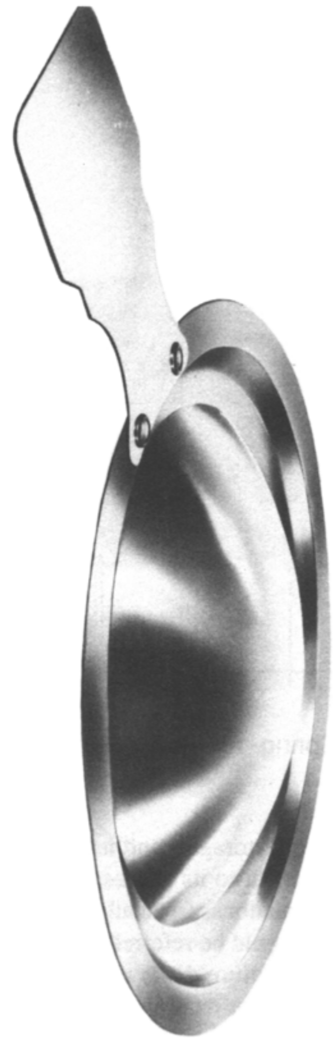


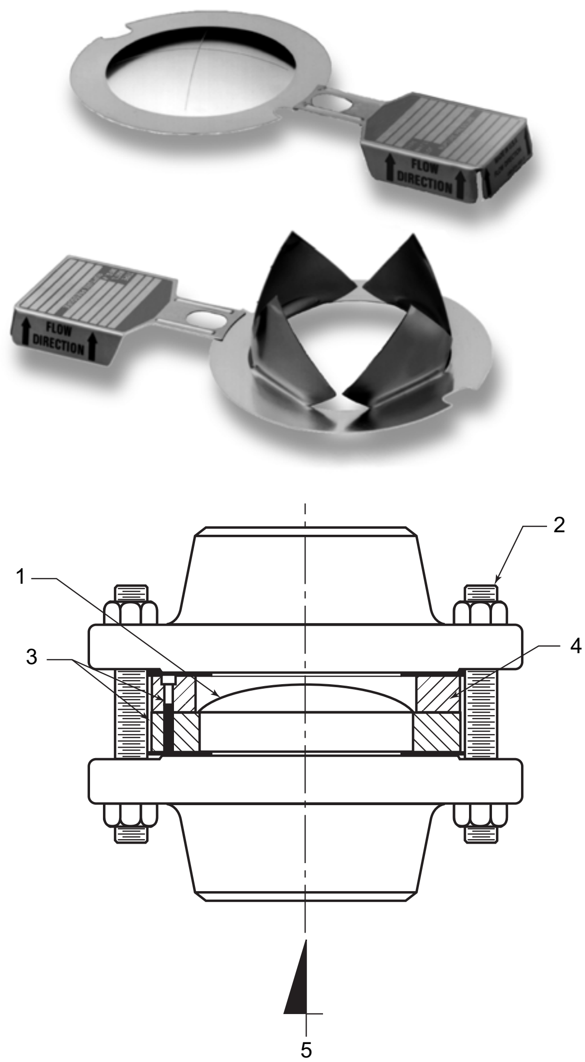
Figure 13—Conventional Domed Rupture Disk

rupture disks are generally available in burst pressures lower than those of the conventional domed rupture disks The slit-top section provides a predetermined opening pattern for the rupture disk and minimizes fragmentation when the top section is supplied with a nonmetallic seal. As with the conventional domed rupture disk, a support is generally required when vacuum or backpressure conditions are present.

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 sides of pressure-relief valves. Intended as corrosion barriers only, flat composite rupture disks may typically operate at 50 % of the rated burst pressure and are generally installed between companion flanges rather than specific rupture disk holders. Rupture disks that act in either direction are available; these provide positive pressure and vacuum protection.

4.10.2.4 Reverse-acting Rupture Disk

A reverse-acting rupture disk is a domed solid metal disk designed to burst when it is overpressured on the convex side. Reverse-acting rupture disks are designed to open by such methods as shear, knife blades, knife rings, or scored lines (see Figure 15 and Figure 16).



Key
1 rupture disk
2 standard studs and nuts
3 preassembly side clips or preassembly screws
4 insert-type rupture disk holder (inlet and outlet shown)
5 flow

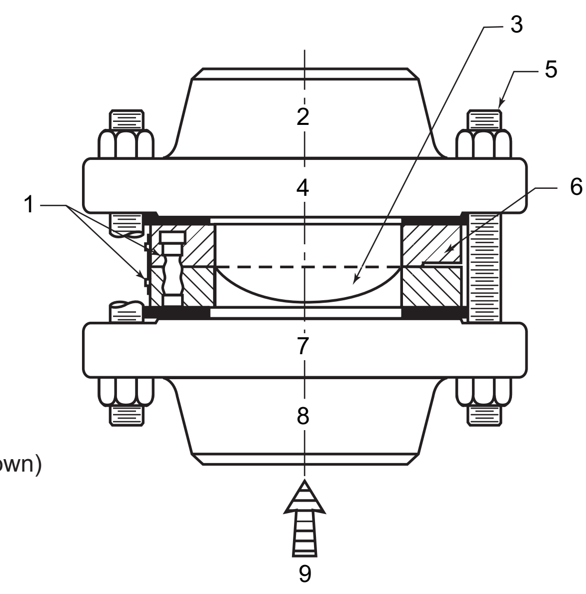
Figure 14—Scored Tension-loaded Rupture Disk

The reverse-acting rupture disk is designed to allow a higher ratio of system operating pressure to burst pressure, up to 90 % of the rated burst pressure. This type of disk is usually nonfragmenting. Because the reverse-acting rupture disk is actuated by overpressure on the convex side, the stresses in the disk are generally compressive and tend to provide longer service life under pressure/vacuum cycling conditions and temperature fluctuations. Caution should be exercised when inspecting a reverse-acting disk utilizing knife blades. If the knife edges become dull, the knife may not sever the disk. High overpressures may result.

4.10.2.5 Graphite Rupture Disk

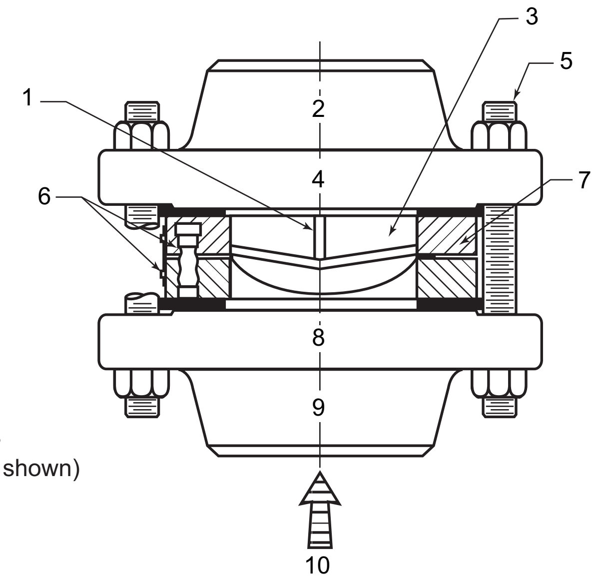
A graphite rupture disk is manufactured from graphite impregnated with a binder material and designed to burst by bending or shearing (see Figure 17).

Graphite rupture disks are resistant to most acids, alkalis, and organic solvents. Operation to 70 % of the rated burst pressure is generally permissible. A support may be required for disks that are rated 15 lbf/in.^{2} (103 kPa) or less; a



Key
1 preassembly side clips or preassembly screws
2 outlet
3 rupture disk
4 standard flange
5 standard studs and nuts
6 insert-type rupture disk holder (inlet and outlet shown)
7 standard flange
8 inlet
9 pressure

Figure 15—Reverse-acting Scored Rupture Disk



Key

1 knife-blade or knife-ring assembly
2 outlet
3 rupture disk
4 standard flange
5 standard studs and nuts
6 preassembly side clips or preassembly screws
7 insert-type rupture disk holder (inlet and outlet shown)
8 standard flange
9 inlet
10 pressure

Figure 16—Reverse-acting Scored Rupture Disk with Knife Blades

support also may be required under conditions of higher backpressure. Graphite rupture disks fragment upon rupture; provisions for capturing fragments may be required in certain applications.

4.10.3 Applications

Rupture disk devices are sometimes used:

a) to protect the upstream side of pressure-relief valves against corrosion by the system fluid;

b) to protect pressure-relief valves against plugging or clogging by viscous fluids or polymerization products;

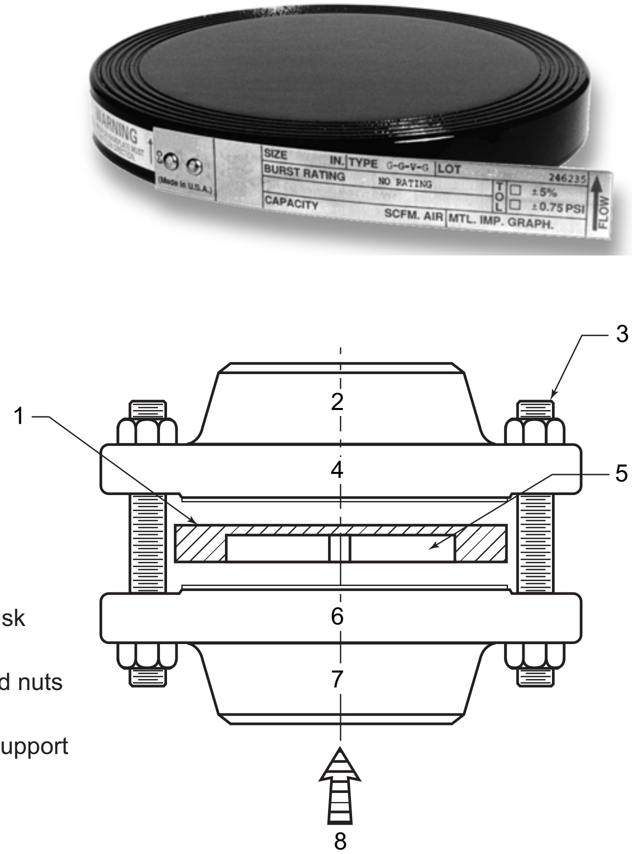
c) instead of pressure-relief valves if the protected system can tolerate process interruptions or loss of fluids in case the disk ruptures;

d) if a faster response than pressure-relief valves typically provide is desirable;

e) as secondary pressure-relieving devices when the difference between the operating pressure and the rupture pressure is large, depending on the type of rupture disk selected;

f) to protect the downstream sides of pressure-relief valves against downstream corrosion from headers or against atmospheric corrosion;

g) to minimize process/product leakage and reduce fugitive emissions.



Key

1 graphite rupture disk
2 outlet
3 standard studs and nuts
4 standard flange
5 optional vacuum support
6 standard flange
7 inlet
8 pressure

Figure 17—Graphite Rupture Disk

The proper receipt, storage, handling, and installation of a rupture disk are critical to its successful performance. Refer to the manufacturer's installation instructions, especially those concerning specifications on bolt torque.

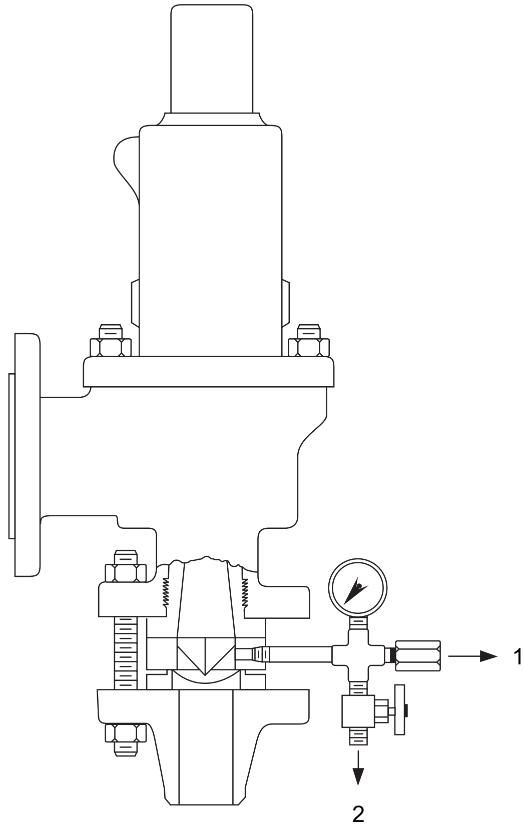
Some rupture disks using knife blades to open have failed to open properly. Consultation with the manufacturer concerning proper installation and maintenance of these kinds of rupture disks may be beneficial.

A pressure gauge, a try cock, a free vent, or a suitable tell-tale indicator must be inserted between a rupture disk device installed at the inlet of a pressure-relief valve and the valve (see Figure 18), permitting the detection of disk rupture or leakage. Since rupture disks are designed to burst at a specified differential pressure, pressure buildup on the downstream side of the disk may inhibit the disk's ability to provide overpressure protection.

A rupture disk device must have full pipe area and must not fragment into the pressure-relief valve inlet after the disk bursts. When a rupture disk device is used with a pressure-relief valve, consult the ASME *BPVC* Section VIII, Division 1, Paragraph UG-127, for the capacity reduction and installation details.

4.10.4 Limitations

For prebulged metal rupture disks installed so that pressure acts against the concave side and for flat metal rupture disks, the operating pressure of the protected system is usually limited to 65 % to 85 % of the disk's marked bursting pressure. Consult the manufacturer to determine the limits for a specific design.



Key
1 excess flow valve (optional)
2 bleed valve (may be car-sealed open)

Figure 18—Combination of Reverse-buckling Disk Assembly and Safety-relief Valve

The service life of prebulged metal rupture disks under normal operating conditions is usually one year. They are subject to relatively rapid creep stress failure, especially at high operating temperatures. If not replaced periodically, they may fail without warning at normal operating pressures.

Higher operating pressures (up to 90 % of the marked bursting pressure) are possible with the reverse-buckling disk. Less fatigue due to pulsating and cyclic operating pressure results in a longer service life than would be expected if the disk were installed with the pressure acting against the concave side. Most reverse-buckling disks should not be used in liquid full service. However, if an assured gas pocket rests against the disk and the disk manufacturer is consulted, liquid service can be considered. With finite lives, these disks should be replaced periodically. Consult the manufacturer for recommended replacement times.

Impervious graphite rupture disks offer nearly the same advantages and disadvantages as the reverse-buckling, metal type (other than graphite disks tend to fragment). However, with impervious graphite rupture disks, uneven flange bolt loads or thermal strains in the piping may crack the disk.

Rupture disks that tend to fragment, such as conventional and graphite disks, should not be installed beneath pressure-relief valves.

Caution—When rupture disks are removed for inspection or when an accompanying relief valve is serviced, the disks can easily be damaged and can fail prematurely if reused. Replacement of disks at every maintenance interval will minimize the chance of damage and premature failure.

An appropriate replacement period should be established before a rupture disk device is put into service. The following factors should be considered:

— type of disk,

— materials,

— operating ratio (operation pressure/set point),

— temperature conditions,

— service conditions.

See ISO 4126-6, Annex B, for further guidance on establishing the appropriate replacement period.

5 Causes of Improper Performance

5.1 Corrosion

5.1.1 Most corrosion mechanisms are present in refinery and chemical plant services. Corrosion is a basic cause of many of the difficulties encountered with pressure-relief devices. Corrosion often appears as: pitted or broken valve parts, deposits of corrosive residue that interfere with the operation of the moving parts, or a general deterioration of the material of the relieving device. Figure 19 through Figure 25 illustrate the effects of corrosion on relief devices. In addition to internal parts, exposed studs are vulnerable to environmental corrosion attack.

5.1.2 Corrosion may be slowed or mitigated by the selection of more suitable devices or device materials. Proper maintenance is also a consideration since a leaking valve allows fluids to circulate in the upper parts of the valve, which can contribute to the corrosion of its movable parts. Protective coatings as shown in Figure 26 may offer protection against corrosion in some services.

5.1.3 In certain applications, a rupture disk device installed on the inlet or outlet of a pressure-relief valve can provide added corrosion protection of the valve internals.

5.1.4 In many instances, valves with differing materials of construction can impede or altogether mitigate the effects of corrosion. The use of an O-ring seat in a pressure-relief valve may stop leakage past the seating surface and eliminate corrosion in the valve's working parts (see Figure 3). However, O-ring elastomers may have a limited life under stress due to degradation caused by temperature, aging, or swelling. A bellows seal can be used to protect the spring and the bonnet cavity of the valve from the corrosive loading fluid (see Figure 5).

5.2 Damaged Seating Surfaces

5.2.1 To prevent leakage of the loading fluid, an optical precision on the order of three light beads/bands [0.0000348 in. (0.0008838 mm)] must be maintained in the flatness of seating surfaces on metal-seated pressure-relief valves (see API 527). Imperfections in these seating surfaces may contribute to improper valve action in service.

5.2.2 There are many causes of damaged valve seats in refinery or chemical plant service, including the following.

a) Corrosion.

b) Foreign particles introduced into the valve inlet and pass through the valve when it opens, such as mill scale, welding spatter or slag, corrosive deposits, coke, or dirt. The particles may damage the seat contact required for tightness in most pressure-relief valves. The damage can occur either in the shop during maintenance of the valve or while the valve is in service.

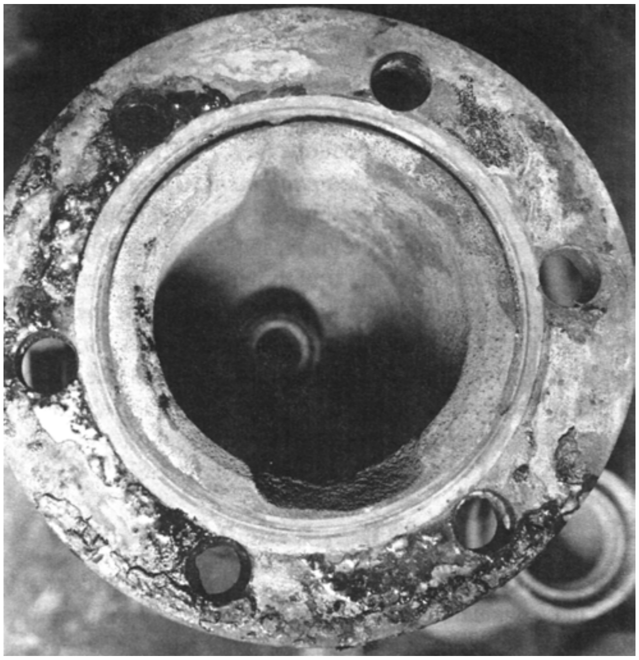


Figure 19—Acid Corrosion in Carbon Steel Bonnet Caused by Leaking Seating Surfaces

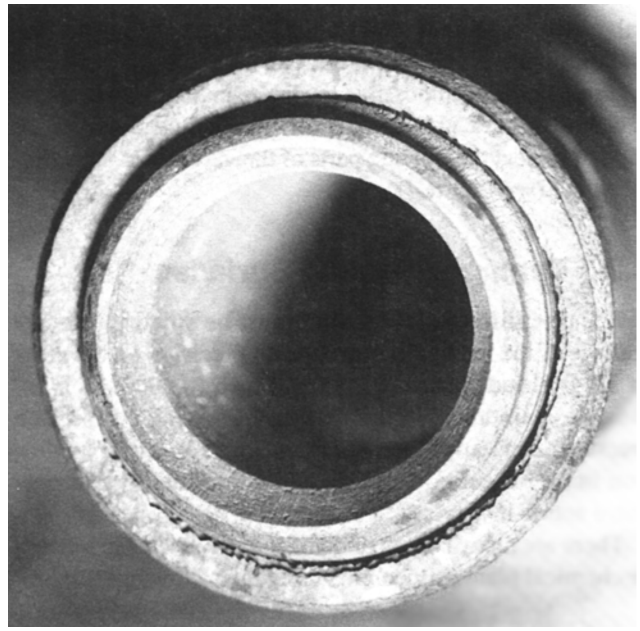


Figure 20—Acid Corrosion on 18Cr-8Ni Steel Inlet Nozzle

c) Improper or lengthy piping to the valve inlet or obstructions in the line. These can cause a valve to chatter. The pressure under the seat may become great enough to open the valve. However, as soon as the flow is established, the built-up pressure drop in the connecting piping may be so great that the pressure under the seat falls and allows the valve to close. A cycle of opening and closing may develop, become rapid, and subject the valve seating surfaces to severe hammering, which damages the seating surfaces, sometimes beyond repair. Figure 27 and Figure 28 show seating surfaces damaged by chattering and frequent fluctuations of pressure.

d) Careless handling during maintenance, such as bumping, dropping, jarring, or scratching of the valve parts.

e) Leakage past the seating surfaces of a valve after it has been installed. This leakage contributes to seat damage by causing erosion (wire drawing) or corrosion of the seating surface and thus aggravating itself. It may be due to improper maintenance or installation such as misalignment of the parts, piping strains resulting from improper support, or complete lack of support of discharge piping. Other common causes of this leakage are improper alignment of the spindle, improper fitting of the springs to the spring washers, and improper bearing between the spring washers and their respective bearing contacts or between the spindle and disk or disk holder. Spindles should be checked visually for straightness. Springs and spring washers should be kept together as a spring assembly during the life of the spring. Seat leakage may also result from the operating pressure being too close to the set pressure of the valve.

f) Improper blowdown ring settings. These can cause chattering in pressure-relief valves. The relief valve manufacturer should be contacted for specific blowdown ring settings for liquid service and for vapor service.

g) Severe oversizing of the pressure-relief valve for the relief loads encountered can cause the valve to close abruptly, resulting in disc and nozzle seating surface damage.

Figure 21—Chloride Corrosion on 18Cr-8Ni Steel Nozzle (with Machined Seating Surface)

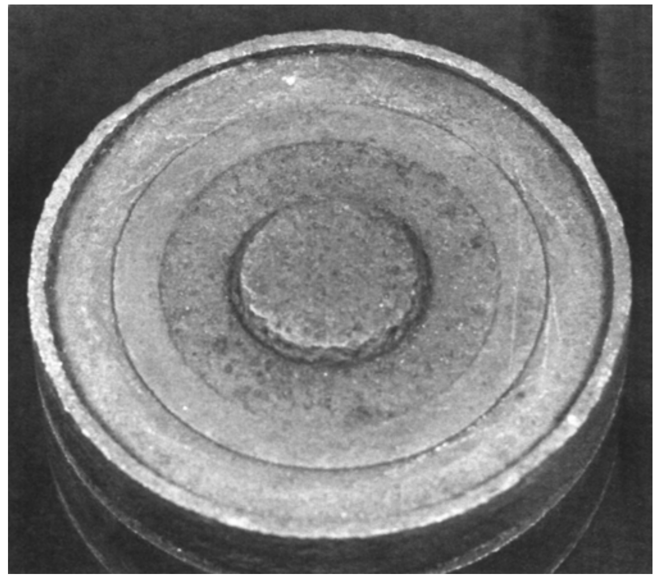


Figure 22—Sulfide Corrosion on Carbon Steel Disk from Crude Oil Distillation Unit

5.3 Failed Springs

5.3.1 Spring failures occur in two forms. The first is a weakening of the spring, which causes a reduction in set pressure and the possibility of premature opening. The second is a mechanical failure (complete break) of the spring, which causes uncontrolled valve opening.

5.3.2 Although springs may weaken and fail due to the use of improper materials in high-temperature service, failed springs are almost always caused by corrosion. Surface corrosion and stress corrosion cracking are the most prevalent of this type of failure in refineries.

5.3.3 Surface corrosion attacks the spring surface until the cross-sectional area is not sufficient to provide the necessary closing force. It may also produce pits that act as stress risers and cause cracks in the spring surface and subsequent spring failure (see Figure 29).

5.3.4 Stress corrosion cracking sometimes causes spring failure. It is particularly insidious because it is difficult to detect before the spring fails. A brittle-type spring failure due to stress corrosion cracking is shown in Figure 30. Hydrogen sulfide (H_2S) frequently causes stress-corrosion cracking of springs (see NACE MR 0175 and NACE MR 0103 for material recommendations and guidance). Consult the manufacturer to select an

Figure 23—Chloride Attack on 18Cr-8Ni Steel Disk

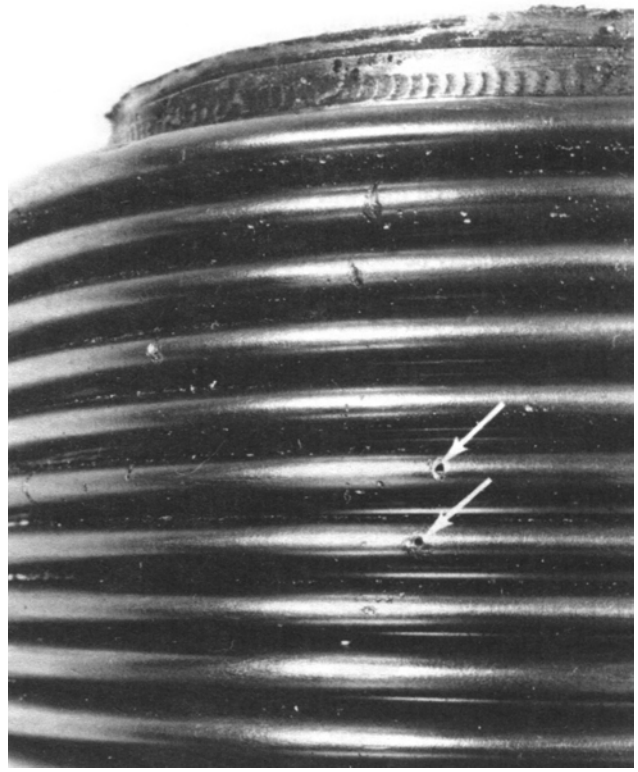


Figure 24—Pit-type Corrosion on 18Cr-8Ni Steel (Type 316) Bellows

Figure 25—Monel Rupture Disks Corroded in Sour Gas Service

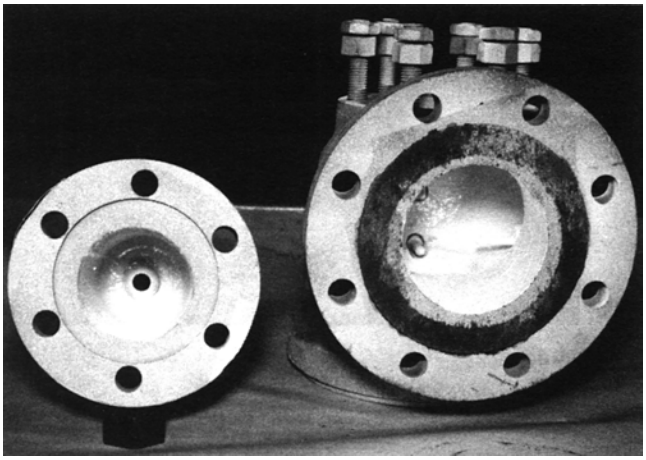


Figure 26—Body and Bonnet Coated with Epoxy for Corrosion Protection

Figure 27—Seating Surface of Disk Deformed by Chattering

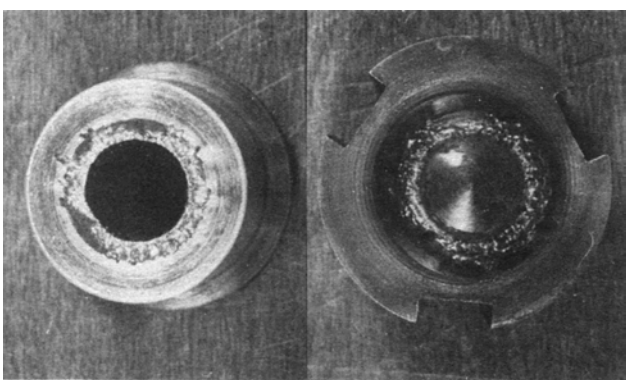


Figure 28—Seat and Disk Damaged by Frequent Operation of Valve Too Close to Operating Pressure

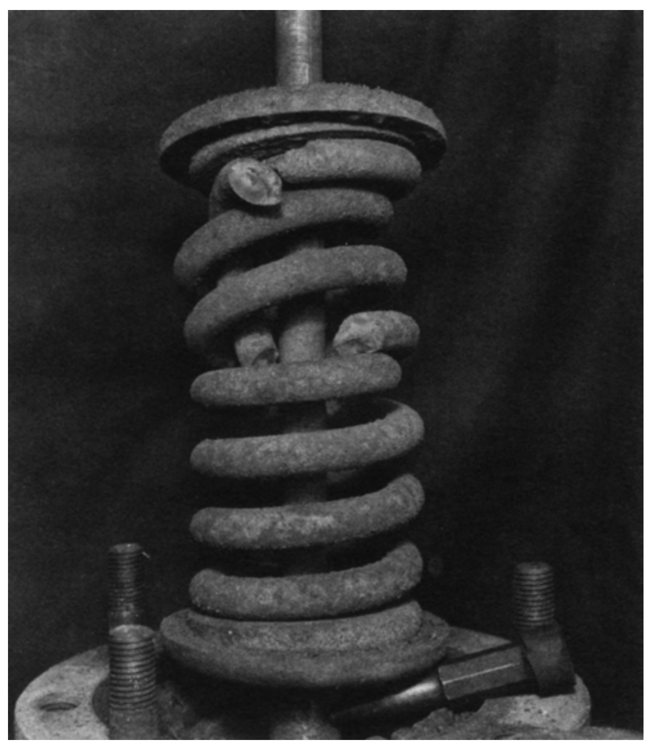


Figure 29—Spring Failure Due to Corrosion

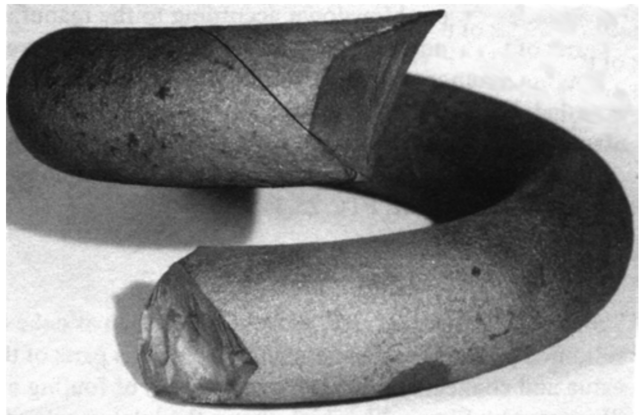


Figure 30—Spring Failure Due to Stress Corrosion

appropriate spring in susceptible applications since the material strength, hardness and heat treatment of the spring can affect its resistance to stress corrosion cracking.

Where corrosion prevails, three courses of preventive action may be taken.

a) Spring material that will satisfactorily resist the action of the corrosive agent may be used.

b) The spring may be isolated by a bellows. Certain pilot-operated pressure-relief valves have diaphragms or pistons that isolate the pilot spring from the process.

c) The spring may be specially coated with a corrosion-resistant coating that can withstand the operating temperature and environment.

5.4 Improper Setting and Adjustment

5.4.1 Manuals provided by the valve manufacturer help eliminate improper setting and adjustment by indicating how to adjust their valves for temperature, backpressure, and other factors.

5.4.2 In refinery and chemical plant services, setting a pressure-relief valve while it is in place on the equipment to be protected may be impractical and should be performed only after special consideration as noted in 6.2.17. Generally, direct spring-loaded valves should be set in the valve maintenance shop while on appropriate test equipment. During inspection and repair, a properly designed test block facilitates the setting and adjusting of the pressure-relief valve (see Annex A).

5.4.3 Water, air, or an inert gas such as bottled nitrogen is generally used as the testing medium in the shop, depending on the design of the valve being tested and the requirements of applicable design and testing codes. To ensure that the valve is opening, some overpressure should be carefully applied because an audible leak could otherwise be misinterpreted as the result of reaching the set pressure. However, most pressure-relief valves produce a distinct pop at the set pressure, making misinterpretation unlikely. The size of the test stand is important since insufficient surge volume might not cause a distinct pop, and may cause an incorrect set pressure. Vapor service valves should be set using air or inert gas. Steam service valves should be set using steam, but air may be used if suitable corrections are applied. Liquid service valves should be set using water.

5.4.4 Consult the manufacturer for the proper technique for setting pilot-operated pressure-relief valves on liquid as the water in the dome area and pilot assembly may create problems when placed in service.

5.4.5 Incorrect calibration of pressure gauges is a frequent cause of improper valve setting. To ensure accuracy, gauges should be calibrated frequently on a regularly calibrated dead weight tester. The pressure range of the gauge should be chosen so that the required set pressure of the pressure-relief valve falls within the middle third of the gauge pressure range. Snubbers on pressure gauges are not generally recommended since they tend to clog and produce pressure lag.

5.4.6 Adjustment of the ring or rings controlling the valve is frequently misunderstood. The valve adjusting ring or rings will control either the valve blowdown—the difference between the set pressure and the reseating pressure—or valve blowdown and simmer, depending on the design of the valve being tested. Because the density and expansion characteristics of material handled through pressure-relief valves are variable and the volume of testing facilities is limited, it is usually impractical to adjust the valve rings on a maintenance shop test block. The rings should therefore be adjusted to obtain a pop on the valve test drum and then inspected and readjusted for proper blowdown according to the manufacturer's recommendation. This should permit the best average performance characteristics of the valve when installed. For liquid or vapor service, the relief valve manufacturer should be contacted regarding the proper blowdown ring settings. Full understanding of terminology is important (see ASME PTC 25).

5.5 Plugging and Sticking

5.5.1 In refinery and petrochemical services, process solids such as coke or solidified products can sometimes plug various parts of the valve and connected piping. Additionally, monomer service can lead to polymer formation and plugging. All valve parts, particularly guiding surfaces, should be checked thoroughly for any type of fouling. Lubricate all load bearing surfaces such as spindle to disk holder, spring buttons to spindle, disk-to-disk holder and threads with a lubricant that is compatible with the process materials and service temperatures.

Illustrations of valve fouling are provided in the following figures:

— Figure 31 illustrates an extreme case of fouling where the inlet nozzle of a relief valve was completely plugged with a mixture of coke and catalyst,

— Figure 32 shows the outlet nozzle of a valve plugged with deposits from other valves that discharge into a common discharge header,

— Figure 33 and Figure 34 show partial fouling that will also impede proper valve operation.

5.5.2 Valve malfunction may also be due to sticking of the disk or disk holder in the guide. This sticking may be caused by corrosion or galling of the metal or by foreign particles in the guiding surfaces. Foreign particles in the guiding surfaces tend to roll metal up, causing severe galling. The use of a bellows can keep the foreign particles away from the guiding surfaces. Sticking of valves illustrates a disk that is frozen in the guide as a result of corrosion in sour gas service. There are four corrective actions that may mitigate corrosion caused by sticking. First, the use of a bellows can protect moving parts from the corrosive substance; especially in closed systems (see Figure 4). Second, an O-ring seat (see Figure 3) can seal the guiding surfaces from the loading fluid until a relief cycle occurs. Third, the use of a rupture disk on the valve inlet will isolate the valve internals from the upstream process material. Fourth, the use of a rupture disk on the valve outlet can seal the guiding surfaces from substances in the discharge system until a relief cycle occurs

5.5.3 When galling of the metal in the guiding surfaces is not due to corrosion or foreign particles, it is often due to valve chatter or flutter caused by improper piping at the valve inlet or outlet or by severe over sizing of the valve. Correction of improper piping at the valve inlet or outlet will usually stop the action of chatter or flutter. Improper finishing of the guiding surfaces can also result in galling caused by chatter or flutter. Consult the valve manufacturer for recommendations as this is potentially a design and manufacturing issue.

5.5.4 Sticking of pressure-relief valves may also be caused by poor alignment of the valve disk, which is usually due to debris on the contact surface between the guide and the body of the valve, or misalignment of a gasket at assembly.

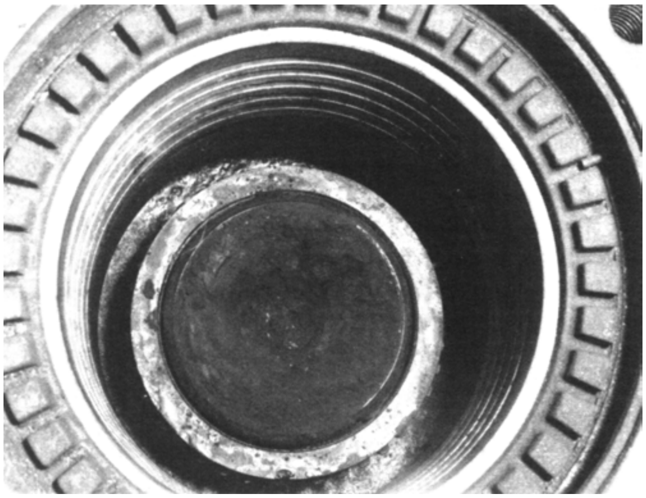


Figure 31—Inlet Nozzle Plugged with Coke and Catalyst After Nine Months in Reactor Vapor Line

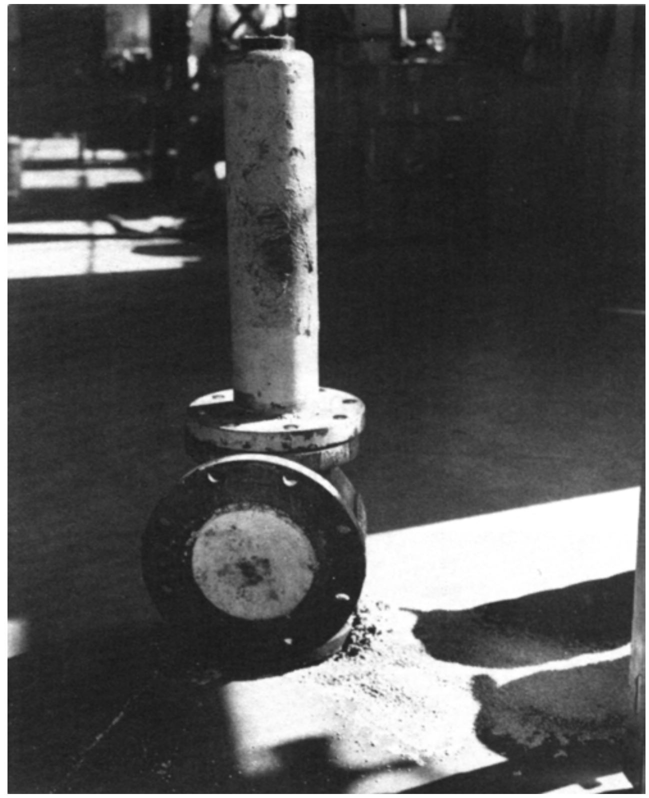


Figure 32—Outlet Valve Plugged with Deposits from Other Valves in Common Discharge Header

5.6 Misapplication of Materials

5.6.1 In general, the temperature, pressure, corrosion protection requirements, and the atmospheric conditions of the service determine the materials required for a pressure-relieving device in a given service. The selection of standard valves that meet those requirements and are appropriate for those conditions is advisable. Occasionally, severe corrosion or unusual pressure or temperature conditions in the process require special consideration. Manufacturers can usually supply valve designs and materials that suit special services. Catalogs have a wide selection of special materials and accessory options for various chemical and temperature conditions. Addition of a rupture disk device at the inlet or outlet may help prevent corrosion.

5.6.2 The H_2S attack on the carbon steel spring in Figure 22 and the chloride attack on the 18Cr-8Ni steel disk in Figure 23 exemplify the results of the misapplication of materials. When service experience indicates that a selected valve type or material is not suitable for a given service condition, an immediate correction that will ensure dependable operation should be made. Great care should be taken to record the identity of special materials and the locations requiring them. An adequate system of records should provide the information needed for the repair or reconditioning of valves in special service and for developing optimum purchase specifications.

5.7 Improper Location, History, or Identification

If not installed at the exact location for which it is intended a pressure-relief valve may not provide the proper protection.

To assist in the identification of valves and to provide information necessary for correct repairs and installation, a comprehensive set of specification and historical records should be maintained and referred to when valves are

Figure 33—Moving Parts of Valve Fouled with Iron Sulfide (FeS_2)

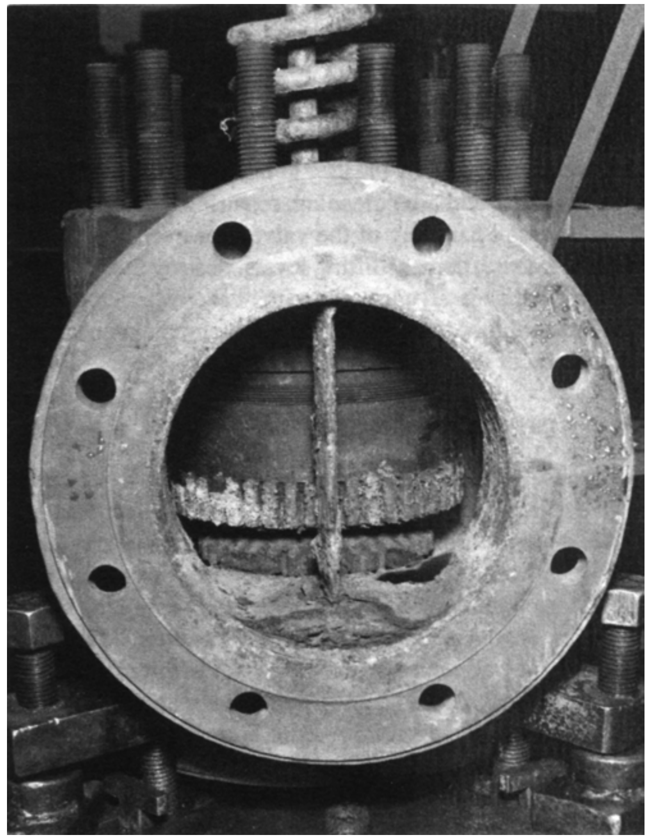


Figure 34—Spring Failure Due to Stress Corrosion

removed for inspection and repair. Most pressure-relief valves have an identifying serial or shop number placed on the valve by the manufacturer or an identifying number tagged, stamped, or otherwise placed on the valve by the user. Some users also stamp mating pipe flanges with device numbers. This identification specifies the location of the valve and, by reference to the specification record, its limitations and construction (see Section 7).

5.8 Rough Handling

5.8.1 General

Due to the difficulty in obtaining absolute tightness in most pressure-relieving devices, valves are manufactured according to a commercial tightness standard (see API 527). Valves are checked for tightness in the manufacturer's plant before they are shipped to the user. Valve tightness is sometimes checked by the user in the maintenance shop before initial use and usually checked after subsequent cleaning, repairing, or testing. Subsequent rough handling of the valve, however, can change the set pressure, damage lifting levers, damage tubing and tubing fittings, damage pilot assemblies or cause internal or external leakage when the valve is in service. Rough handling can occur during shipment, maintenance, or installation.

5.8.2 During Shipment

5.8.2.1 Because of their operation, most pressure-relief valves have a sturdy appearance that may obscure the fact that they are delicate instruments with very close tolerances and sensitive dimensions. Accordingly, commercial carriers sometimes subject them to rough handling. This may cause a valve to leak excessively in service or during

Figure 35—Disk Frozen in Guide Because of Buildup of Products of Corrosion in Sour Oil Vapor Service

testing. This rough handling may also expose the valve inlet to dirt or other foreign particles that could damage the valve seating surface the first time the valve opens and cause leakage thereafter.

5.8.2.2 Pressure-relief valves should be shipped in an upright position—this is especially true of large valves and valves with low set pressures. When large, low-pressure valves are allowed to lie on their sides, the springs may not exert the same force all around the seating surfaces.

5.8.3 During Maintenance

5.8.3.1 Pressure-relief valve parts are usually precision items manufactured to extremely close tolerances. Rough handling can degrade these tolerances. Rough handling can also destroy the basic valve alignment on which the fine, exacting performance characteristics of the device primarily depend. Careful handling of the valve during all phases of maintenance is important. Both before and after repairs, rough handling of the completely assembled valve should be avoided. Before the valves leave the shop, valve inlets and outlets should be covered.

5.8.3.2 Rough handling during maintenance includes application of excessive backpressure, which should not be applied to a bellows valve during a maintenance-related test.

5.8.4 During Installation

5.8.4.1 Valve inlets and outlets should have been covered before the valves left the shop. If they were not covered when received for installation, provisions should be made to ensure that in the future they are covered before leaving the shop.

5.8.4.2 Pressure-relief valves should be transported in an upright position.

5.8.4.3 Rough handling of a pressure-relief valve by personnel during installation may cause poor valve performance in service. Bumping or dropping the valve should be carefully avoided. The valves shown in Figure 36 were dropped from the bed of a truck after being repaired. As a result, they leaked once they were installed.

NOTE Pressure-relief valves should be installed in a vertical orientation, with the disk or piston oriented horizontally, such that the disk or piston moves upward as the valve opens. Other orientations may permit the disk holder to become misaligned in the guide. ASME *BPVC* Section VIII, Division 1, Appendix M, describes under what conditions an orientation other than vertical may be acceptable.

Figure 36—Rough Handling of Valves Should be Avoided

5.9 Improper Differential Between Operating and Set Pressures

5.9.1 The differential between operating and set pressures provides seat loading to keep the pressure-relief valve tightly closed. Due to a variety of service conditions and valve designs, only general guidelines can be given for designing a system. NB-23, Appendix F, ASME *BPVC* Section VIII, Division 1 and ASME *BPVC* Section VIII, Division 1, Appendix M, and API 520 are useful references. However, individual applications and experience may be relied on.

5.9.2 Although greater differentials between operating and set pressures promote trouble-free operation, they may also increase the cost of the equipment. Inspections should record operating experience and provide feedback to be considered in future design and remedial action.

5.10 Improper Discharge Piping Test Procedures

When hydrostatic tests of discharge piping are performed, blinds shall be installed. Otherwise, results such as the following might occur:

— the disk, spring, and body area on the discharge side of the valve are fouled;

— the bellows of a balanced relief valve are damaged by excessive backpressure;

— the dome area and/or pilot assembly of a pilot-operated pressure-relief valve are fouled and damaged by the backflow of fluid;

— exceeding the design pressure of the discharge side of spring-loaded pressure-relief valves in some of the larger sizes.

5.11 Improper Handling, Installation, and Selection of Rupture Disks

Rupture disk problems are often associated with improper handling, installation, and selection. The following should be considered.

a) Ensure the rupture disk is installed in the proper orientation. Some reverse-acting rupture disks will open at a significantly higher burst pressure if installed upside down.

b) Once a rupture disk is removed from its holder, the rupture disk should not be reinstalled. Installation in a holder can form an imprint on the disk. Once removed from its holder, it would be difficult to reinstall the disk perfectly in the same imprint. The most likely result will be premature failure below the intended burst pressure.

c) Always follow the manufacturer's recommended torque settings when installing the rupture disk in the holder. An improper torque could affect the opening pressure of the disk and in some cases cause nonfragmenting disks to fragment.

d) Touching the rupture disk surface could lead to localized corrosion leading to premature failures. Some types of disks that become dented or otherwise damaged may open outside their burst-pressure tolerance or may not open completely when required thereby potentially restricting the relief path.

e) Temperature can significantly affect rupture disk opening pressure for some materials. Specification of appropriate burst temperature should consider ambient heating or cooling if uninsulated and/or untraced. Consult the manufacturer and see API 520, Part 1, for additional information.

f) Rupture disks should be installed away from unstable flow patterns to avoid premature failures (see API 520, Part 1, for additional information). API 520, Part 2, provides general requirements for installation of pressure-relief devices.

6 Inspection and Testing

6.1 Reasons for Inspection and Testing

6.1.1 Pressure-relieving devices are installed on process equipment to release excess pressure due to operational upsets, external fires, and other hazards. These hazards are discussed in API 521. Failure of pressure-relieving devices to function properly when needed could result in the overpressure of the vessels, exchangers, boilers, or other equipment they were installed to protect. A properly designed, applied, and installed pressure-relieving device that is maintained in good operating condition is essential to the safety of personnel and the protection of equipment during abnormal circumstances. The principal reason for inspecting pressure-relieving devices is to ensure that they will provide this protection.

6.1.2 Inspections of pressure-relief devices must determine the general physical and operating conditions of the devices, and ensure that their performance meets the requirements for a given installation. In making this determination, two types of inspections can be used. They are "shop inspection/overhauls," and "visual on-stream inspections." Pretesting and posttesting of the pressure-relieving device should be included in the "shop inspection/ overhaul." Each is discussed in the following sections.

6.2 Shop Inspection/Overhaul

6.2.1 General

Periodically, pressure-relief devices will be removed, disassembled, and inspected. These inspections are referred to as "shop inspection/overhaul" (although some, if not all of the work can be performed in the field). Also, while the device is removed, inlet and outlet piping should be inspected for the presence of internal deposits, and records should be kept of their condition and cleaning. If necessary, piping should be radiographed or dismantled for inspection and any cleaning to be performed.

6.2.2 Safety

6.2.2.1 Before inspection and any repairs on pressure-relieving devices are executed, general precautions should be taken to maintain the safety of the equipment protected by the devices, especially if the equipment is in operation. When inspection and repairs on an operating unit are required, the unit operations should be normal and the proper authority and permits for the work should be obtained.

6.2.2.2 Some pressure-relieving valves have set pressures that exceed their outlet flange rating. If these valves are equipped with outlet block valves, the pressure-relief valve inlet block valve should be closed before the outlet valve is closed. Also, the pressure-relief valve body must be vented immediately after the outlet isolation block valve is closed. This prevents high pressures from the pressure-relief valve inlet from possibly over-pressuring the pressure-relief valve body. Similar caution should be exercised when installing a blind in the pressure-relief valve outlet. Installation of drain valves between the inlet and outlet block valves and the pressure-relief valve should be considered, as shown in API 520, Part 1.

6.2.2.3 Before disconnecting pressure-relieving devices, the connected piping and block valves should be checked to ensure that they are sufficiently supported. After reinstalling pressure-relief valves, the related piping should be checked to ensure that it is not imposing loads that would cause problems with the pressure-relief valve body such as distortion leading to in-service leakage, a change in set pressure or binding of the internal components leading to a stuck valve.

6.2.2.4 Some devices may trap hazardous toxic process material in bonnet cavities or dome cavities. Special steps during decontamination should be taken to minimize exposure of shop personnel.

6.2.3 Valve Identification

To minimize errors in the testing and handling of pressure-relief valves, each should carry an identifying tag, stencil, plate, or other means to show its company equipment number. This number readily identifies the device's unit, the equipment that the device should be installed on, the device's set pressure, and the date of its last test (see Figure 37 for an example of an identifying tag). If a relief device cannot already be easily and correctly identified by a marking on it, it should be marked and identified as described above before it is removed from its equipment. Also see ASME *BPVC* Section VIII, Division 1, Paragraph UG-129, for instructions on marking nameplates of pressure-relieving devices.

6.2.4 Operating Conditions Noted

An operating history of each pressure-relief valve since its last inspection should be obtained and should include pertinent information such as the following:

— information on upsets and their effect on the valve,

— the extent of any leakage while in service,

— any other evidence of malfunctioning,

— whether any rupture disks under the pressure-relief valve have been replaced.

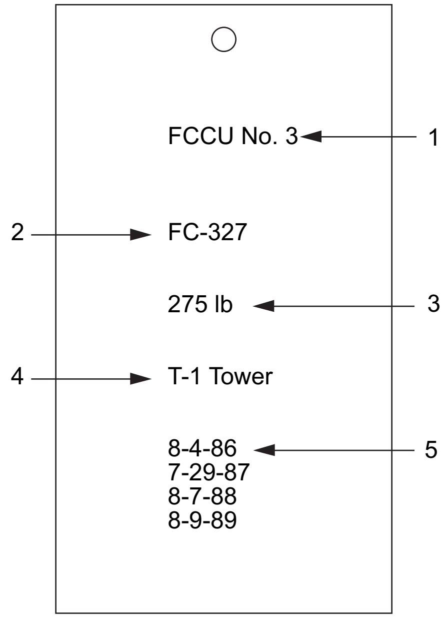
In addition, records of valve performance during previous runs should be checked to determine whether changes are needed in the valve materials or components or in the inspection interval.

6.2.5 Removal of Device from System in Operation

Caution—The removal of a pressure-relief valve from equipment in operation should be planned to minimize its duration.

Relief devices are safety devices and must be treated as such. The precautionary steps in 6.2.1 should be followed. Before a pressure-relief valve is inspected and/or repaired while equipment is in operation, the following precautions should be taken.

a) Only an authorized person should isolate a relief device by closing any adjacent block valves upstream or downstream (see ASME *BPVC* Section VIII, Division 1, Appendix M). This may require providing or identifying alternate relief protection.



Key

1 unit designation
2 company number
3 set pressure
4 equipment designation
5 test dates

Figure 37—Identification Tag for Pressure-relieving Device

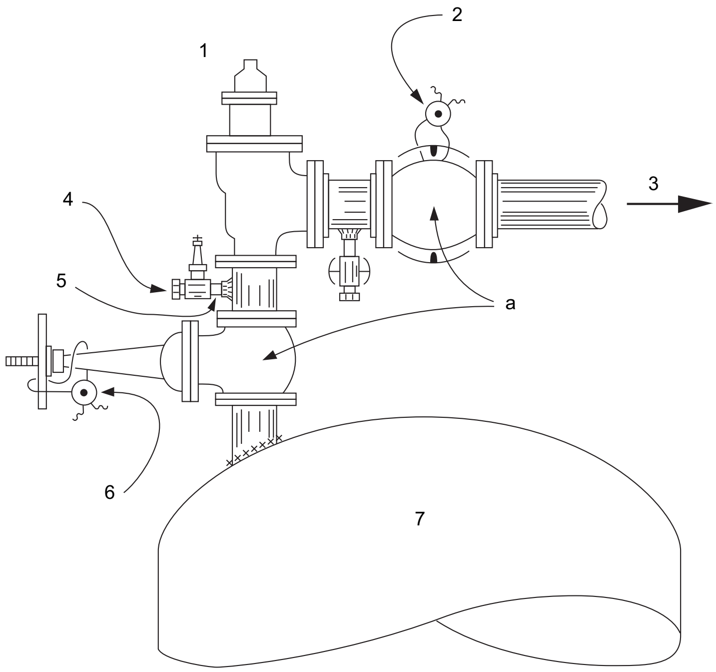
b) The space between the relief device and any adjacent block valve should be vented to a safe location to release trapped loading fluid and to determine whether the block valve is holding.

c) If a block valve is not installed on the downstream side of a relief device discharging into a common header, a blind or other suitable isolation should be applied to prevent discharge through the open outlet pipe in case one of the other relief devices opens.

d) In situations where a relief device is to be serviced in place, a blind or other positive isolation device should be inserted between the pressure-relief valve and any adjacent upstream and/or downstream block valve before a pressure-relief valve is even partially disassembled. When a relief device is removed, blinds or other suitable covers should be placed over open piping/valves to protect seating surfaces and prevent entry of foreign material.

e) If there is a rupture disk device associated with the pressure-relief valve and the rupture disk device is disturbed as part of the accompanying relief valve removal, serious consideration should be given for installing a new rupture disk since the disk could easily be damaged and could fail to burst at the proper pressure if reused.

f) All blinds should be removed after the relief device has been inspected, repaired, or replaced. The block valves on the inlet and outlet should be opened and locked or sealed in that position. Figure 38 shows a pressure-relief valve installation with the block valves sealed open. When used with a relief device, these block valves must have full pipe area through them to prevent flow restriction and possible instability when the relief device opens. In cases where there are installed spare pressure-relief valves, the inlet block valve of the spare should be closed. The outlet side should be protected from overpressure caused by leakage through the inlet block and the relief valve. The outlet block valve could either be locked open, or positive means of venting could be provided if the outlet is shut.



Key
1 safety-relief valve
2 car-seal valve in "open" position and install horizontally
3 to blowdown header
4 plug
5 short nipple
6 car-seal valve in the "open" position
7 vessel

a Block valves should have full port area and be at least the size of the inlet and outlet of the relief valve.

Figure 38—Block Valves on Safety-relief Valve Inlet and Outlet Sealed Open and Bleeders Installed to Depressure Inlet and Outlet

6.2.6 Initial Inspection

6.2.6.1 Many types of deposits or corrosion products in a pressure-relief valve may be loose and may drop out during transportation of the valve to the shop for inspection, testing, maintenance, and resetting. As soon as a valve has been removed from the system, a visual inspection should be made. Figure 39 shows sulfur deposits in a valve. When fouling is a problem, it may be prudent to collect samples for testing and to record deposit locations and appearances. Any obstructions in the valve should be recorded and removed.

Caution—Valves that have been exposed to materials hazardous to humans or that may contain material that could be an auto-ignition source should be handled with special precautions.

6.2.6.2 Some precautions to follow when inspecting valves exposed to hazardous materials include the following.

a) Evaluate the potential for the valve to contain pyrophoric (e.g. FeS) or reactive materials and determine the appropriate precautions for the material involved.

b) Valves in acid or caustic service must be correctly neutralized immediately after removal. Even after neutralization, the safety precautions indicated by the material safety data sheets and other appropriate sources of handling information must be taken.

6.2.6.3 Rupture disks are sometimes used to protect other pressure-relieving devices from corrosion. Normally in this case, a rupture disk cannot be inspected without being removed. Therefore, inspection of the disk should be part of the routine developed for inspection of the pressure-relief valve (see 6.2.21).

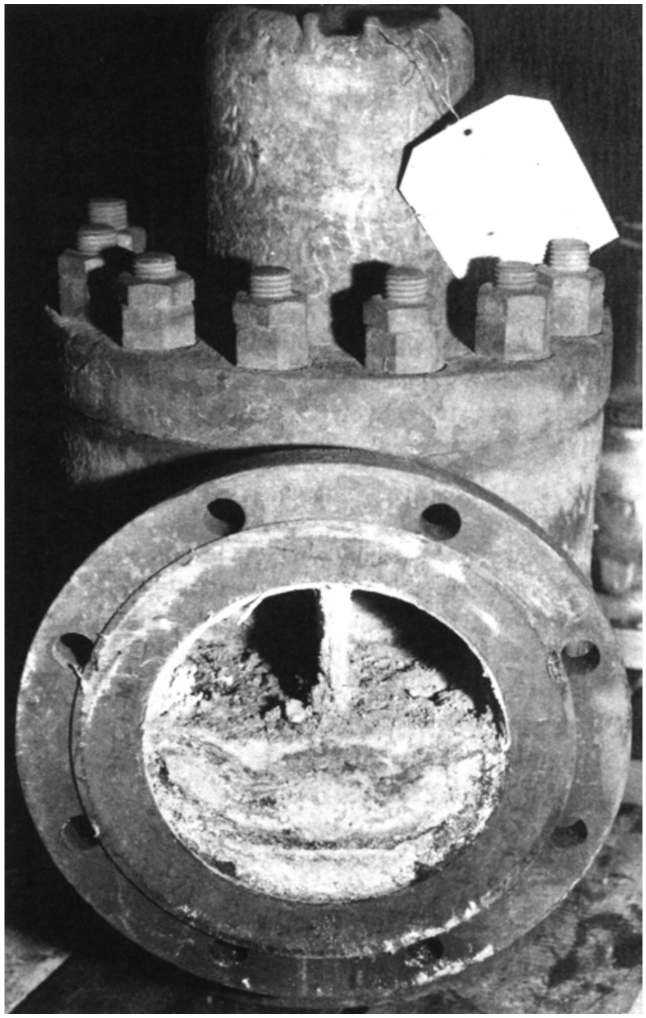


Figure 39—Sulfur Deposits in Body of Valve

6.2.7 Inspection of Adjacent Inlet and Outlet Piping

6.2.7.1 When a pressure-relief valve is removed from service, the upstream and downstream piping is often open and available for inspection. However, where block valves are closed to enable removal of relief devices from equipment during operation, it is usually impossible to directly inspect this piping. It should instead be directly inspected once the operating equipment is out of service. Before then, radiographs of the piping can sometimes indicate any major fouling or stoppage.

6.2.7.2 Inspection of the piping at the pressure-relief valve will often indicate the condition of the process piping whose interior is not visible. Piping should be checked for corrosion, indications of thinning, and deposits that could interfere with valve operation. The character of the deposits may indicate the cause of any leakage from the valve in a closed system. Figure 31 through Figure 35, and Figure 39 show fouling deposits in pressure-relief valves.

6.2.8 Transportation of Valves to Shop

The improper shipment and transport of pressure-relief devices can have detrimental effects on device operation. Pressure-relief devices should be treated with the same precautions as instrumentation, with care taken to avoid rough handling or contamination prior to installation. Improper handling during transportation to the repair shop may also result in inaccurate “as received” pop tests, which may cause improper adjustments to relief device inspection intervals.

The following practices are recommended.

a) Flanged valves should be securely bolted to pallets in the vertical position to avoid side loads on guiding surfaces.

b) Careful handling of threaded valves during transport in a manner to avoid damage to threaded connections.

c) Valve inlet and outlet connection, drain connections and bonnet vents should be protected during shipment and storage to avoid internal contamination of the valve. Ensure all covers and/or plugs are removed prior to installation.

d) Lifting levers should be wired or secured so they cannot be moved while the valve is being shipped or stored. These wires should be tagged for removal by the manufacturer or repair shop and removed before the valve is placed in service.

e) Rupture disks should be handled by the disk edges. Any damage to the surface of the disk can affect the burst pressure.

6.2.9 Determining “As Received” Pop Pressure

6.2.9.1 Check that the seals are intact on the pressure set screw cover and blowdown ring screw cover. Before the valve is dismantled, the pop pressure of the valve should be obtained. Generally the pressure-relief valve is mounted on the test block, and the inlet pressure is slowly increased. The pressure at which the valve relieves is recorded as the “as received” pop pressure.

Typically, the inlet pressure is not increased beyond 150 % of the pressure-relief valve set pressure.

6.2.9.2 If the valve initially opens at the CDTP, no further testing to determine the “as received” pop pressure is needed. If the initial pop is at a pressure higher than the CDTP, the valve should be tested a second time. If it then pops near the CDTP, the valve may not have originally popped at the CDTP because of deposits. If on the second try the valve does not pop within the tolerances allowed by the ASME *BPVC*, either the valve setting was originally in error or it changed during operation. Pressure-relief valves that do not pop at inlet pressures of 150 % of CDTP should be considered as stuck shut. If the initial pop is at a pressure lower than the CDTP, the spring has become weakened, the valve was set improperly at its last testing, or the setting changed during operation. It is the first test that is recorded as the “as received” pop pressure. This “as received” pop pressure is used in determining the inspection interval.

Caution—If the valve is extremely fouled and dirty when received and the “as received” popping of the valve may damage the valve's seats, the user may waive the “as received” test and instead reduce the inspection interval. After reducing the valve's inspection interval, the valve should be clean at the next inspection. If it is not clean, the inspection interval should again be shortened or other measures should be taken to reduce the fouling.

6.2.9.3 It is often necessary to clean the valve of potentially hazardous materials before sending it to the shop for pop testing. This cleaning can remove deposits that would have prevented the valve from opening at set pressure. A visual inspection of those parts of the valve visible without disassembly, and before cleaning, should be performed and the results of that inspection recorded and used to help determine the appropriate inspection interval.

6.2.10 Visual Inspection

After the “as received” pop test, a valve should be visually inspected to estimate its condition when removed from service. This inspection should be made by the shop's pressure-relief valve repair mechanic unless unusual corrosion, deposits, or conditions are noted in the pressure-relief valve (see Caution 1 as follows). The results of this inspection should be noted on appropriate forms. Points that should be checked include:

a) the flanges, for evidence of pitting, roughening, or decreases in the width of seating surfaces;

b) the springs, for evidence of corrosion or cracking and for the correct pressure range at the valve's operating pressure and temperature;

c) if the valve is of the bellows type, the bellows for evidence of corrosion, cracking or deformation;

d) the positions of the set screws and openings in the bonnet;

e) the inlet and outlet nozzles, for evidence of deposits of foreign material or corrosion;

f) the external surfaces, for any indication of a corrosive atmosphere or of mechanical damage;

g) the body wall thickness;

h) valve components and materials, for a match with the information on the identification tag and specification card;

i) the pilots and associated parts.

Caution 1—When unusual corrosion, deposits, or conditions are noted in the pressure-relief valve, an inspector representing the user should assist in the inspection.

Caution 2—If the pressure-relief valve is from equipment handling hazardous materials, caution should be exercised during the inspection.

6.2.11 Dismantling of Valve

6.2.11.1 After the valve is received and its testing and initial visual inspection is completed, it may require dismantling for a thorough shop inspection and repair. If the valve has been tested at the appropriate interval set in accordance with API 510 the guidance in 6.2.9 for determining the "as received" pop pressure and the results of the "as received" test show that the valve tests properly, disassembly of the valve for further inspection may not be required, unless restoration of the valve to the "as new" condition is required.

6.2.11.2 When appropriate, valves should be carefully dismantled in accordance with the manufacturer's manuals and recommendations. Before dismantling valves in light hydrocarbon service, thoroughly clean the valve with a solution recommended by chemical cleaning agencies whose chemicals are compatible with the valve material to avoid a flash due to sparks created by the dismantling operations. The pilot assembly and dome area of pilot-operated pressure-relief valves in liquid service could be filled with process fluid, therefore, added precautions should be taken during disassembly. Proper facilities should be available for segregation of the valve parts as the valve is dismantled. At each stage in the dismantling process, the various parts of the valve should be visually inspected for evidence of wear and corrosion. The valve stem, guide, disk, and nozzle require visual inspection. The bellows in balanced valves should be checked for cracks or other failures that may affect performance (see Figure 24).

6.2.12 Cleaning and Inspection of Parts

6.2.12.1 To keep the parts of each valve separate from those of other valves, the valve parts should be properly marked, segregated, and cleaned thoroughly. The valve parts that most often require cleaning are the nozzles, springs, and seats. Deposits that are difficult to remove should be cleaned with solvents, brushed with wire, glass bead blasted or carefully scraped.

6.2.12.2 After being cleaned, check each part carefully with the proper equipment for measuring valve dimensions, with frequent reference to the proper drawings and literature.

6.2.12.3 The components should be checked for wear and corrosion. Seating surfaces on the disk and nozzle should be inspected for roughness or damage (see Figure 27 and Figure 28), which might result in valve leakage. They should also be checked with appropriate seat gauges to assure that neither wear nor previous machining has caused the seat dimensions to exceed the manufacturer's tolerances. Seat flatness can be checked with suitable lap rings recommended by the manufacturer, optical flats, or other suitable inspection devices. If the appropriate equipment is available, the springs should be checked for the proper force. The springs should also be checked for cracking or deformation. The fit between the guide and disk or disk holder should be checked for proper clearance and visually inspected for evidence of scoring. The nozzle should be checked for obstructions and deformation. Bellows should be checked for leaks, cracks, or thin spots that may develop into leaks. In addition, if the bellows has collapsed, it has probably been subjected to backpressure greater than its design pressure. High backpressure may be due to downstream restrictions that are created by deposits, or to higher relief flows than used in the original design. The cause should be determined, and corrective action should be taken.

6.2.13 Reconditioning and Replacement of Parts

Parts that are worn beyond tolerance or damaged should be replaced or reconditioned. Damaged springs, bellows, and single-use components, even those that are apparently undamaged, should be replaced. All soft goods, even those that are apparently undamaged, should be replaced. Spare parts for a particular pressure-relief valve should be obtained from its manufacturer. The valve body, flanges, and bonnet may be reconditioned by means suitable for repairs to other pressure-containing parts of similar material. If evidence of wear or damage is found on the disk or nozzle, their seating surfaces may be machined or lapped. Follow the manufacturer's recommendations when reconditioning valve parts.

6.2.14 Reassembly of Valve

After the valve has been inspected and its parts have been reconditioned or replaced, it should be reassembled in accordance with the manufacturer's instructions. The nozzle and disk seating surfaces should not be oiled. Clearances between assembled parts should be checked. In accordance with the manufacturer's instructions, the spring should be adjusted to pop as close to the desired set pressure as possible. Blowdown rings should be set carefully and accurately in accordance with the manufacture's recommendations for the appropriate vapor or liquid service, and the settings should be noted for future reference. Because most test blocks do not have enough capacity to measure the actual blowdown, manufacturer's recommendations and past performance should be evaluated to estimate any necessary adjustment.

6.2.15 Setting of Valve Set Pressure

6.2.15.1 After the valve has been reconditioned and reassembled, its spring should be adjusted for the last time to ensure the valve will relieve at the required CDTP. Although test procedures will vary with local plant practice, the valve is generally mounted on the test block and air or water pressure is increased slowly until the valve relieves. The manufacturer's recommendations or NB-18 should be used to guide the adjustment of the spring to the correct setting. If a new set pressure is required, the manufacturer's limits for adjustment of the spring must not be exceeded and applicable code requirements must be observed. If necessary, a different spring should be provided.

6.2.15.2 After the valve has been adjusted, it should be popped at least once to prove the accuracy of the setting. Some manufacturers recommend a valve be popped at least three times, as the first pop helps align all of the components after the overhaul while the successive pops verify the set pressure. Normally, the deviation of the pop pressure from the set pressure should not exceed ±2 lbf/in.^{2} (±13.8 kPa) for pressures less than or equal to 70 lbf/in.^{2} (483.0 kPa) or ±3 % for pressures greater than 70 lbf/in.^{2} (483.0 kPa) [see ASME *BPVC* Section VIII, Division 1, Paragraph UG 134(d)(1)]. For pressure-relief valves that comply with ASME *BPVC* Section VIII, Division 1, Paragraph UG 125(c)(3), the deviation shall not be less than 0 % or greater than +10 %. Any allowance for hot setting should be made in accordance with the manufacturer's data. Any adjustment to the CDTP required to compensate for in-service backpressure, service temperature, or test media should be made in accordance with the manufacturer's or user's valve specification data.

6.2.15.3 Follow the valve manufacturer's recommended testing procedure when the pressure-relief valve is tested with water. Typically, the pressure will be raised slowly to the required setting. The discharge should be observed for evidence of leakage, or the test gauge should be observed for a momentary drop in pressure. A small continuous stream of water from the valve discharge usually indicates attainment of the CDTP. The pressure at which the valve releases should be within the tolerances noted above in 6.2.15.2 before the valve is approved for service.

6.2.15.4 Pressure-relief valves set with water may need to have the water drained (e.g. pilot-operated valve dome area) and the valve dried prior to installation to assure proper function in service.

6.2.16 Checking Valve for Tightness

Once the valve is set to pop at its CDTP, it should be checked for leakage. On the test block, it can be tested for seat tightness by increasing the pressure on the valve to 90 % of the CDTP and observing the discharge side of the valve for evidence of leakage. Methods of determining leakage are covered in B.2 and Figure 40.

Where applicable, the bonnet, bellows, gasketed joints and auxiliary piping/tubing should be inspected for leakage.

Caution—Leakage from in-service pressure-relief valves should be minimized because of the hazards to the environment, personnel, and equipment and because leakage leads to fouled and inoperable valves and to product loss.

6.2.17 Completion of Necessary Records

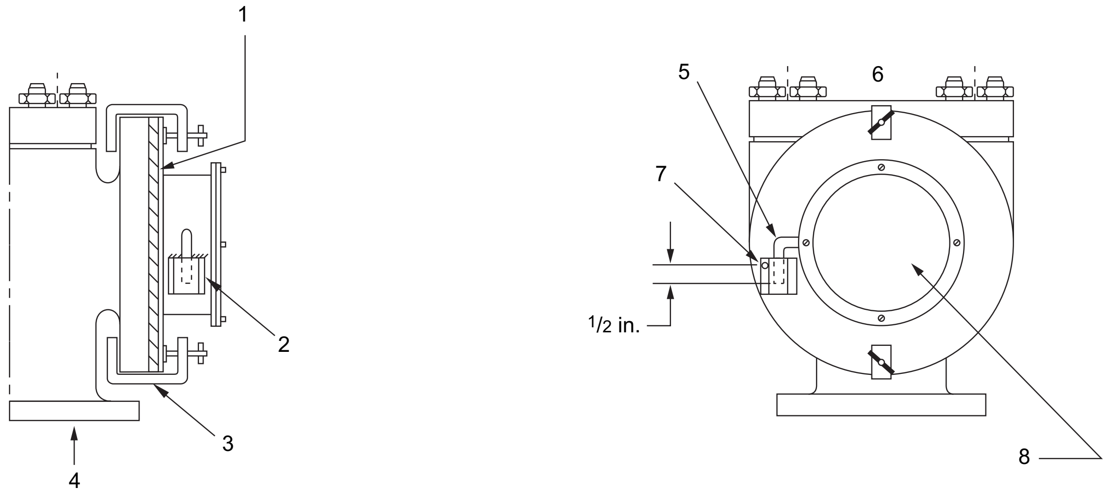
All necessary records should be completed before a valve is placed back into service. By helping to determine when to replace the components of the valve and when to retire it, the records are critical to its effective future use. They form the historical record of the conditions and services under which the valve operated. Retention of maintenance and test records may be required by governmental regulations. See Annex B for example forms. For an explanation of nameplate terms required by repair work, see API 526.

6.2.18 Inspection, Testing, Maintenance, and Setting of ASME *BPVC* Section VIII Pressure-relief Valves on Equipment

6.2.18.1 It is generally more economical and effective to perform a shop inspection/overhaul in the shop at the required intervals than on its equipment. However, when a valve operates in nonfouling service, experience may indicate that inspection of the valve while on the equipment is safe and suitable. When suitable safety precautions have been taken (see 6.2.1), the inlet and outlet block valves may be closed, and the bonnet of the pressure-relief valve may be removed for immediate inspection, testing, and any minor repairs. When major repairs are indicated, the valve should be sent to the shop.

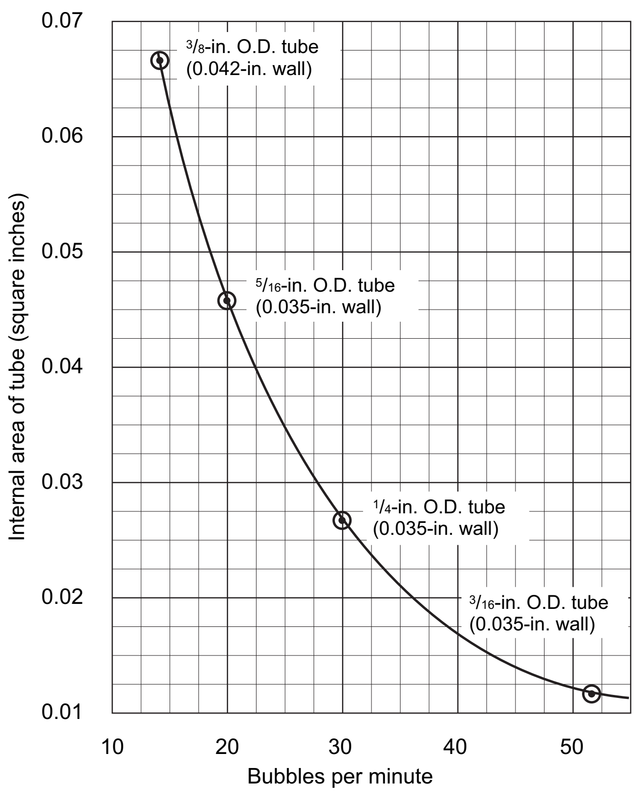
6.2.18.2 In certain cases, the pressure-relief valve may be tested for set pressure and leakage with an inert gas testing medium through a bleeder. This method is inferior to the test block procedure discussed in 6.2.8. It yields inaccurate test results for metal-seated pressure-relief valves unless sufficient upstream volume is provided that allows the valve to open to about half of full lift. If the available upstream volume is not sufficient to cause the pressure-relief valve to attain about half lift, the use of a restricted lift device is recommended to avoid damaging the valve from the impact loading caused by too rapid of a closure.

Caution—This method does not satisfy the need to check for inlet/outlet line fouling or to remove a valve for physical inspection and verification that all of its components are in satisfactory and safe working condition. The method also does not verify the valve blowdown setting.



Key

1 soft rubber gasket attached to face of detector to prevent leakage
2 weld cup to detector
3 C clamp
4 air pressure
5 outlet tube—cut end smooth and square
6 safety valve
7 water level control hole—maintain 1/2 in. from bottom of tube to bottom of hole
8 waxed paper to relieve pressure if valve opens during test



Leakage rates corresponding to 0.3 ft^3 in 24 hours

Figure 40—Safety Valve and Relief Valve Leak Detector

6.2.18.3 A pressure-relief valve may be tested on-stream with a specialized device that will determine the set pressure of the pressure-relief valve. These devices hydraulically lift the pressure-relief valve stem and, in conjunction with lifting the valve, incorporate a method for determining the opening of the pressure-relief valve and the load applied at the point of opening. Numerous technologies are used for determining the opening point and correlation of the applied load. These technologies range from simple audible notification, to software-based data analysis, displacement, or acoustic sensors. The set pressure of the valve is computed by dividing the load at opening by the valve seat area and then adding the value of inlet pressure. Data output ranges from a summary of load, inlet pressure and set pressure to graphing of measured and calculated values such as applied load, valve lift, and inlet pressure. This method may or may not be accepted by local jurisdictions as a valid method of either verifying or adjusting valve set pressures.

There are potential hazards to consider when applying the hydraulic test method:

a) potential failure of the rupture disk in rupture disk/relief valve combinations;

b) possible introduction of foreign material into the valve seating area which may result in mechanical damage and/or leakage through the valve upon reseat;

c) possible release of process material to atmosphere;

d) potential failure of the bellows, in a bellows equipped pressure-relief valve, will cause release of process to atmosphere through the valve's bonnet openings;

e) most devices are electronic and as such should be analyzed for their suitability to hazardous environments;

f) testing with the inlet pressure near the set point of the pressure-relief valve may cause the valve to open necessitating a reduction in operating pressure or a mechanical device to close the valve.

Caution—Although it may be satisfactory for a clean-service pressure-relief valve, the hydraulic test method of checking the set pressure of a pressure-relief valve does not satisfy the need to check for inlet/outlet line fouling or to remove a valve for physical inspection and verification that all of its components are in satisfactory and safe working condition. The hydraulic test method also does not verify the valve blowdown setting.

6.2.19 Inspection, Testing, Maintenance, and Setting of ASME *BPVC* Section I Boiler Safety Valves

6.2.19.1 Although safety valves on steam boilers are similar in construction and operation to relieving devices on process equipment, they are designed and installed in accordance with local, state, and federal regulations and power codes. Inspection of these devices should be in accordance with the regulatory requirements and the manufacturer's recommendations. Company practices may be used to establish an inspection policy if they do not conflict with or compromise the intent of any regulatory requirements.

6.2.19.2 Boiler safety valves may be welded to the boiler and therefore cannot be practically removed for testing or maintenance. Boiler safety valves can be tested periodically by raising the steam pressure until the valve pops. Precision-calibrated pressure gauges should be used to determine the pressure at which the valve pops. The accumulation and blowdown should also be noted. ASME *BPVC* Section I also requires the boiler safety valves have a substantial lifting device by which the valve disk may be lifted from its seat when the working pressure on the boiler is at least 75 % of the set pressure, so that checking for the freedom of moving parts to operate is feasible.

6.2.19.3 In lieu of being tested on the boiler, some safety valves may be removed and tested at regular intervals, which may be determined by local jurisdictional requirements. The testing must meet the requirements of applicable laws, and regulations of the jurisdictions involved. Usually, testing for set pressure and blowdown with steam is required.

6.2.19.4 Some regulatory agencies allow on-stream testing of steam safety valves with special equipment that will determine the set pressure of the safety valve. These devices hydraulically lift the safety valve and, in conjunction with lifting the valve, incorporate a method for determining the opening of the safety valve and the load applied at the point of opening. Numerous technologies are used for determining the opening point and correlation of the applied load. These technologies include simple audible notification, to software-based data analysis, displacement, and acoustic sensors. The set pressure of the valve is computed by dividing the load at opening by the valve seat area and then adding the value of inlet pressure. Data output ranges from a summary of load, inlet pressure and set pressure to graphing of measured and calculated values such as applied load, valve lift, and inlet pressure.

Caution—This method of checking the set pressure and functioning of a safety valve identifies the opening pressure but does not satisfy the need to periodically remove the valve for physical inspection and verification that all of its components are in satisfactory and safe working condition. The hydraulic test method also does not verify the valve blowdown setting. Testing with the inlet pressure near the set point of the safety valve may cause the valve to open necessitating a reduction in operating pressure or a mechanical device to close the valve.

6.2.20 Inspection, Testing, Maintenance, and Setting of Pilot-operated Pressure-relief Valves

6.2.20.1 Inspection, testing, maintenance, and setting of the pilot mechanism may be handled separately from the main valve. With test connections, the set pressure of some types of pilots may be accurately tested while the valve is in service. If there is no block valve under the main valve, it may be inspected and repaired only while the vessel is out of service.

Due to the variety of pilot-operated valves available, the valve manufacturer's recommendations for inspection, repair, and testing should be consulted and followed.

6.2.20.2 Many of the considerations that apply to other pressure-relief valves also apply to pilot-operated valves. The following is a list of additional considerations that apply to pilot-operated valves:

a) inspect soft goods (O-rings, diaphragms, gaskets);

b) check for plugging in pilot assembly and external tubing;

c) check for material trapped in main valve dome area;

d) check all tubing fittings for leakage;

e) inspect the pressure pick-up device and its orientation.

6.2.20.3 Manufacturers of diaphragm valves (see Figure 7) frequently recommend semiannual shop inspection/ overhauls to allow inspection of the diaphragm and other components.

6.2.21 Inspection, Testing, Maintenance and Setting of Weight-loaded Pressure- and/or Vacuum-vents on Tanks

6.2.21.1 The inspection, testing, maintenance, and setting of relieving devices on pressure storage tanks is similar to those of pressure-relief valves on process equipment.

Pressure- and/or vacuum-vent valves on atmospheric tanks are designed to vent air and vapor from the tank during filling operations and to admit air when the tank is drawn down (see Figure 10 and Figure 11). Pressure- and/or vacuum-vent valves are in almost continuous service. They are prone to failure by sticking. Periodic examination may detect this condition. Where temperatures fall below freezing, the devices may need to be checked during the cold period to ensure that the pallets do not stick because of icing. These pallets are usually weight loaded. The inspection of each vent valve in place should include the checking of the discharge opening for obstructions. The top of the valve should be removed and the pallets checked for freedom of movement. Seats should be checked to ensure that there is no sticking or leakage, since the forces actuating the valve are small. If the valve has a flame arrester on the inlet nozzle, it should be inspected for fouling or plugging. If necessary, it should be removed for cleaning.

Caution—Inspection of the flame arrester in service is important because any fouling or plugging may result in equipment damage.

6.2.21.2 Inspection, testing, maintenance, and setting of weight-loaded pressure- and/or vacuum-vent valves should include the following special steps.

1) Sticking should be corrected and prevented. The disks (pallets) of the devices should be checked for sticking. If the disks are stuck, the product's effect on the seal material and on the disk material should be investigated. If necessary the seal material and the disk material should be changed.

2) The disk should be checked and maintained. Once a disk is removed, it should be cleaned. If there is any reason to suspect the mass of the pallet has been changed (tampering, corrosion, etc.) its mass should be determined. Check the mass against the mass required for the correct relieving pressure of the device.

   NOTE The setting of a pressure-vacuum device depends on the mass of the disk compared to the area of the opening covered by the disk. Set pressure is usually a standard 0.5 oz/in.^{2} (0.215 kPa), but may go as high as 24 oz/in.^{2} (10.34 kPa).]

   If the mass is not correct, mass should be added or removed until the correct mass has been achieved. Be sure that any additional mass added does not restrict the lift of the device below the manufacturer's design. Disk condition and serviceability should be checked, and unusable disks should be replaced.

3) The seats and pallets of the disk should be checked and cleaned.

4) The gaskets at the disk seating areas should be checked and, if necessary, replaced.

5) The protective screens should be checked for serviceability and, if necessary, renewed.

6) Hinges and hinge pins should be checked for operability and, as necessary, serviced, lubricated, and replaced.

7) Any special coating used internally or externally on the body should be checked and, if unserviceable, replaced.

8) The hood should be inspected and, if unserviceable, replaced.

9) The bolts should be checked and, as required, replaced.

10) Reassembly and final operability check to assure pallets are free to move.

6.2.22 Inspection and Replacement of Rupture Disks

6.2.22.1 If a disk's manufacturer specifies a bolting torque procedure and the tightened bolts are loosened, the rupture disk should be replaced. Do not reinstall the disk once it has been removed from its holder, even though it has not been ruptured. When stresses are relieved by unbolting, the “set” taken by the disk during its original installation may prevent a tight seal and affect performance if reinstalled.

6.2.22.2 Because they cannot be tested, rupture disks should be replaced on a regular schedule based on their application, the manufacturer’s recommendations, and past experience. If a block valve is located ahead of the disk, the block valve should be locked or car sealed open during operation. If replacement of the disk is necessary, the block valve should be locked, car sealed, or tagged closed until disk installation has been accomplished.

If, however, the risk of a rupture disk opening prematurely is low, and inlet and outlet fouling is monitored, the disk may be left in place indefinitely.

6.2.22.3 Reverse-buckling rupture disks may be used to facilitate and allow on-stream testing of pressure-relief valves. For such testing, the section between the rupture disk and the pressure-relief valve is generally pressured with an inert gas testing medium. Since the rupture disk is exposed to pressure on its downstream side when using this procedure, the rupture disk should be inspected and replaced on a regular basis.

Caution—The block valve may only be closed in accordance with 6.2.1.

The pressure-relief valve must be designed so that it will not fail to open at its proper pressure setting regardless of any backpressure accumulated between the valve disk and any downstream rupture disk.

6.3 Visual On-stream Inspection

A full, visual on-stream inspection should ensure the following.

a) The correct relief device was installed.

b) The company identification (such as a tag or stencil) provides means to establish the last test date and proper pressure setting for the equipment protected by the identified device.

c) That information in 6.3 b) matches the equipment file records and that the established test interval has not been exceeded.

d) No gags, blinds, closed valves, or piping obstructions would prevent the devices from functioning properly.

e) Seals installed to protect the spring setting and ring pin setting have not been broken.

f) The relief device does not leak. Pressure-relief valves that have opened in service frequently leak. Detection and correction of this leakage eliminates product loss and possible pollution and prevents fouling and subsequent sticking of the valve. If the valve is a bellows valve, the bellows vent should be checked for leakage.

g) Bellows vents are open and clear, and the connected piping is routed to a safe location. A “safe location” could mean to atmosphere.

h) Upstream and downstream block valves are sealed or chained and locked in the proper position. Devices that ensure that a block valve is in its proper position include locking plastic bands, car seals, chains and padlocks, and special locking devices made especially for certain types of block valves. The field conditions should mirror the applicable piping and instrumentation diagrams (P&IDs).

i) Vent stacks, discharge piping and small nipples are properly supported to avoid breakage or leakage. Inadequately supported or anchored nipples can be damaged during maintenance and by vibration.

j) Valve body drains and vent stack drains are open.

k) Any lifting lever is operable and positioned properly.

l) Any heat tracing, insulation, or purge that is critical to the proper operation of the relief system is intact and operating properly.

m) A gauge installed as part of a combination of a rupture disk and a pressure-relief valve or a device for checking pressure between a pressure-relief valve and a block valve is serviceable. Verify that there is no pressure buildup between the rupture disk and pressure-relief valve.

n) Any rupture disk is properly oriented.

Although the interval selected for on-stream inspection should vary with circumstances and experience, a visual inspection that includes a check for leakage and vibration damage should follow each operation of a pressure-relief valve. Operating personnel assigned to the process unit may make these inspections provided that they are experienced to recognize any leakage or vibration damage.

6.4 Inspection Frequency

6.4.1 General

6.4.1.1 The inspection of pressure-relieving devices provides data that can be evaluated to determine a safe and economical frequency of scheduled inspections. This frequency varies widely with the various operating conditions and environments to which relief devices are subjected. Inspections may be less frequent when operation is satisfactory and more frequent when corrosion, fouling, operational upsets and leakage problems occur. Historical records reflecting periodic test results and service experiences for each relief device are valuable guides for establishing safe and economical inspection frequencies.

6.4.1.2 A definite time interval between inspections or tests should be established for every pressure-relieving device on operating equipment. Depending on operating experiences, this interval may vary from one installation to another. The time interval should be sufficiently firm to ensure that the inspection or test is made, but it should also be flexible enough to permit revision as justified by past test records.

6.4.1.3 In API 510, the subsection on pressure-relieving devices establishes a maximum interval between device inspections or tests of 10 years, unless qualified by a risk-based inspection (RBI) assessment. It also indicates that the intervals between pressure-relief device testing and inspection should be determined by the performance of the devices in the particular service concerned.

6.4.2 Frequency of Shop Inspection/Overhaul

6.4.2.1 Normal Basis

6.4.2.1.1 Normally, the interval between shop inspection/overhaul of pressure-relieving devices should not exceed that necessary to maintain the device in satisfactory operating condition. The frequency of shop inspection/overhauls is normally determined by operating experience in the various services involved. Normally, the interval of a device in a corrosive and/or fouling service would be shorter than the interval required for the same device in a clean, nonfouling, noncorrosive, service. Likewise, more frequent inspection and testing may be needed for pressure-relief valves subject to vibration, pulsating loads, low differential between set and operating pressures, and other circumstances leading to valve leakage and potentially poor performance.

6.4.2.1.2 Where an inspection or test history extending over a long period of time reflects consistent “as received” test results that coincide with the CDTP (see 6.2), where no change in service is to be made, and where no conflict in jurisdictional requirements exists, an increase in the test interval may be considered. Conversely, if the “as received” test results are erratic or vary significantly from the CDTP, the inspection interval should be decreased or suitable modifications to improve the performance should be made. If a valve fails to activate on the test block at 150 % or more of CDTP, it can be assumed that it would have failed to activate on the unit during an overpressure event.

6.4.2.1.3 Where corrosion, fouling, and other service conditions are not known and cannot be predicted with any degree of accuracy (as in new processes), the initial inspection should be accomplished as soon as practical after operations begin to establish a safe and suitable testing interval.

6.4.2.2 Manufacturer's Basis

Manufacturers of pressure-relieving devices are sometimes able to assist the user in establishing inspection and test intervals, especially if their designs contain features and components that require special consideration. For example, it may be necessary to inspect or replace certain parts, such as nonmetallic diaphragms in pilot-operated valves, at frequencies greater than those required for the parts of conventional pressure-relief valves. Rupture disks and bellows valves may also require special consideration. Manufacturers are familiar with the nature of the loading, stress levels, and operating limitations of their design and are able to suggest inspection intervals appropriate for their equipment.

6.4.2.3 Jurisdictional Basis

In some instances, the required frequency of inspection and testing of pressure-relieving devices is established by regulatory bodies.

6.4.2.4 RBI Assessment Basis

6.4.2.4.1 RBI techniques to determine the initial and subsequent inspection intervals may be used which consider the probability and consequence of failure of pressure-relief devices to open on demand during emergency overpressure events. The risk-based techniques recognize the fact that there are many different overpressure events or scenarios and that some pressure-relief device applications are much more critical than others. The determination of risk should be based on the equipment being protected, the associated flammability, toxicity, corrosivity and fouling severity of the fluid services, as well as the overpressure event probability and potential overpressure as a result of failure to open upon demand. Other considerations, such as production losses, damage to surrounding equipment, the potential for personnel injury and any environmental impact should also be considered when evaluating the criticality of a pressure-relief device application.

6.4.2.4.2 The assessment should also consider the probability that a pressure-relief device will leak in service and the potential environmental and economic consequences associated with this leakage during normal operation.

6.4.2.4.3 As with conditioned-based inspection programs, risk-based programs make extensive use of knowledge gained from pressure-relief device operational experience and historical inspection servicing records. These are valuable inputs into the risk-based assessment models.

6.4.2.4.4 Risk assessments can range from the qualitative to the highly quantitative. Although quantitative assessments typically require more input, this is offset by the fact that these approaches result in a significant reduction in risk while better optimizing the inspection effort.

6.4.2.4.5 The requirements of API 580 should be incorporated into these assessments. API 581 provides details on a RBI methodology that has all of the key elements defined in API 580, The potential benefits of a risk-based assessment include the following:

a) systematic and well-developed technical methods and tools for evaluating pressure-relieving devices which have a wide array of considerations,

b) focus on risk management by addressing critical concerns to protect equipment overpressure,

c) organized approach to improving pressure-relief device performance,

d) incorporation of operational history and inspection servicing records,

e) cost-effective risk mitigation task identification to address safety/health/environmental consequences and lessen economic loss.

6.4.3 Frequency of Visual On-stream Inspections

As noted in 6.3, visual on-stream inspections are intended to find problems with the maintenance and operating practices surrounding pressure-relieving devices. The interval selected should vary with circumstances, based on the results of previous on-stream inspections. The maximum interval for visual on-stream inspections is five years. Although not always a full visual on-stream inspection, some companies perform inspections for leakage and vibration damage each time a relief device operates.

After maintenance turnarounds are completed, some companies perform a full visual on-stream inspection before startup. This provides a critical check that the proper relief device is in the proper location, installed properly, and has the proper set pressure for the intended service.

6.5 Time of Inspection

6.5.1 Inspection on New Installations

All pressure-relief valves and other automatic pressure-relieving devices that depend on a spring adjustment for proper functioning should be inspected and tested before they are installed on process equipment (i.e. verify CDTP pressure and visual inspection as described in 6.2). This inspection is used to determine any damage or changes in factory adjustment due to shipping, confirm the set pressure, and initiate appropriate records. If the factory setting is done in a nearby shop, this additional testing may be unnecessary.

Pressure- and/or vacuum-vent valves on atmospheric storage tanks should also be inspected after installation but before the tank is hydrostatically tested or put into service. Pressure- and/or vacuum-vent valves on atmospheric storage tanks should also be inspected whenever the tank is taken out of service.

6.5.2 Routine

The ideal time to inspect pressure-relief valves is when the inspection least interferes with the process and maintenance manpower is readily available. These conditions may prevail during planned shutdowns. All relief devices not equipped with block valves should be inspected at this time if an inspection would otherwise become due before the next scheduled shutdown. The relief devices with block valves may be inspected at this time to minimize process interruptions and avoid the increased risk of inspecting equipment in operation.

6.5.3 Unscheduled Inspection

If a valve fails to open within the set pressure tolerance, it requires immediate attention. If it opens at the set pressure but fails to reseat properly, the urgency of inspection and repairs depends on the type of leakage, its environmental and human impact, the amount of leakage, and the characteristics of the leaking substance such as whether it's toxic, flammable, or fouling.

6.5.4 Inspection After Extended Shutdowns

A pressure-relief valve left on a unit during an extended shutdown should be inspected and tested before the resumption of operations. This inspection is necessary to ensure that corrosion, fouling, tampering, or other conditions or acts that would impede the proper performance of the device have not occurred during the shutdown. When a change in operating conditions is to follow the shutdown, the inspection interval should be reviewed.

7 Records and Reports

7.1 Objective

7.1.1 A suitable system of keeping records and generating reports is essential to the effective administration and control of any pressure-relieving device program in a process industry. The system should be as simple and clear as possible.

7.1.2 The primary objective for keeping records is to make available the information needed to ensure that the performance of pressure-relieving devices meets the requirements of their various installations. Records may be considered as tools needed to implement the program, and reports may be considered as the means to distribute those tools to all the participants of the program so that they coordinate their work and effectively discharge their responsibilities. In some cases, reports may be retained in files and considered as permanent records.

7.2 The Need to Keep Records

7.2.1 For each pressure-relieving device in service, a complete, permanent record should be kept. The record of each device should include its specification data, including sizing calculations and a continuously accumulating history of inspection and test results. Some governmental agencies require that certain records and reports be maintained.

The specification record provides the basic information needed to evaluate the adequacy of a device for a given installation or for a contemplated change in operating conditions, provides the correct dimensional and material information needed to minimize shop errors and expedite repairs, and provides design information that facilitates the purchase of a similar device and that is required to inventory spare parts. This information allows a pressure-relieving device to be assembled, tested, and exchanged with an identical device on the unit to minimize the time the unit's equipment is unprotected during a scheduled inspection.

7.2.2 Historical records (service records) showing dates and results of inspections and tests are necessary for the follow-up or control phase of the pressure-relieving device program. They enable periodic reviews to determine whether the planned test intervals for a device are being realized. They also provide performance data that helps evaluate the suitability of the device for its particular service, that can indicate problems in the device's design and materials, and that can even indicate a misapplication of the device. It is especially important that the records offer a practical and realistic basis for establishing and maintaining safe and economical inspection intervals for the device.

7.3 Responsibilities

7.3.1 The duties and responsibilities entailed by the various facets of an inspection and testing program for pressure-relieving devices should be clearly defined to avoid confusion and be explicitly assigned to assure compliance. Some companies assign these duties and responsibilities to equipment inspectors. Others have process unit operators or maintenance personnel follow up on an established program under the guidance of the engineering-inspection group.

7.3.2 This subsection is not designed to assign responsibilities to any individual. The following outline of duties is meant primarily to facilitate the understanding of how to use the sample record and report forms in the Annex B. These duties are typical of a well-designed, pressure-relieving device program in the process industries.

7.3.3 The responsibilities of engineering and/or inspection personnel may include the following:

a) to furnish specifications and sizing calculations for relief devices and connected piping;

b) to determine allowable pressure settings;

c) to specify test intervals;

d) to record service data;

e) to prepare lists of devices due for inspection;

f) to review performance data and provide engineering services;

g) to review, approve, and/or purchase replacement valves or spare parts;

h) to ensure piping and instrumentation diagrams (P&IDs) match the field installation and equipment protected.

7.3.4 The responsibilities of process unit operators and/or inspection personnel may include the following:

a) to initiate work requests,

b) to see that devices are reinstalled in their proper location,

c) to prepare in-service reports,

d) to check for leaking valves and rupture disks,

e) to ensure that the correct block valves (if any) are locked or sealed open or closed as required,

f) to check vents and drains for operability,

g) to check the upstream and downstream piping for blockage and to perform condition assessment inspections.

7.3.5 The responsibilities of maintenance personnel may include the following:

a) to perform the mechanical work required to repair, test, reinstall, and attach identification tags to the devices;

b) to maintain specification records to facilitate repairs;

c) to furnish test reports;

d) to initiate purchase orders for spare parts.

7.4 Sample Record and Report System

The precise recording and reporting format in a pressure-relieving device program is a matter of individual company choice. The forms in Annex B are samples of records and reports. Much of the report writing, recordkeeping, inspection, and test scheduling handled by the reports and records should be managed with an electronic database system.

Annex A
(informative)

Pressure-relief Valve Testing

A.1 Need and Function of Test Block

A.1.1 After a pressure-relief valve is removed from service, it is usually taken to the shop for inspection and repair. An important phase of maintenance is testing to determine the set pressure and tightness of the valve "as received" and after its overhaul. The testing is usually performed on a test block with facilities for applying pressure to a valve and indicating the pressure applied. Most test blocks have facilities for testing with either air or water to simulate, as closely as possible, the media handled by safety and relief valves, respectively. Bottled nitrogen may be used instead, especially for high-pressure valves. See ASME *BPVC* Section I, Section IV, and Section VIII, for requirements on setting safety valves and pressure-relief valves in steam service.

A.1.2 The test block and its supporting facilities are necessary for the maintenance of pressure-relief valves. It is practically impossible to make accurate adjustments on these devices without some method of measuring their performance. The shop test block, unfortunately, does not duplicate field conditions exactly. Thus, the amount of liquid or gas that it can discharge is limited, and it is not generally practical to measure relieving capacity or blowdown. Also, test stands with insufficient surge volume may fail to cause a distinct pop, and an inaccurate set pressure may result. However, if properly functioning, the shop test block gives good indications of the pressure at which the valve will open and its tightness.

A.1.3 For safety, the valve discharge nozzle must be positioned to prevent exposure of personnel to a sudden blast of air, water, or other projectiles from the valve. Ear protection may also be required for personnel working in the test area. Do not attempt to test relief devices at pressures above that for which the test block is designed.

A.1.4 If a pressure-relief valve is dirty and popping the valve would damage its seats, the "as received" pop test may be waived. If the test is waived, reduction of the valve's test interval should be considered.

A.2 Testing with Air

A.2.1 Most test blocks are designed to test pressure-relief valves with air because it is a nontoxic and readily available medium. Air is compressible and causes reaction-type valves to relieve with a short pop and closely approximates operating conditions for pressure-relief valves in vapor and gas services. The air test is generally used to test safety, relief, and pressure-relief valves for set pressure and valve tightness.

A.2.2 The arrangement to detect leakage during the air test depends on the construction of the valve. Blinding of the valve discharge is usually required. Leakage may be detected qualitatively by placing a thin membrane, such as a wet paper towel, over the outlet and noting any bulging. This is not a rigid test and is not intended to be used as a commercial standard tightness test. A quantitative measurement may be made by trapping the leakage and conducting it through a tube submerged in water. Figure 40 shows the standard equipment used to determine leakage rates in API 527. Leaks can also be detected with ultrasonic sound detection equipment.

A.3 Testing with Water

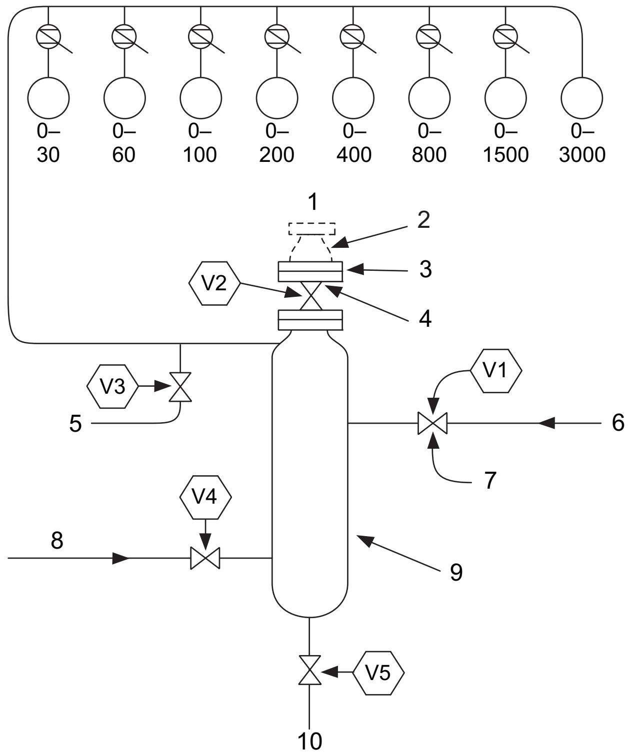
Test blocks may include facilities that test relief valves with a liquid test medium such as water. Water is nontoxic and inexpensive and may allow a close simulation of operating conditions. Because very small water leaks are not readily detected, a water test is usually limited to measuring the set pressure. Leakage or tightness tests are usually made with air (see 6.2). However, leakage tests may instead be made with water as described in API 527.

A.4 Description of Test Block

A.4.1 The test block is the assembly of equipment required to test pressure-relief valves for set pressure and tightness. It is used often and must be readily available on short notice. Test block designs vary widely and are even offered as packaged equipment by some manufacturers. The schematic arrangement in Figure A.1 illustrates the essential elements of and instructions for a test block that uses air as the testing medium. Where air pressure is unavailable, water systems may instead be used to test relief valves if acceptable to the local authority or jurisdiction.

A.4.2 The air-system test block includes a compressor or other source of high-pressure air, a supply reservoir, a test drum or surge tank large enough to accumulate enough air to cause the valves to open sharply at the set pressure, and the piping, pressure gauges, valves, and other instrumentation necessary to control the tests. The water-system test block usually includes a positive displacement pump that with a reasonably steady flow of water develops high pressures and the piping, valves, and other instrumentation necessary to control the tests. Some test blocks use a combination gas over water arrangement in which the gas provides the source of pressure.

A.4.3 Both the air-system test block and the water-system test block use a manifold. The wide range of flange sizes on a manifold allows it to test many different valves. To cover the wide range of pressures usually required to test pressure-relief valves, several precision-calibrated pressure gauges are connected with the manifold. These pressure gauges should be routinely calibrated, and a progressive calibration record should be maintained.



Key

1 test station
2 adaptor for mounting safety-relief valves of various sizes
3 threaded flange
4 6-in. full-area gate or ball valve
5 drain and gauge vent
6 from reservoir
7 3-in. diamond-point plug valve that is extended-wrench mounted vertically to facilitate testing
8 water in under pressure
9 test drum 12 in. in diameter and 6 ft long
10 drain

CONSTRUCTION NOTES

1) This layout uses the available air supply at the highest pressure possible. If required, the pressure can be raised further by inserting water that is under pressure into the test drum until the desired pressure is reached.
2) A single test drum is shown. Duplicate stations for flanged valves can be added if desired. Another duplicate station with a smaller test drum is sometimes desirable for testing small valves with screwed connections.
3) Flanged valves are to be secured to test stations by bolting, clamping, or use of a pneumatic clamping device.
4) Line from reservoir to test drum is to be designed for minimum pressure drop to allow reservoir volume to hold up test drum pressure when needed.
5) Test drum pressure and piping are to be made of oxidation-resistant materials.

OPERATION NOTES

1) When test station is not in use, Valves V1, V2, V4, and V5 should be closed. Valve V3 should be opened to prevent possible buildup pressure in the test drum if Valve V1 should leak.
2) Before testing the first valve, the test drum should be blown to remove any accumulation of dust or sediment that might blow through the safety-relief valve and damage the seats. To blow the drum, close Valve V3, open Valve V2, and release air through the drum by opening and closing Valve V1.
3) Close Valve V2.
4) Secure safety-relief valve to test station.
5) Open Valve V2.
6) If safety-valve set pressure is lower than available air pressure, slowly increase pressure through Valve V1 until safety-relief valve pops. Then close Valve V1. If safety-valve set pressure is higher than available air pressure, open Valve V1 and fill test drum with maximum air pressure available. Then close Valve V1. Open Valve V4 and increase pressure by inserting water that is under pressure until safety-relief valve opens. Then close Valve V4 and drain water from drum by opening and closing Valve V5.
7) If necessary, adjust valve spring so that safety-relief valve opens at the required set pressure.
8) Vent test drum to 90 % of the set pressure.
9) Test safety-relief valve for leakage.
10) After satisfactory test, close Valve V2.
11) Remove safety-relief valve from test rack. Loosen bolts or clamps slowly to allow pressure in adapter and valve nozzle to escape.
12) Vent test drum through V3 to approximately 75 % of the set pressure of the next valve to be tested. Repeat Items 4) through 11).
13) If another valve is not to be tested immediately, leave test station as specified in Item 1).

Figure A.1—Typical Safety Valve and Relief Valve Test Block Using Air as a Test Medium

Annex B
(informative)

Sample Record and Report Forms

B.1 The specification record for a pressure-relieving device shown in Figure B.1 is a typical permanent record for specifying a pressure-relief valve. This record holds the basic information needed to properly repair or replace the valve.

B.2 The historical record for a pressure-relieving device shown in Figure B.2 is a typical permanent service record that holds the dates and results of periodic inspections and tests. The information recorded will form a basis for determining test intervals and design changes.

B.3 In the record and report program illustrated in Figure B.3, the engineering-inspection group maintains the records and periodically informs the operations group responsible for operating the pressure-relief valves of the due dates of any work to be done. A report such as that shown in Figure B.3 (with sample data) is a simple and effective means for initiating inspection, testing and repair work. Its return to the engineering-inspection group indicates that the operations group responsible for operating the pressure-relief valves has taken action. The report should list all the pressure-relieving devices at a given unit to help minimize oversights and clerical work.

B.4 When a valve is sent to the shop for inspection, it is inspected and tested by the maintenance group in the "as received" condition. A report such as the testing report for a pressure-relieving device shown in Figure B.4 is filled out to document the results of this inspection and testing.

B.5 Inspection and testing of a device may lead to its setting and repair by the maintenance group. Orders and records such as the condition, repair, and setting record for a pressure-relieving device and the setting record and repair order for pressure-relieving devices shown in Figure B.5 should be filled out as appropriate.

B.6 At the shop, the valve may have a part replaced with a spare part by the maintenance group. In this case, Figure B.6 is prepared indicating the replacement as well as other basic information on the condition, repair, and setting record for a pressure-relieving device form.

B.7 After a pressure-relief valve has been returned to the process unit and installed by the operations group, the authority in the operations group responsible for writing the valve work orders should prepare a report such as the in-service report for a pressure-relieving device shown in Figure B.7. This report is filled out to certify that the valve has been reinstalled in its proper location. The report should be sent to the engineering-inspection group. It serves as an independent check on earlier steps and as the final expected report on this particular inspection of the pressure-relieving device. [5]

[5] The following samples are merely examples for illustration purposes only. (Each company should develop its own approach.)

SPECIFICATION RECORD FOR A PRESSURE–RELIEVING DEVICE

Device No.	Unit	Location	Set Pressure	Test Interval

Make ______________ Style ________________ Remarks ______________________________

Body and bonnet material ______________________ ______________________________

Nozzle and disk material ______________________ ______________________________

Trim material ______________________________ ______________________________

Spring material: ❍ Carbon steel ❍ Alloy ______________________________

Spring no. _________________________________ ______________________________

Flange sizes ______________________________

Inlet ______________ Outlet ______________ ______________________________

Orifice ______________ Backpressure ________ ______________________________

Spring set pressure ______________________ ______________________________

Relieving pressure ______________________ ______________________________

Normal operating temperature ______________ Maintenance engineer's phone no. ______________

Figure B.1—Sample Form for Recording Pressure-relieving Device Specifications [5]

HISTORICAL RECORD FOR A PRESSURE–RELIEVING DEVICE

Device No.	Unit	Location	Set Pressure	Test Interval

Date Tested	Popped	Reset	Disposition	Condition	Repairs	Remarks

Figure B.2—Sample Historical Record [5]

INSPECTION AND REPAIR WORK ORDER AND REPORT FOR PRESSURE–RELIEVING DEVICES (WITH SAMPLE DATA)

To ______________________________
Unit ____________________________
Period __________________________

All pressure-relieving devices installed on the unit are shown on this list. Those due for testing before expiration of the above period are indicated in the "Due for Test" column by an "X." Please prepare a work request to cover the inspection and repair of the devices indicated and return this work order and report to the engineering-inspection group by ____.

Due for Test	Device No.	Location	Work Requested	Work Request No.
X	FC-100	C-2A compressor discharge		
	FC-101	C-2B compressor discharge		
	FC-102	C-2C compressor discharge		
	FC-103	E-1 tower overhead line		
X	FC-104	E-1 tower bottoms line		
	FC-105	D-35 caustic drum		
	FC-106	J-10A blower discharge		
	FC-107	Rerun tower E-5		
	FC-108	J-63 pump-out		
	FC-109	E-20 exchanger (tube side)		
	FC-110	F-21 drum		
	FC-111	D-37 air drum		
	FC-112	E-2 tower		
	FC-113	E-3 tower		
	FC-114	E-4 tower		
	FC-115	F-1 drum		
	FC-116	E-18 exchanger (tube side)		

Date issued ______________________ By ____

Figure B.3—Sample Inspection and Repair Work Order Form 5

TESTING REPORT FOR A PRESSURE–RELIEVING DEVICE

Fill in this report for each device tested and send this report to the quality-assurance group.

Date tested ________	Type
Device no. ________	Make ________
Unit ________	Style ________
Location ________	Material ________
Size ________	Special material ________
Inlet ________	Body ________
Orifice ________	Trim ________
Outlet ________	
Fill in blanks below on one side only.	
From unit	From spare stock or check of new device
Date last bench tested ________	Set pressure ________
Popped at ________	Check pressure ________
Set pressure ________	
Check (dirty pop) pressure ________	
If set pressure changed,	
new set pressure ________	
Test used	
Standard ________	
Dry seal ________	
Disposition	
To unit ________	
To spare ________	
To junk ________	
Condition	
Leaking ________	
Stuck ________	
Fouled ________	
Corroded ________	
Tested by ________	

Figure B.4—Sample Testing Report [5]

CONDITION, REPAIR, AND SETTING RECORD FOR A PRESSURE–RELIEVING DEVICE

Manufacturer________ Size in____inches Rating____ Orig. thickness of body________ Sizing cond.________
Figure no.________ Size out____inches Rating____ Orig. thickness of outer port________ Amount________
Serial no.________ Spring no.________ Max. pressure in____# @____°F Mol. wt. or spec. grav.________
Order no.________ Spring range________ Max. pressure out____# @____°F Rel. temperature________°F
Material of body________ Ori ce no. ________ Bonnet test pressure________ Compression factor________
Trim________ Valve factor________ Percent accumulation________
Spring________ B.D. adj. percent________ Calculation area________
Bellows________

Set Pressure	Reseat Pressure	Relieving Pressure	Remarks	Test Medium	Dismantled		Disk Stuck		Deposits – *Nozzle*				Deposits – *Body*				Deposits – *Bonnet*				Corrosion					Date
					N	Y	N	Y	N	L	M	H	N	L	M	H	N	L	M	H	N	L	M	H	Part	

Legend

Deposits and Corrosion
N = None
L = Light
M = Medium
H = Heavy

Parts
B = Bonnet
Be = Bellows
Bo = Body outlet
D = Disk
G = Guide
N = Nozzle
S = Seat
Sp = Spring
St = Stem

Test Medium
A = Air
S = Steam
W = Water
N = Nitrogen
O = Other inert gas

Dismantled/ Disk Stuck
N = No
Y = Yes

Device no. ________
Sheet no. ________
Unit________
Location________
Inspection interval ________

Figure B.5—Sample Condition, Repair, and Setting Record [5]

SETTING RECORD AND REPAIR ORDER FOR PRESSURE–RELIEVING DEVICES

To Mr./Ms.______________________________:

Please relieve, dismantle, repair, and reset the following relief valves. Return properly executed original of this form to the engineering-inspection group after completion of work.

Unit ________________________________

Inspector ________________________________

Order no. ________________________________

Date ________________________________

Foreman ________________________________

Legend

Deposits and Corrosion	Parts		Test Medium	Dismantled/ Valve Stuck
N = None	B = Bonnet	N = Nozzle	A = Air	N = No
L = Light	Be = Bellows	S = Seat	S = Steam	Y = Yes
M = Medium	Bo = Body outlet	Sp = Spring	W = Water	
H = Heavy	D = Disk	St = Stem	N = Nitrogen	
	G = Guide		O = Other inert gas	

Size	Device No.	Location	Set Pressure	Reseat Pressure	Bonnet Test	No. Notch D. D. Ring	Relieving Pressure	Remarks	Test Medium	Dismantled		Valve Stuck		Deposits												Corrosion					Repairs	Repair Man	Date
														Nozzle				*Body*				*Bonnet*											
										N	Y	N	Y	N	L	M	H	N	L	M	H	N	L	M	H	N	L	M	H	Part			

Figure B.6—Sample Setting Record and Repair Order [5]

IN-SERVICE REPORT FOR A PRESSURE-RELIEVING DEVICE

Upon completion of this report, put it in the special envelope provided and send it to the engineering-inspection group.

Device no.	____________	Unit	____________
Date tested	____________	Location	____________
Date installed	____________		____________

Figure B.7—Sample In-service Report [5]

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