

Guide for Inspection of Refinery Equipment

Chapter XVI—Pressure-Relieving Devices

Refining Department

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**American
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PREFACE

This chapter is one of a series that make up the manual *Guide for Inspection of Refinery Equipment*. It is based on the accumulated knowledge and experience of engineers of the petroleum industry. All users are invited to submit suggested revisions to the director of the Refining Department, American Petroleum Institute, 1220 L Street, Northwest, Washington, D.C. 20005.

The information contained in this publication has been arranged in its present form as a means of facilitating continuity of presentation and convenience of reference. It does not constitute, and should not be construed to be, a code of rules, regulations, or minimum safe practices. It is not intended that the practices described in this publication supplant practices that have proven satisfactory. Nor is it intended that this publication discourage innovation and originality in the inspection of refineries. Users of the publication are reminded that no book or manual is a substitute for good judgment.

The *Guide for Inspection of Refinery Equipment* is subdivided as follows:

Chapter I	Introduction
Chapter II	Conditions Causing Deterioration or Failures
Chapter III	Inspection Planning
Chapter IV	Inspection Tools
Chapter V	Preparation of Equipment for Safe Entry and Work
Chapter VI	Pressure Vessels (Towers, Drums, and Reactors)
Chapter VII	Heat Exchangers, Condensers, and Cooler Boxes
Chapter VIII	Fired Boilers and Auxiliary Equipment
Chapter IX	Fired Heaters and Stacks
Chapter X	Pumps, Compressors, and Blowers, and Their Drivers
Chapter XI	Pipe, Valves, and Fittings
Chapter XII	Foundations, Structures, and Buildings
Chapter XIII	Atmospheric and Low-Pressure Storage Tanks
Chapter XIV	Electrical Systems
Chapter XV	Instruments and Control Equipment
Chapter XVI	Pressure-Relieving Devices
Chapter XVII	Auxiliary and Miscellaneous Equipment
Chapter XVIII	Protection of Idle Equipment
Appendix	Inspection of Welding

CONTENTS

CHAPTER XVI—PRESSURE-RELIEVING DEVICES

	PAGE
16.1 Scope	1
16.2 Referenced Publications	1
16.3 Description of Types	1
16.3.1 Safety Valves	1
16.3.2 Relief Valves	2
16.3.3 Safety Relief Valves	3
16.3.4 Conventional Safety Relief Valves	3
16.3.5 Balanced Safety Relief Valves	4
16.3.6 Pilot-Operated Safety Relief Valves	4
16.3.7 Pressure and Vacuum Vents	6
16.3.8 Rupture Disks	7
16.3.9 Resilient Valve Seats	9
16.4 Reasons for Inspection	10
16.4.1 Personnel and Equipment Safety	10
16.4.2 To Determine the Condition of a Device	10
16.4.3 To Evaluate Inspection Frequency	10
16.5 Causes of Improper Performance	11
16.5.1 Corrosion	11
16.5.2 Damaged Seating Surfaces	12
16.5.3 Broken Springs	14
16.5.4 Improper Setting	14
16.5.5 Plugging and Sticking	15
16.5.6 Misapplication of Materials	16
16.5.7 Improper Identity	17
16.5.8 Rough Handling	17
16.5.9 Improper Differential Between Operating and Set Pressures	18
16.6 Frequency and Time of Inspection	18
16.6.1 Inspection Frequency	18
16.6.2 Time of Inspection	19
16.7 Preparatory Work, Tools, and Equipment	20
16.7.1 Preparatory Work	20
16.7.2 Shop Test Block	21
16.7.3 Tools and Repair Parts	22
16.8 Inspection and Test Procedures	24
16.8.1 Inspection of Pressure-Relief Valves Before Removal to the Shop	24
16.8.2 Inspection of Pressure-Relief Valves in the Shop	25
16.8.3 Inspection of Pressure-Relief Valves on Equipment	26
16.8.4 Inspection of Pilot-Operated Safety-Relief Valves	27
16.8.5 Inspection of Rupture Disks	27
16.9 Records and Reports	28
16.9.1 Objective	28
16.9.2 Need for Keeping Records	28
16.9.3 Responsibilities	28
16.9.4 Sample Record and Report System	28

APPENDIX A—SPECIFICATION RECORD	31
APPENDIX B—HISTORICAL RECORD	33
APPENDIX C—DUE LIST FOR PRESSURE-RELIEVING DEVICES	35
APPENDIX D—TEST REPORT FOR SAFETY-RELIEVING DEVICES	37
APPENDIX E—IN-SERVICE REPORT FOR SAFETY DEVICES	39
Figures	
1—Wing-Guided Safety Valve	2
2—Top-Guided Safety Valve	2
3—Relief Valve	3
4—Conventional Safety Relief Valve	3
5—Balanced-Bellows Type of Safety Relief Valve	4
6—Balanced Bellows with Auxiliary Balancing Piston	5
7—Pilot-Operated Valve with Remotely Mounted Pilot	5
8—Low-Pressure Diaphragm-Type Pilot-Operated Valve	5
9—High-Pressure Pilot-Operated Valve	6
10—High-Pressure Pilot-Operated Valve with Optional Dual Outlets	6
11—Solid Pallet and Diaphragm Pallet Vent Valve	7
12—Pilot-Operated Vent Valve	7
13—Rupture Disk	7
14—Rupture Disk in a Typical Holder	8
15—Reverse-Buckling Disk Assembly in Combination with a Safety Relief Valve	9
16—Safety Relief Valve with O-Ring Seal	9
17—Acid Corrosion in Carbon-Steel Bonnet Caused by Leaking Seating Surfaces	11
18—Acid Corrosion on 18-8 Chrome-Nickel Steel Inlet Nozzle	11
19—Chloride Corrosion on 18-8 Chrome-Nickel Steel Nozzle	11
20—Sulfide Corrosion on Carbon-Steel Disk from a Crude-Oil Distillation Unit	12
21—Chloride Attack on 18-8 Chrome-Nickel Steel Disk	12
22—Pit-Type Corrosion on 18-8 Chrome-Nickel Steel (Type 316) Bellows	12
23—Monel Rupture Disks Corroded in Sour-Gas Service	13
24—Body and Bonnet Coated with Epoxy for Corrosion Protection	13
25—Seating Surface of disk Deformed by Chattering	13
26—Seat and Disk Damaged by Frequent Operation of Valve Set Too Close to Operating Pressure	14
27—Spring Failure Caused by Corrosion	14
28—Spring Failure Resulting from Stress Corrosion	14
29—Inlet Nozzle Plugged with Coke and Catalyst After Nine Months in Reactor Vapor Line	15
30—Outlet of Valve Plugged with Deposits from Other Valves in Common Discharge Header	15
31—Moving Parts of Valve Fouled with Iron Sulfide	16
32—Iron-Sulfide Deposits Caused Valve to Stick	16
33—Disk Frozen in Guide as a Result of Buildup of Products of Corrosion in Sour-Oil Vapor Service	17
34—Rough Handling of Valves Should Be Avoided	18
35—Identification Tag for Pressure-Relieving Device	19
36—Block Valves on Inlet and Outlet Sealed Open and Bleeders to Depressure Safety Relief Valve Inlet and Outlet	21
37—Safety-Valve and Relief-Valve Leak Detector	22
38—Typical Safety-Valve and Relief-Valve Test Block Using Air as the Test Medium	23
39—Sulfur Deposits in Body of Valve on Way to Repair Shop	24

Guide for Inspection of Refinery Equipment

CHAPTER XVI—PRESSURE-RELIEVING DEVICES

16.1 Scope

This chapter describes automatic pressure-relieving devices commonly used in the oil and petrochemical industries. It is intended as a guide for the inspection and control of these devices in the user's plant to ensure proper performance. This information is not intended to supersede requirements established by regulatory bodies.

Included in this chapter are automatic devices such as spring-loaded pressure-relief valves, pilot-operated valves, and rupture disks. Inspections and tests made at manufacturers' plants, however, which are usually covered by codes or purchase specifications, are not discussed in this chapter. Other items not included are weak seams or sections in tanks, explosion doors, fusible plugs, control valves, and other devices that either depend upon an external source of power for operation or are manually operated.

16.2 Referenced Publications

The most recent editions of the following standards, manuals, and specifications are cited in this chapter.

ASME¹

Boiler and Pressure Vessel Code

Section I, "Power Boilers"

Section IV, "Heating Boilers"

Section VI, "Recommended Rules for Care and Operation of Heating Boilers"

Section VII, "Recommended Rules for Care of Power Boilers"

Section VIII, "Pressure Vessels," Division 1, Division 2

PTC 25.3 *Safety and Relief Valves*

NBBPVI²

National Board Inspection Code

API

Guide for Inspection of Refinery Equipment

Chapter V, "Preparation of Equipment for Safe Entry"

API 510 *Pressure Vessel Inspection Code*

RP 520 *Recommended Practice for the Design and Installation of Pressure-Relieving Systems in Refineries*, Part I, "Design," Part II, "Installation"

RP 521 *Guide for Pressure Relief and Depressuring Systems*

Std 526 *Flanged Steel Safety Relief Valves*

Std 527 *Commercial Seat Tightness of Safety Relief Valves with Metal-to-Metal Seats (ANSI/API 527)*

Std 620 *Recommended Rules for Design and Construction of Large, Welded, Low-Pressure Storage Tanks*

Std 2000 *Venting Atmospheric and Low-Pressure Storage Tanks (Non-Refrigerated and Refrigerated)*

Bull. 2521 *Use of Pressure-Vacuum Vent Valves for Atmospheric Pressure Tanks to Reduce Evaporation Loss*

16.3 Description of Types

Pressure-relieving devices protect equipment and personnel by automatically functioning at a predetermined pressure to prevent excessive overpressure in refinery process systems and storage vessels. Basic designs include spring-loaded devices, weight-loaded devices, pressure-loaded devices, pilot-operated devices, and rupture disks. Pressure-relief valves (including safety valves, relief valves, and safety relief valves) are spring-loaded pressure-relieving devices. Other types of pressure-relieving devices include vacuum vents and rupture disks.

16.3.1 SAFETY VALVE

16.3.1.1 Description

Safety valves are automatic, spring-loaded, pressure-relieving devices actuated by the static pressure upstream of a valve. The spring of a safety valve, usually fully exposed outside the valve casing to protect it from contact with escaping steam, causes the valve to pop open at a predetermined set pressure. These valves are usually supplied with a lifting lever so that the valve can be manually opened to ensure that the working parts are free. They are normally not pressure-tight on their downstream side.

¹American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017.

²National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, Ohio 43229.

Figure 1 illustrates a wing-guided-type safety valve. Figure 2 shows a top-guided, nozzle-type valve, which has a greater capacity for a given size because of its improved flow characteristics.

16.3.1.2 Application

Safety valves are used on steam-boiler drums and superheaters. They may also be used for general air and steam services in a refinery. Discharge piping, when used, usually contains vented drip pan elbows.

16.3.1.3 Limitations

Safety valves should not be used:

1. In corrosive refinery services.
2. In any back-pressure service (see RP 520, Part I—Design).
3. Where the discharge must be piped to a remote location.
4. Where the escape of the lading fluid around the blowing valve is not desirable.
5. In liquid service.
6. As pressure-control or bypass valves.

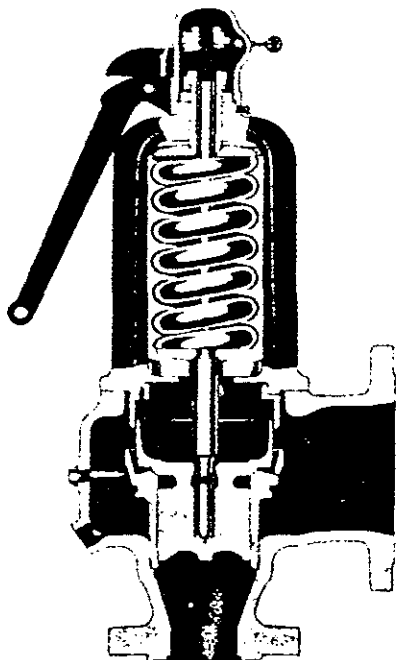


Figure 1—Wing-Guided Safety Valve

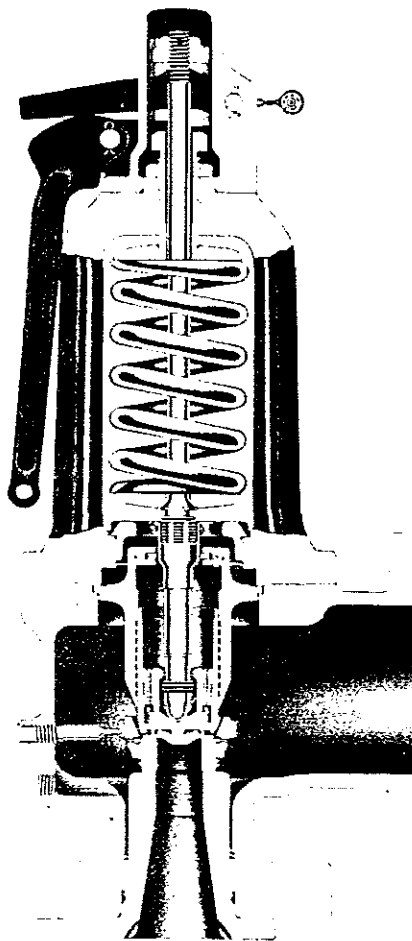


Figure 2—Top-Guided Safety Valve

16.3.2 RELIEF VALVES

16.3.2.1 Description

Relief valves are automatic, spring-loaded, pressure-relieving devices actuated by static pressure upstream of a valve. They lift in proportion to the increase in pressure-tightness on the downstream side of the valve. Relief valves cannot be operated manually because they are not furnished with a lifting lever. Figure 3 illustrates one type of relief valve.

16.3.2.2 Application

Relief valves are used primarily in liquid services. See RP 520, Part I—Design.

16.3.2.3 Limitations

Relief valves generally should not be used:

1. In steam, air, gas, or vapor service.
2. In variable back-pressure service.
3. As pressure-control or bypass valves.

16.3.3 SAFETY RELIEF VALVES

16.3.3.1 Description

Safety relief valves are automatic, spring-loaded, pressure-relieving devices actuated by the static pressure upstream of a valve. They are characterized by a rapid full opening, or pop action, when they are overpressured by gas or vapor. They are suitable for use as either a safety or relief valve. There are two types of safety relief valves, conventional and balanced.

16.3.3.2 Application

Safety relief valves are designed for refinery process industries that handle flammable, hot, or toxic material. Such material may pass through a closed discharge system to be released through the valve at a safe, remote point.

Safety relief valves are normally used:

1. In general refinery service for gas, vapor, steam, air, or liquids.
2. In corrosive refinery services.
3. When the discharge from the valve must be piped to a remote point.

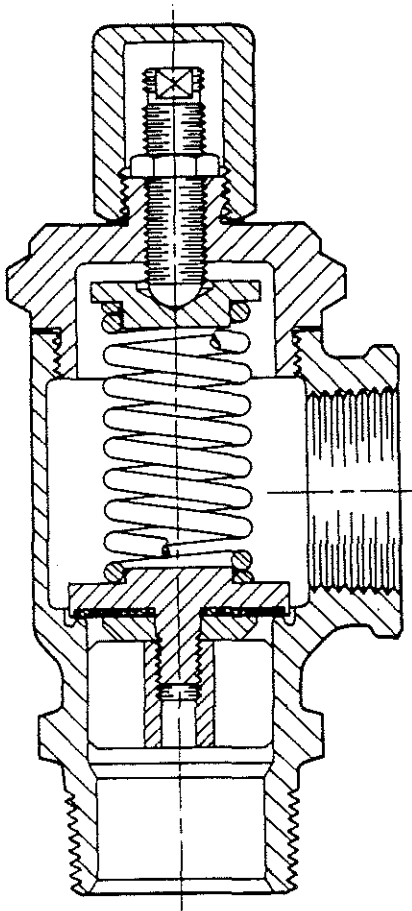


Figure 3—Relief Valve

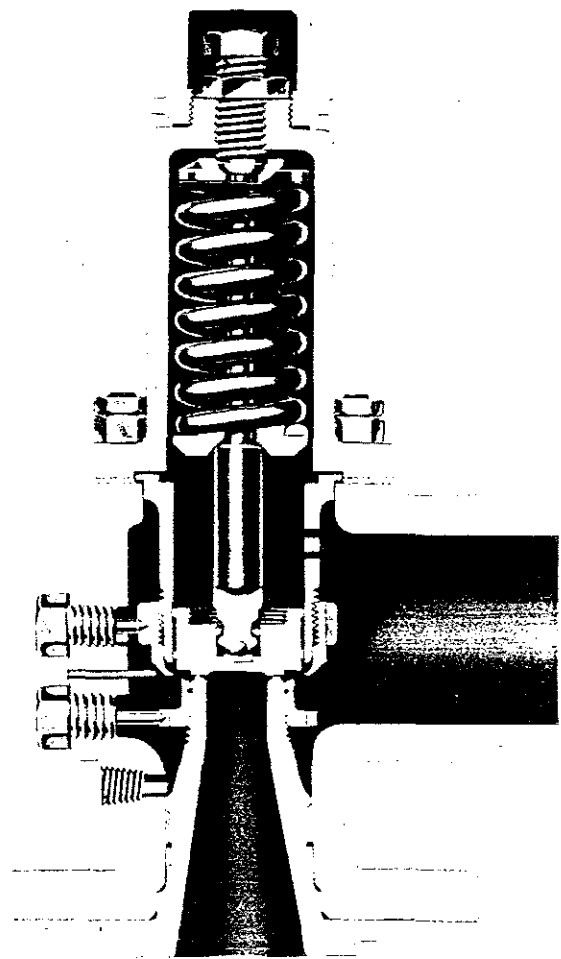


Figure 4—Conventional Safety Relief Valve

4. When the escape of the lading fluid around the open valve is not desirable.

16.3.3.3 Limitations

Safety relief valves should not be used:

1. On steam-boiler drums or superheaters.
2. As pressure-control or bypass valves.

16.3.4 CONVENTIONAL SAFETY RELIEF VALVES

16.3.4.1 Description

Conventional safety relief valves are constructed so that the back pressure on the downstream side of the valve affects the action of the valve. A variable back pressure will cause erratic action of the valve. Conventional safety relief valves are normally pressure-tight on the downstream side of the valve and can be furnished with a lifting lever. Figure 4 illustrates a conventional safety relief valve.

16.3.4.2 Application

Conventional safety relief valves are normally used in all of the services mentioned in 16.3.3.2 where any superimposed back pressure is constant, or where any built-up back pressure does not exceed 10 percent of the set pressure.

16.3.4.3 Limitations

Conventional safety relief valves should not be used:

1. On steam-boiler drums or superheaters.
2. In cases of variable back pressure. See RP 520, Part I—Design.
3. As pressure-control or bypass valves.

16.3.5 BALANCED SAFETY RELIEF VALVES

16.3.5.1 Description

Balanced safety relief valves incorporate pressure-balancing bellows and/or pistons in their design to decrease the valve's sensitivity to changes in back pressure. They may or may not be pressure-tight on the downstream side of the valve, depending on the specific design. A lifting lever is optional. A balanced-bellows valve is depicted in Figure 5, and this type of valve is shown with an auxiliary balancing piston in Figure 6.

16.3.5.2 Application

Balanced safety relief valves may be used in all of the services mentioned in 16.3.3.2 where the back pressure is either constant or variable, in high-viscosity lading fluid service, and in pump discharge service. The balanced-bellows type of safety relief valve is especially effective in corrosive services because it prevents sticking by sealing the corrosive lading fluid away from the valve's guiding surfaces.

16.3.5.3 Limitations

Balanced-type safety relief valves should not be used:

1. On steam-boiler drums or superheaters.
2. As pressure-control or bypass valves.

Because balanced-type valves must have vented bonnets, the need for piping the vent to a safe location must be determined. The balanced-bellows type, with or without an auxiliary balancing piston, will only discharge fluid from the bonnet vent in case of failure of the bellows.

The back pressure limitation listed in the manufacturer's catalog, which relates to the mechanical strength of the bellows, must not be exceeded.

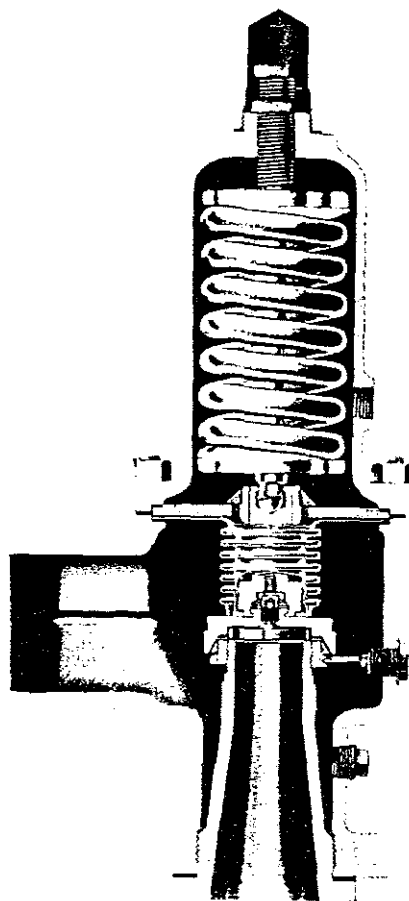


Figure 5—Balanced-Bellows Type of Safety Relief Valve

16.3.6 PILOT-OPERATED SAFETY RELIEF VALVES

16.3.6.1 Description

A pilot-operated pressure relief valve is a pressure-relief valve in which the major relieving device is combined with and is controlled by a self-actuated pressure-relief valve. The two basic units of these valves are the pilot or control unit and the main valve. These two units are mounted either on the same connection or separately, depending upon the design. The pilot is a spring-loaded valve that measures the pressure and causes the main valve to open and close. Process pressure is applied to the top of the unbalanced piston, diaphragm, or bellows of the main valve to close the pilot, and this pressure is vented off to open it. These valves are required by Section VIII of the ASME *Boiler and Pressure Vessel Code* to open and relieve full capacity at not over the set pressure if some essential part of the pilot should fail. Figure 7 shows a pilot-operated valve with a remotely

mounted pilot in which the main valve diaphragm is held closed by a combination of spring and pressure loading. Figure 8 shows a low-pressure diaphragm type pilot-operated valve. Figures 9 and 10 show high-pressure pilot-operated valves using an unbalanced piston, with integrally mounted pilots. Figure 10 illustrates optional remote pressure sensing from the vessel and optional dual outlets to equalize thrust.

16.3.6.2 Application

Pilot-operated valves are used in the following services:

1. Where a large relief area at high set pressures is required. Many pilot-operated valves can be set to the full rating of the inlet flange.
2. Where low differential exists between the normal vessel-

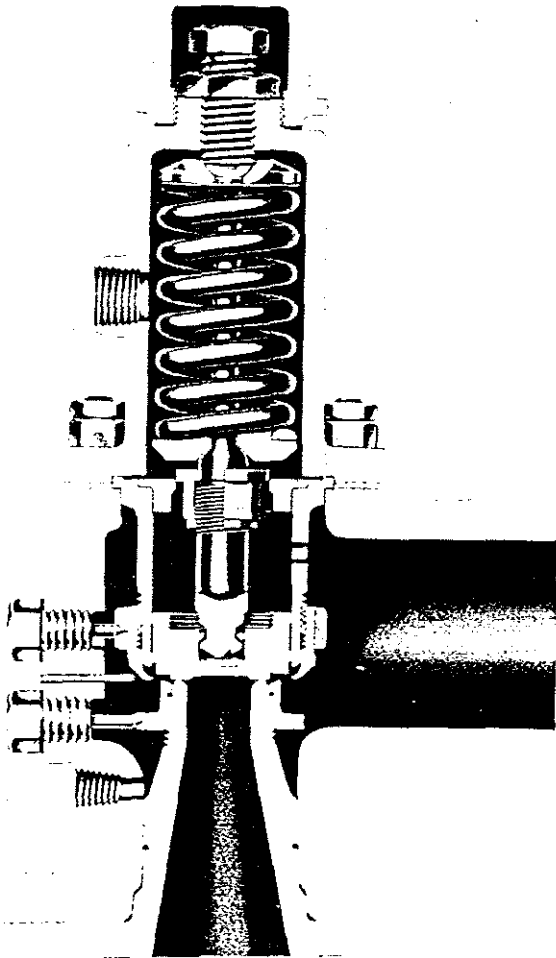


Figure 6—Balanced Bellows with Auxiliary Balancing Piston

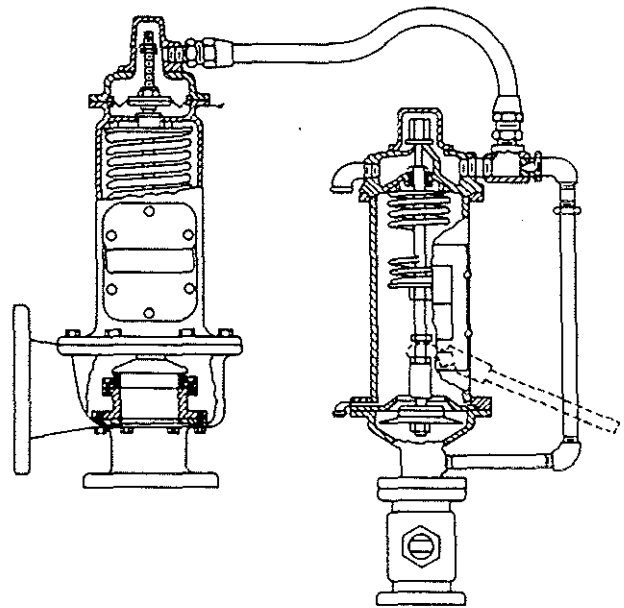


Figure 7—Pilot-Operated Valve with Remotely Mounted Pilot

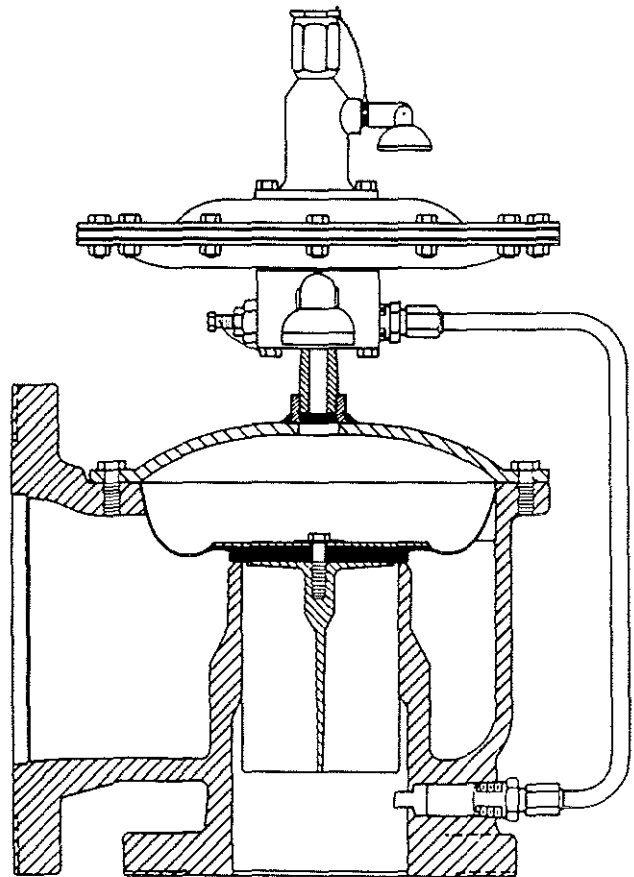


Figure 8—Low-Pressure Diaphragm-Type Pilot-Operated Valve

operating pressure and the set pressure of the valve.

3. On large low-pressure storage tanks (see Standard 620).

4. Where very short blowdown is required.

5. Where back pressures are very high and balanced design is required. A pilot-operated valve with the pilot vented to atmosphere is fully balanced.

6. In general process services where their use is economical and not limited by conditions in 16.3.6.3.

16.3.6.3 Limitations

These valves are not generally used:

1. In service where fluid is dirty.
2. In viscous liquid service. Pilot-operated valves have relatively small orifices that become plugged by viscous liquids.
3. With vapors that will polymerize in the valve.
4. In service where the temperature exceeds the safe limits for the diaphragms or seals selected.
5. Where chemical compatibility of the lading fluid with the diaphragms or seals of the valve is questionable, or where corrosion buildup can impede the actuation of the pilot.

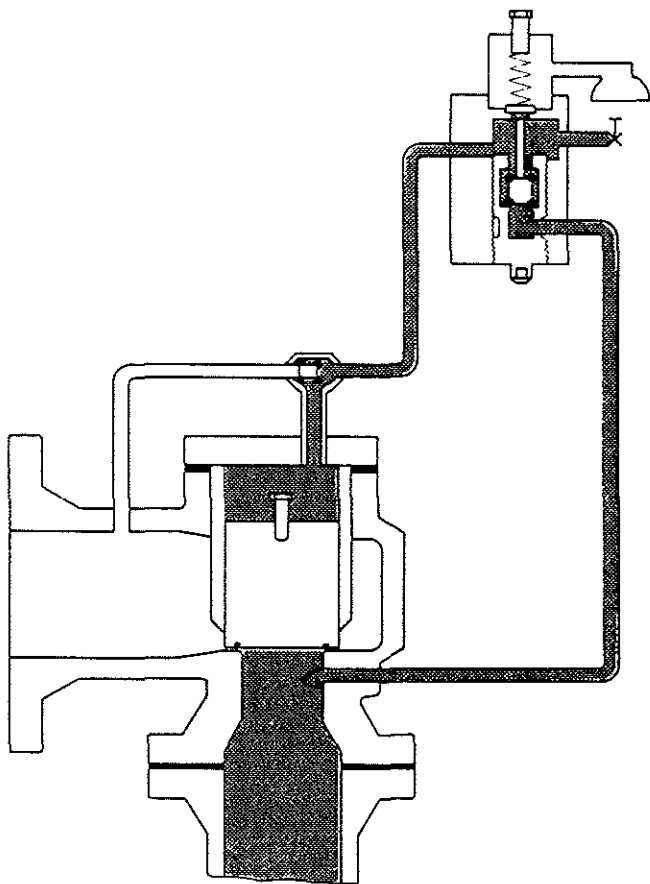


Figure 9—High-Pressure Pilot-Operated Valve

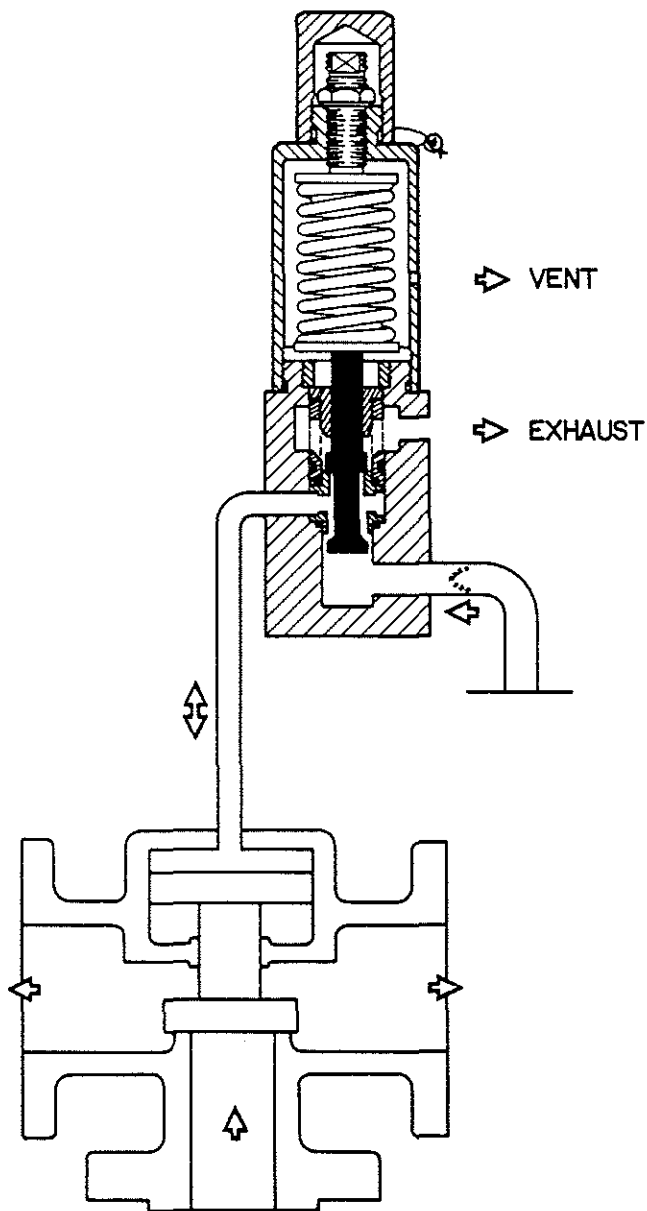


Figure 10—High-Pressure Pilot-Operated Valve With Optional Dual Outlets

16.3.7 PRESSURE AND VACUUM VENTS

16.3.7.1 Description

Pressure and vacuum vents are automatic pressure- or vacuum-relieving devices actuated by the pressure or vacuum in the protected storage tank. These pressure-vacuum vents fall into two main categories:

1. Weight-loaded pallet vents, as shown in Figure 11.
2. Pilot-operated vents, as shown in Figure 12.

16.3.7.2 Application

Pressure and vacuum vents are used to protect atmospheric and low-pressure storage tanks against a differential pressure (the pressure or vacuum inside the tank versus the atmospheric pressure outside the tank) large enough to damage the tank. Although breather valves (single units composed of both pressure and vacuum vents, also called conservation vents) are suggested for use on atmospheric storage tanks containing oil with a flash point below 100 F, they may also be used on heavier oils if desired (see Bulletin 2521 and Standard 2000).

16.3.7.3 Limitations

Pressure and vacuum vents are designed to protect atmospheric storage tanks and, in general, should be limited to that type of service unless modified to do otherwise.

16.3.8 RUPTURE DISKS

16.3.8.1 Description

Rupture disks are thin diaphragms usually held between special flanges. They relieve pressure from a vessel or system by rupturing at a predetermined pressure. Figure 13 shows a typical preformed, or prebulged, rupture disk. These are available in various metals, plymetals, plastic/metals, and coated metals. Nonmetallic disks, such as those of impervious graphite, are flat. The combination of a rupture disk and its holder is known as a rupture disk device. It is sometimes referred to as a nonreclosing pressure-relief device. A typical assembly is illustrated in Figure 14.

Some bulged metal disks are designed for installation with the concave side toward the source of pressure. This places

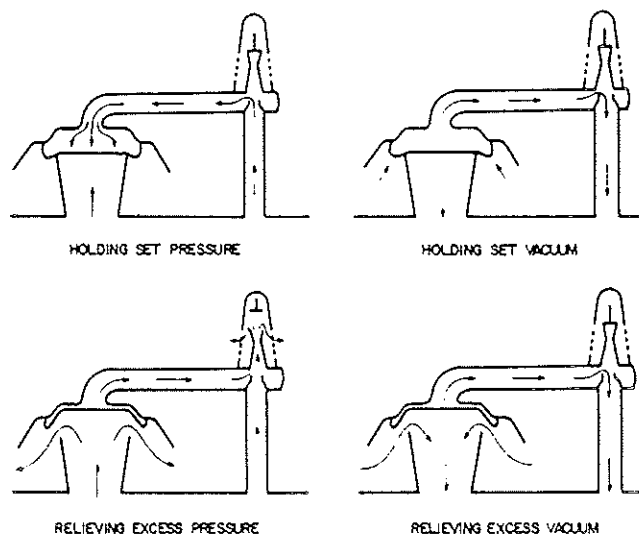


Figure 12—Pilot-Operated Vent Valve

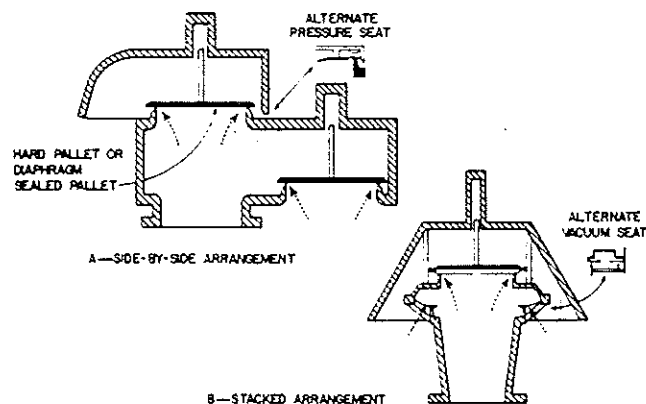


Figure 11—Solid Pallet and Diaphragm Pallet Vent Valve



Figure 13—Rupture Disk

the disk material in tension. A vacuum support may be required if the protected system operates with continuous or periodic vacuum.

Another type is the reverse-buckling disk as illustrated in Figure 15. Most reverse-buckling disks are good for vapor service only and should not be used in full liquid service without consulting the manufacturer. The preformed reverse-buckling disk is installed with the convex side of the bulge facing the pressure. This places the disk material in compression. No vacuum support is required. If the system pressure rises to the predetermined level, the disk will suddenly buckle or completely reverse with a snap action. The rupture disk opens after reversal by either tearing along score lines, or being cut or sheared by knife blades or teeth, providing a full-flow opening.

Impervious graphite rupture disks have several unique characteristics not found in the metallic types. The advantages of such a disk include high corrosion resistance, resistance to fatigue, immunity to thermal shock within its range, and bursting accuracy independent of temperature within its specified temperature range. These disks are flat and require vacuum supports when vacuum is expected in the protected vessel or system. Piping arrangements in-

volving traps for use with these disks are designed to prevent pieces of graphite from falling back into the system or passing through the relief valve if the rupture disk is used for upstream protection of the relief valve.

The receipt, storage, handling, and installation procedures used for rupture disks are critical to their successful use. The manufacturer's instructions should be referred to and followed, especially where limits on bolt torque are given.

16.3.8.2 Application

Rupture disks are sometimes used under the following conditions:

1. To protect a pressure-relief valve on the upstream side from corrosion by the system fluid.
2. To protect the valve against viscous fluids or polymerization products, which could plug or clog the valve.
3. In lieu of a pressure-relief valve when the protected system can tolerate process interruptions or loss of fluids in the event the disk ruptures.
4. As secondary pressure-relief devices where a large differential exists between the operating and rupture pressures, depending on the type of rupture disk selected (see 16.3.8.1 and 16.3.8.3).
5. To protect a pressure relief valve on the downstream side from atmospheric corrosion or downstream corrosion from a header.
6. To minimize leakage.

Section VIII of the ASME *Boiler and Pressure Vessel Code* covers several important points to be taken into account when installing rupture disks upstream of safety relief valves. For example, the capacity of the safety relief valve should either be limited to 80 percent of the rated relieving capacity of the valve alone or the capacity of the combination should be established in accordance with ASME *Boiler and Pressure Vessel Code* rules (see 16.3.8.3). The ASME code and any other applicable state or local codes and company standards should be consulted when rupture disk installations are contemplated or designed.

16.3.8.3 Limitations

Normally, for flat or bulged metal rupture disks having the bulge installed so that pressure acts against the concave side, the operating pressure of the protected system is usually limited to 65 to 85 percent of the disk's predetermined bursting pressure. The exact percentage depends on the type of disk used. The lower value of this range should be used if pulsating pressures or continuous or periodic wide swings in pressure are anticipated in the system. The service life of these disks under normal operating conditions is usually 1 year. They are subject to relatively rapid creep-stress failure, especially with the higher operating temperatures.

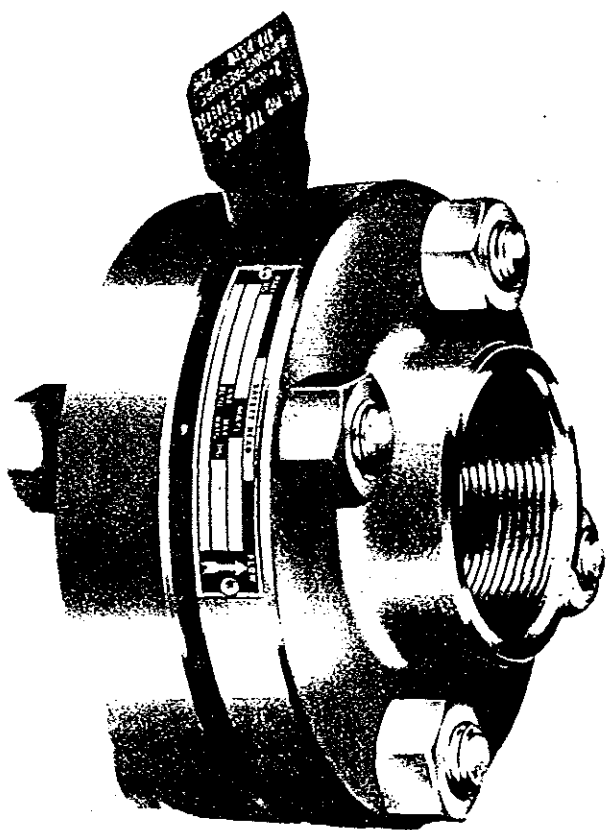


Figure 14—Rupture Disk in a Typical Holder

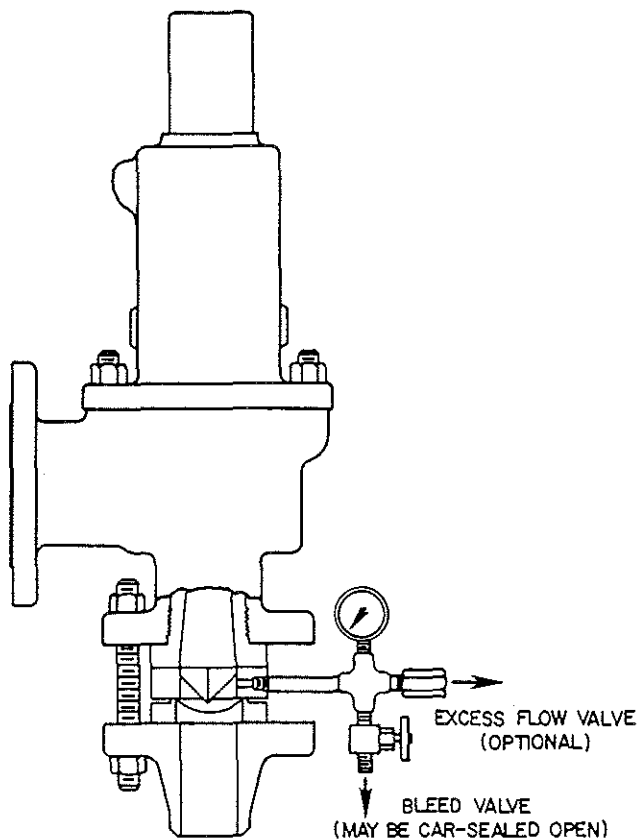


Figure 15—Reverse-Buckling Disk Assembly in Combination with a Safety Relief Valve

If not replaced periodically they may fail without warning at normal operating pressures.

Higher operating pressures up to 90 percent depending on the disk design bursting pressure are possible with the reverse-buckling type disk. Reduced fatigue effects from pulsating and cyclic operating pressure result in a longer service life than can be expected from the disk installation cited previously with the process on the concave side. Most reverse-buckling disks should not be used in full liquid service. However, provided that there is an assured gas pocket against the disk and the disk manufacturer is consulted, liquid service can be considered. Impervious graphite rupture disks offer about the same advantages and disadvantages as the reverse-buckling, metal type. However, the piping arrangement may be more complicated (see 16.3.8.1), and uneven flange bolt loads or thermal strains in the piping may crack the disk.

The manufacturer should be consulted when designing or setting up an installation for information about the probable bursting accuracy of their particular disks when used in the different sizes, designs, temperatures, and service pressures.

When a rupture disk device assembly is installed at the inlet of a pressure-relief valve, the space between the rupture

disk and the valve must be provided with a pressure gage, a try cock, a free vent, or a suitable telltale indicator (see Figure 15). This arrangement permits the detection of disk rupture or leakage. A rupture disk device must also have full pipe area and must not fragment into the safety relief valve inlet after the disk bursts. When used in combination with a pressure-relief valve, ASME *Boiler and Pressure Vessel Code* rules on capacity of the rupture disk must be followed (see 16.3.8.2).

16.3.9 RESILIENT VALVE SEATS

16.3.9.1 Description

Some relief and safety relief valves are manufactured with resilient O-rings or other types of soft seals to supplement or replace the conventional metal-to-metal valve seating surfaces. Usually the valves are similar in all respects to the basic valves previously described, except the disks are designed to accommodate some type of seal ring to promote a degree of tightness exceeding the usual commercial tightness of conventional metal seats. Figure 16 shows one type of O-ring seat seal.

16.3.9.2 Application

Resilient valve seats are frequently used when a greater degree of seat tightness is required than is likely with metal-to-metal seats and for the following conditions:

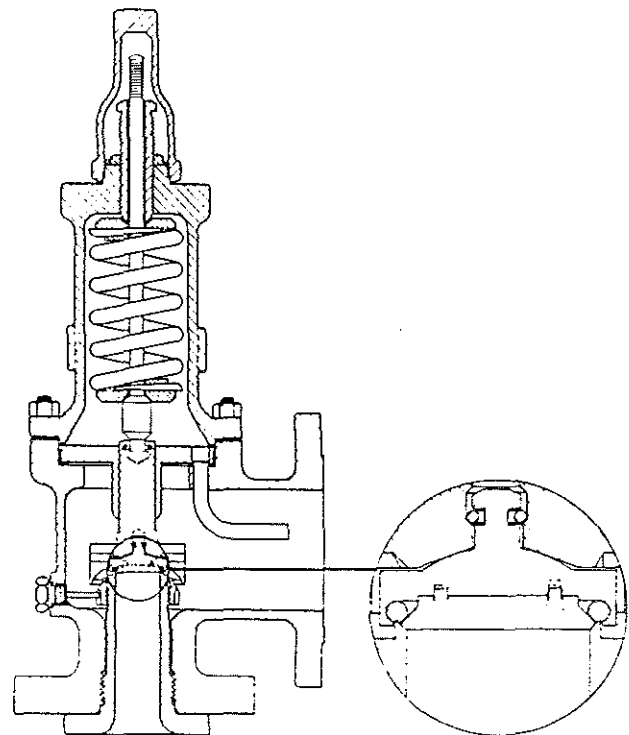


Figure 16—Safety Relief Valve with O-Ring Seal

1. Where the service fluid is corrosive or hard to hold with metal-to-metal seats. Slight leakage of a corrosive gas, vapor, or liquid could deteriorate or foul the moving parts of a valve with corrosion products.
2. To prevent loss of expensive fluids and to minimize the escape of explosive, toxic, or irritant fluids into the area.
3. Where operating pressures may of necessity be too close to the set pressure. As the operating pressure approaches the valve set pressure, the net differential forces on the disk are reduced. This adversely affects seat tightness. Resilient valve seats provide a better degree of tightness than metal-to-metal types under this condition.
4. When small, hard, foreign particles are carried in flowing fluids, they usually scratch or mar metal-to-metal seats when the valve discharges. This usually results in leakage when the valve closes. The resilient seal can absorb the impacts of the particles, shield the mating metal seating surface, and reduce the likelihood of leakage.
5. When a safety relief valve is subject to a minor pressure-relief situation, the disk may only lift enough to cause a slightly audible escape of fluid or visible drip of liquid. This may relieve the system pressure accumulation, but the valve does not significantly pop or lift open. Under this condition, with metal-to-metal seats, the disk may not reseat properly and the valve may continue to leak to below the system's normal operating pressure. A resilient seat valve provides tight shutoff when the system pressure falls after a minor relief.
6. Vibration and pulsating pressure tend to reduce the effect of the spring load on the disk. This causes the disk and nozzle seat to rub against each other, resulting in seat leakage. Where safety and relief valves are subject to this condition, resilient seating can maintain a greater degree of tightness than metal-to-metal seating.

16.3.9.3 Limitations

A variety of resilient materials is available for seals in valves. No single material is yet suitably resistant to all pressures, temperatures, and chemicals. Therefore, each resilient seat application should be selected after considering the specific service conditions. Certain materials may be excellent with respect to chemical resistance, but unsuitable for the intended service temperatures, and vice versa.

There are practical pressure limits to the use of O-ring seal rings. Extremely high pressure may result in extrusion of the O-ring from its retaining groove or damage to the ring with resultant loss of its proper function.

Past plant experience is the best guide in choosing seal material and pressure limitations. Lacking this source, the valve manufacturers and their catalogs may be useful.

16.4 Reasons for Inspection

16.4.1 PERSONNEL AND EQUIPMENT SAFETY

Pressure-relieving devices are installed on process equipment to release excess pressure resulting from upset operations, external fires, or other hazards. These conditions are included in Table 2 of RP 520, Part I—Design and discussed in RP 521. Failure of these devices to function properly when needed could result in the rupture of vessels, exchangers, boilers, or other equipment that they were intended to protect. The subsequent release of combustible material could jeopardize the safety of personnel and expose the process equipment to fire damage. A properly designed, applied, and installed pressure-relieving device, maintained in good operating condition, is essential to the safety of personnel and protection of equipment during abnormal circumstances. One of the principal reasons for inspecting pressure-relieving devices is to ensure that they are capable of providing this protection.

16.4.2 TO DETERMINE THE CONDITION OF A DEVICE

Inspections of pressure-relieving devices must result in a determination of general physical condition, as well as operating condition, to ensure that performance meets requirements for a given installation. In making this determination, two areas of inspection are involved:

1. Shop inspection to determine the internal conditions, operability on the test stand, and conformance to specifications (see 16.8.2.1).
2. Inspection of the protected equipment to seek out any conditions or situations that might prevent the device from functioning as required, including coke or corrosion deposits that could foul the moving parts or restrict inlet or outlet flow. Inlet and outlet piping should be inspected for the presence of internal deposits, and records should be kept of the condition. If deposits are observed, the piping should be thoroughly cleaned. If necessary, piping should be dismantled for inspection and cleaning. Visual onstream inspection should be made periodically (see 16.6.2.5).

16.4.3 TO EVALUATE INSPECTION FREQUENCY

The inspection of pressure-relieving devices provides data that can be evaluated to determine a safe and economical frequency of scheduled inspections. This frequency can be expected to vary widely because of the different operating conditions and environments to which relief devices are often subjected.

Inspections are usually less frequent when operation is satisfactory and more frequent when corrosion, fouling, and leakage problems exist. Historical records reflecting periodic test results and service experiences for each relief device are valuable guides for establishing safe and economical inspection frequencies.

16.5 Causes of Improper Performance

16.5.1 CORROSION

Practically all types of corrosion are present in refinery service, and corrosion is the basic cause of most difficulties encountered. Corrosion is often apparent: pitted or broken

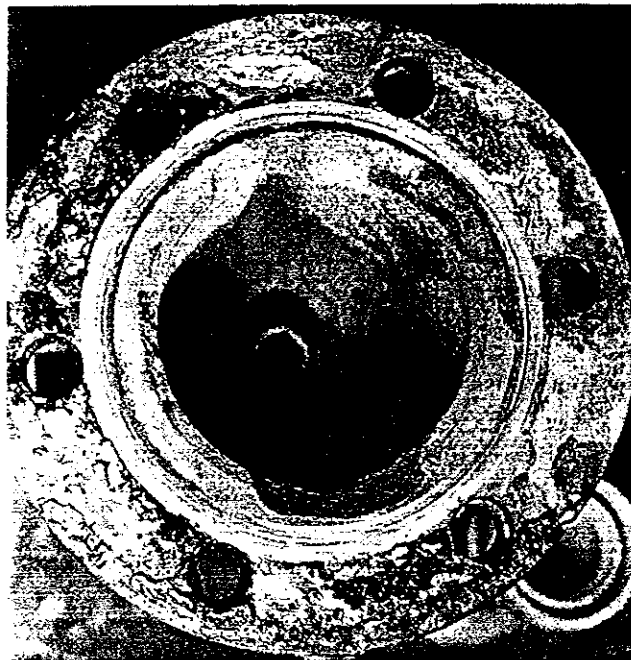


Figure 17—Acid Corrosion in Carbon-Steel Bonnet Caused by Leaking Seating Surfaces

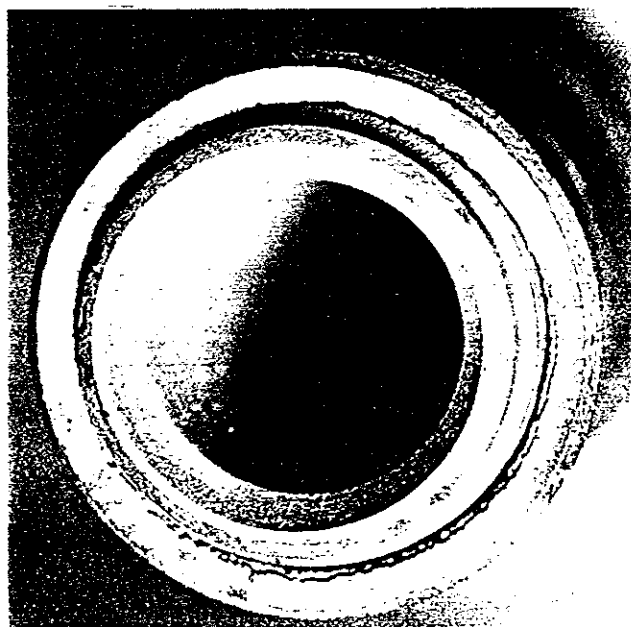


Figure 18—Acid Corrosion on 18-8 Chrome-Nickel Steel Inlet Nozzle

valve parts, deposits of corrosive residue that interfere with the operation of the moving parts, or a general deterioration of the material in the relieving device. Figures 17 through 23 illustrate several examples of the effects of corrosion on relieving devices.

Corrosive attack can usually be retarded by the selection of more suitable valves or materials or by better workmanship in the shop's maintenance repair section to ensure greater valve tightness. A leaking valve allows corrosive fluids to circulate in the upper parts of the valve, which can contribute to the corrosion of its movable parts. The corrosion-protection coatings shown in Figure 24 are applicable in some services.

In many instances, valves of different construction can avoid, reduce, or sometimes completely contain the effects of the corrosive attack. The use of an O-ring seat seal in a pressure-relief valve will sometimes stop leakage past the seating surface and eliminate corrosion in the valve's work-



Figure 19—Chloride Corrosion on 18-8 Chrome-Nickel Steel Nozzle (seating surface has been machined)

ing parts caused by fluid leaking past the valve seats (see Figure 16). If it is not possible to eliminate leakage entirely, or if corrosive back pressure is present, a bellows seal can be used to protect the moving parts of the valve from the action of the corrosive fluid (see Figure 5).

In addition to internal parts, exposed studs are vulnerable to environmental corrosion attacks.

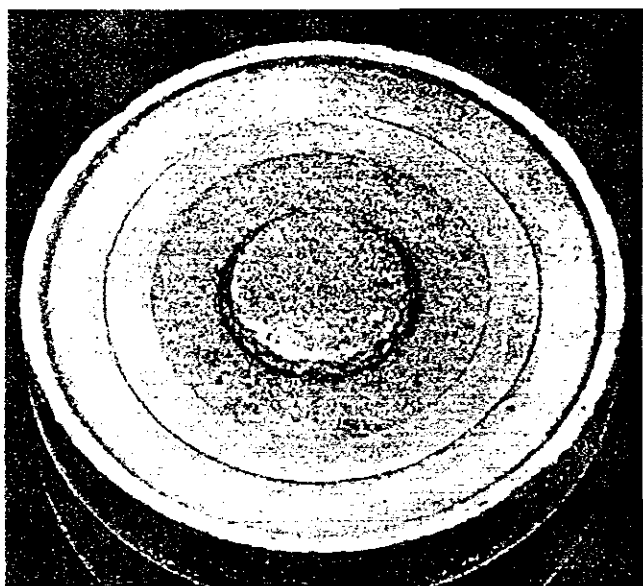


Figure 20—Sulfide Corrosion on Carbon-Steel Disk from a Crude-Oil Distillation Unit

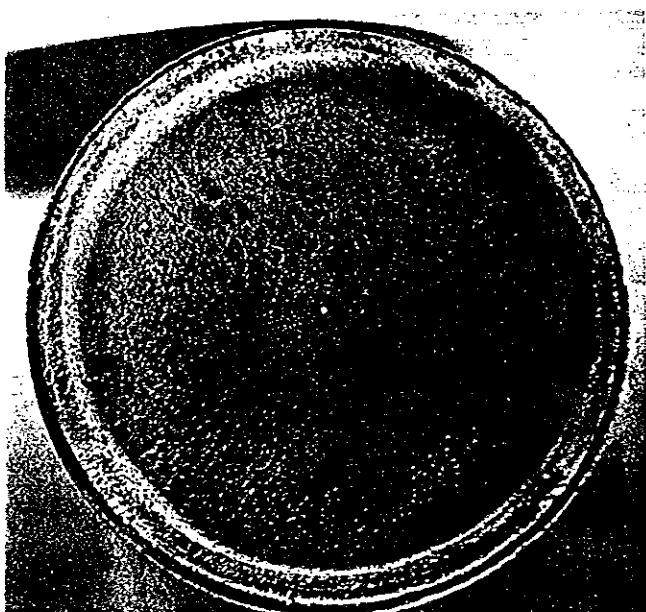


Figure 21—Chloride Attack on 18-8 Chrome-Nickel Steel Disk

16.5.2 DAMAGED SEATING SURFACES

Seating surfaces on pressure-relief valves must be maintained to optical precision, such as 3 light beads flatness, because of the relatively small differential loading that must prevent leakage of the lading fluid (see Standard 527). Any imperfection in these seating surfaces will contribute to improper valve action in service. There are many causes of damaged valve seats in refinery service, including the following:

1. Corrosion.
2. Foreign particles, such as mill scale, welding spatter or slag, corrosive deposits, coke, or dirt that get into the valve inlet and pass through the valve when it opens. This may destroy the precision seat contact required for tightness in most pressure-relief valves. This damage can occur either in the maintenance shop or on the unit the valve is protecting.
3. Improper or lengthy piping to the valve inlet or obstructions in the line. This causes valve chatter. In such an installation, the pressure under the seat may build up to a level sufficient to cause the valve to open. However, as soon as the flow is established, the pressure drop in the connecting piping may be so high that the pressure under



Figure 22—Pit-Type Corrosion on 18-8 Chrome-Nickel Steel (Type 316) Bellows

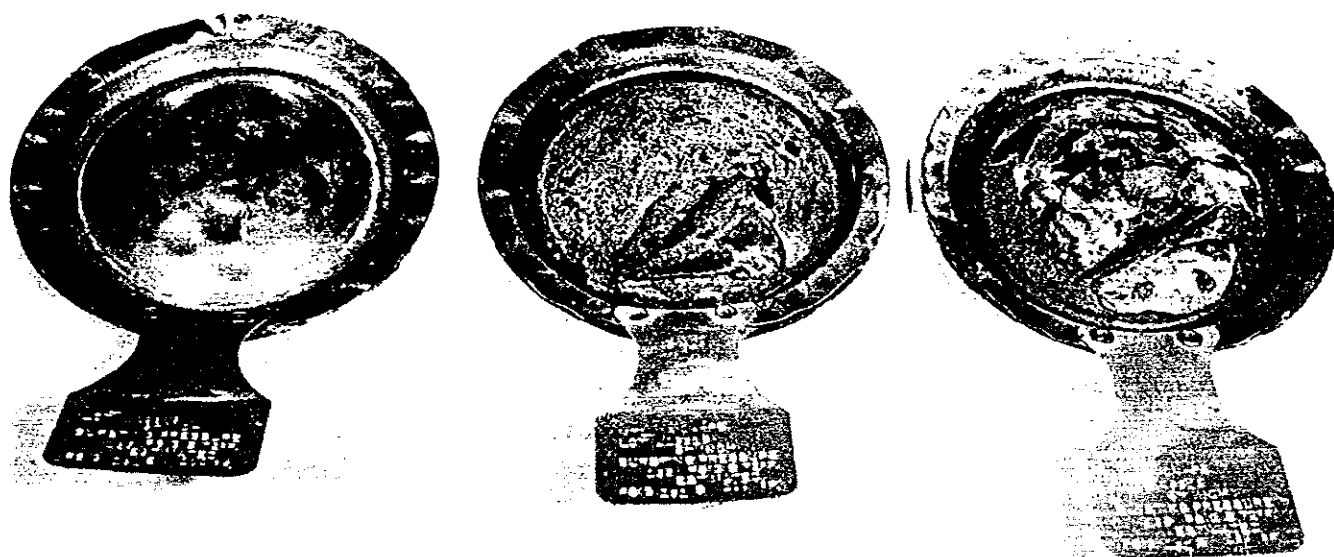


Figure 23—Monel Rupture Disks Corroded in Sour-Gas Service

the seat falls, thus allowing the valve to close. The cycle of opening and closing may continue repeatedly, sometimes at a rather rapid rate, thus subjecting the valve seating surfaces to a severe hammering action. This hammering damages the seating surfaces, sometimes beyond repair. Figures 25 and 26 show seating surfaces damaged by chattering and frequent fluctuations of pressure.

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

5. Leakage past the seating surfaces of a valve after it has been installed on the unit. This may be caused by inadequate maintenance or installation procedures such as misalignment

of the parts; by piping strains resulting from improper support; or by complete lack of support of discharge piping. This leakage, of course, contributes to seat damage because it causes erosion (wire drawing) or corrosion of the seating surface and thus progressively aggravates the leakage problem. Other frequent causes of this type of 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

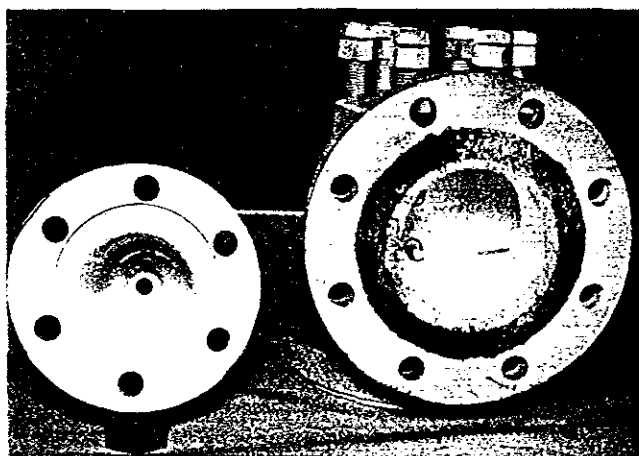


Figure 24—Body and Bonnet Coated with Epoxy for Corrosion Protection



Figure 25—Seating Surface of Disk Deformed by Chattering

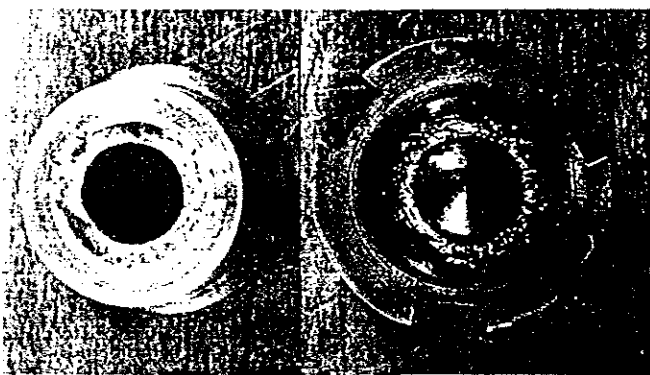


Figure 26—Seat and Disk Damaged by Frequent Operation of Valve Set Too Close to Operating Pressure

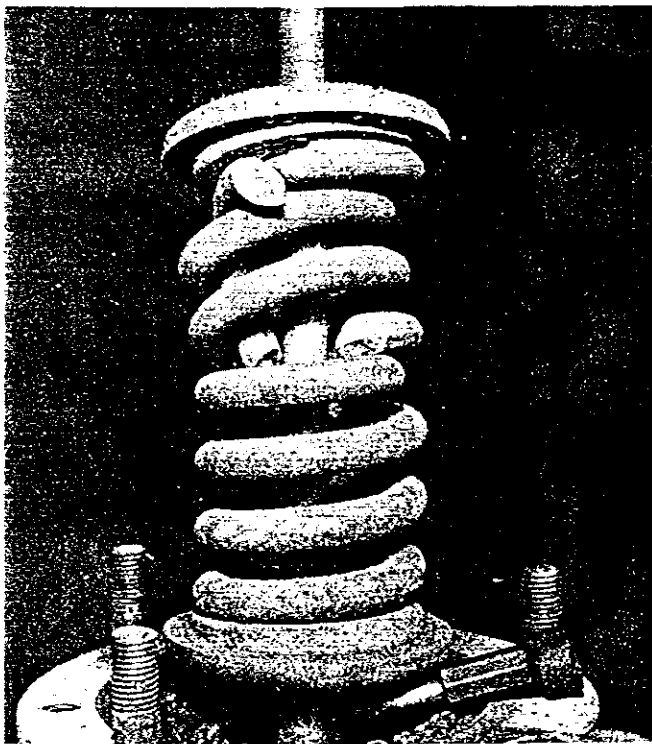


Figure 27—Spring Failure Caused by Corrosion

washers should be kept together as a spring assembly during the life of the spring.

6. Improper blowdown ring settings, which can cause chattering in pressure-relief valves. The relief valve manufacturer should be contacted for specific blowdown ring settings for both liquid and vapor service.

16.5.3 BROKEN SPRINGS

Broken springs in pressure-relief valves are almost always caused by corrosion. Two types of corrosion are most prevalent in this type of failure in refineries:

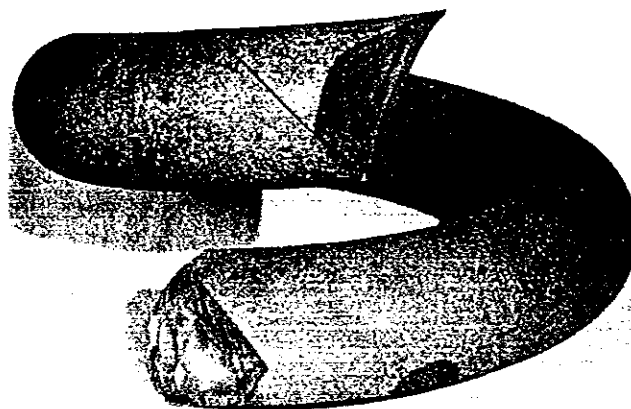


Figure 28—Spring Failure Resulting from Stress Corrosion

alent in this type of failure in refineries:

1. General corrosion that attacks the spring surface until the cross-sectional area of the spring is finally no longer sufficient to provide the necessary strength. Corrosion may also produce pits that act as stress heighteners and cause cracks in the spring surface with subsequent spring failure (see Figure 27).
2. Stress corrosion that sometimes results in quite rapid spring failure. This type is particularly insidious because it is very difficult to detect until the spring breaks. A brittle-type spring failure resulting from stress corrosion is shown in Figure 28. Hydrogen sulfide is one medium that frequently causes this type of spring failure in refineries.

Spring failures are also dependent on the type and strength of the corrodent, the stress level in the spring, the spring material itself, and time.

Where corrosion is prevalent, two courses of preventive action may be taken. First, a spring material that will satisfactorily resist the action of the corrosive agent may be used. Second, the spring can be isolated using a bellows.

16.5.4 IMPROPER SETTING

Improper setting is usually the result of carelessness on the part of maintenance personnel, inadequate testing equipment in the maintenance shop, or lack of knowledge regarding the proper adjustments required in the pressure-relief valve. Manuals provided by valve manufacturers help eliminate such problems by giving details on compensation for temperature, back pressure, and other adjustments.

In refinery services, setting pressure-relief valves in place on protected equipment using the fluid that will flow through the valve when it opens during operation is usually impractical. Therefore, valves must be set in the valve main-

tenance shop on test equipment available for that purpose. During inspection and repair, a properly designed test block is important to facilitate setting and adjusting of the pressure-relief valve (see 16.7.2). For nameplate terms necessary during repair work, see Standard 526.

Water, air, or an inert gas such as bottled nitrogen is generally used as the testing medium in the shop. It is better to set a safety relief valve on air or some other gas rather than on water since, depending upon the type of valve being tested, a gaseous effluent will produce either a definite pop or a clearly defined audible opening at the set pressure. Some overpressure should be carefully applied to the valve to be certain the valve is opening because an audible leak could otherwise be misinterpreted as the set pressure of the valve. Most types of safety relief valves produce a distinct pop at the valve set pressure, making misinterpretation impossible.

Incorrect calibration of pressure gages is another frequent cause of improper valve setting. Gages should be calibrated frequently on a regularly calibrated dead-weight tester to ensure accuracy. The pressure range of the gage should be chosen so that the required set pressure of the pressure-relief valve falls within the middle third of the gage pressure range.

Snubbers on pressure gages are not generally recommended since they tend to clog and produce pressure lag.

Adjustment of the ring or rings controlling the valve action is quite frequently misunderstood when the valve is being set. 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 ma-

terial handled through pressure-relief valves are variable and the size of testing facilities is limited, it is not always possible to adjust the rings for the best possible performance on a test drum in the maintenance shop. 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 on the unit.

The relief valve manufacturer should be contacted regarding the proper blowdown ring settings for liquid or vapor service. Full understanding of definitions and terminology is important (see ASME PTC 25.3).

16.5.5 PLUGGING AND STICKING

In refinery service, process solids such as coke or solidified products can sometimes plug various parts of the valve and connected piping. Figure 29 shows the inlet nozzle of a valve plugged solid with a mixture of coke and catalyst, and Figure 30 shows the outlet nozzle of a valve plugged with deposits attributed to other valves discharging into a common discharge header. These are extreme variations. Fouling to a lesser degree, as shown in Figures 31 and 32,

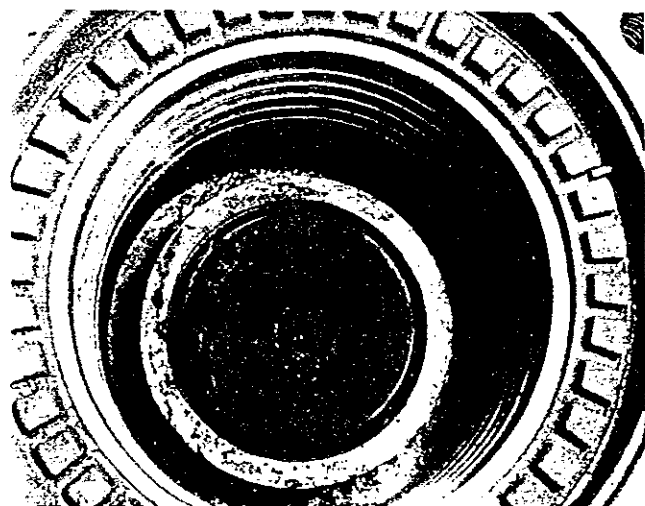


Figure 29—Inlet Nozzle Plugged with Coke and Catalyst After Nine Months in Reactor Vapor Line

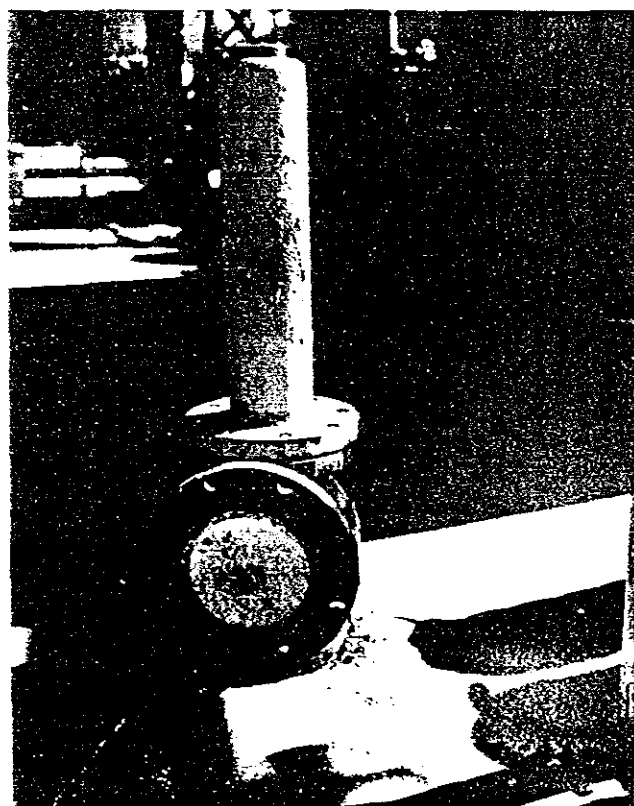


Figure 30—Outlet of Valve Plugged with Deposits from Other Valves in Common Discharge Header



Figure 31—Moving Parts of Valve Fouled with Iron Sulfide

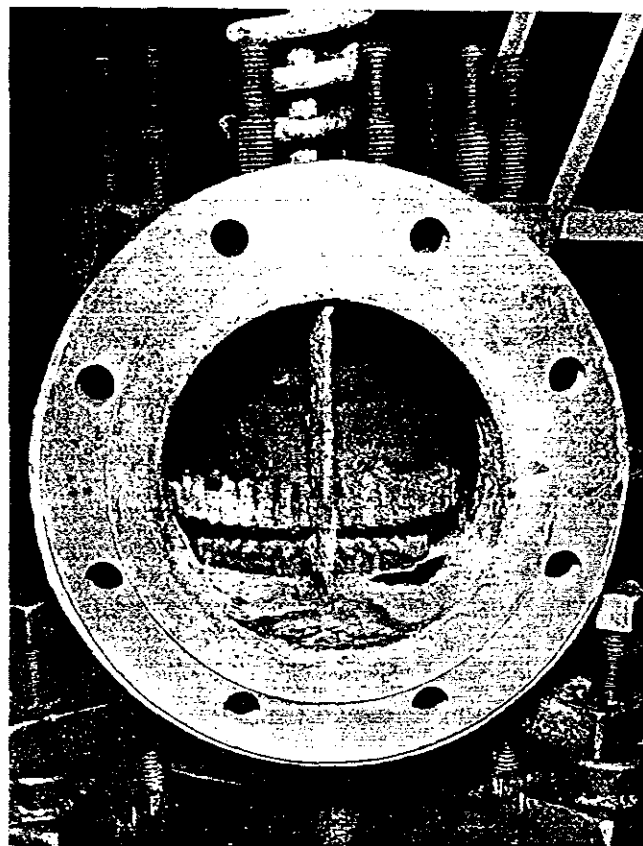


Figure 32—Iron-Sulfide Deposits Caused Valve to Stick

is also likely to affect valve operation adversely. All valve parts, particularly guiding surfaces, should be checked thoroughly for any type of fouling. Lubrication of all sliding surfaces and threads with molybdenum disulfide compounds or graphite and grease is recommended.

Valve malfunction may also occur when the disk or disk holder sticks in the guide. This may be caused by corrosion or galling of the metal in the guiding surfaces or by foreign particles. Figure 33 shows the disk frozen in the guide as a result of corrosion in sour-gas service. If corrosion is the cause, two possible cures are available. A bellows, especially in closed systems, can protect moving parts from the corrosive substance (see Figure 5). Otherwise, an O-ring seal (see Figure 16) can seal the guiding surfaces from the lading fluid.

In the guiding surfaces, foreign particles tend to start rolling up metal, which is evident as severe galling. If this is the cause of sticking, the use of a bellows can keep the foreign particles away from the guiding surfaces.

When galling occurs from causes other than corrosion or foreign particles, it can usually be traced to valve chatter or flutter which, in turn, may be caused by improper piping

at the valve inlet or outlet or by oversizing the valve. Correction of this piping will usually stop galling of the metal in the guiding surfaces.

Galling of the guiding surfaces can also be caused by improper finishing of those surfaces. They should be polished as smoothly as possible to reduce the chances of galling. All possible precautions against galling should be used, since the use of corrosion-resistant metals in pressure-relief valves in refineries is unavoidable and frequently creates conditions that lead to galling. Galling may be minimized by using different materials and different hardnesses for the contacting parts.

Malfunction of pressure-relief valves may also be caused by poor alignment of the valve disk. This is usually the result of improper cleaning of the contact surface between the guide and the body of the valve or misalignment of a gasket at assembly (see RP 520, Part II—Installation).

16.5.6 MISAPPLICATION OF MATERIALS

In general, the materials required for a given service are dictated by the temperature, pressure, or corrosion-resistance requirements of the service, and the atmospheric con-



Figure 33—Disk Frozen in Guide as a Result of Buildup of Products of Corrosion in Sour-Oil Vapor Service

ditions to which they are exposed. The selection of standard valves within these limitations is advisable. Occasionally, however, severe corrosion or unusual pressure or temperature conditions in the process require special consideration. Manufacturers can usually supply designs and materials for valves that will be suitable for special service requirements. Catalogs show a wide choice of special materials for chemical and temperature conditions.

The hydrogen-sulfide attack on the carbon-steel disk in Figure 20 and the chloride attack on the 18-8 chrome-nickel steel disk in Figure 21 are examples of misapplied materials. Where service experience indicates that the selected type of valve or material is not suitable for a given service condition, an immediate correction should be made that will ensure dependable operation. Great care should be taken to retain the identity of special materials for the locations requiring them. An adequate system of records should provide the information needed for the repair or reconditioning of such valves and for developing optimum purchase specifications.

16.5.7 IMPROPER IDENTITY

A pressure-relief valve loses its effectiveness and may not provide the proper protection if it is not installed at the precise location for which it was intended. 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 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 or stamped on the valve by the user. This identification specifies the location of the valve and, by reference to the specification record, its limitations and construction (see 16.9).

16.5.8 ROUGH HANDLING

Because of the difficulty in obtaining absolute tightness in most pressure-relieving devices valve manufacturers use, valves are manufactured according to a commercial tightness standard, found in Standard 527. Valves are checked for tightness in the manufacturer's plant before they are shipped to the user. They are also usually checked in the maintenance shop before initial use and after cleaning, repairing, or testing. Subsequent rough handling of the valve, however, can change the set pressure, damage lifting levers, destroy the tightness, and produce excessive leakage in the valve when it is placed in service. Rough handling can occur during shipment, maintenance, or installation of the valve.

16.5.8.1 During Shipment

Because of their rugged construction, most pressure-relief valves have a deceptively sturdy appearance that may conceal the fact that they are delicate instruments with very sensitive tolerances and dimensions. Commercial carriers sometimes subject them to rough handling, which may cause the valves to leak excessively in service or during testing. Exposure of the valve inlet to dirt and foreign particles may damage the valve-seating surface the first time the valve opens and cause leakage thereafter.

16.5.8.2 During Maintenance

Pressure-relief valve parts are usually precision items manufactured to extremely close tolerances. These tolerances can be destroyed by rough handling in the maintenance shop. 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 the maintenance procedure is important. Rough handling of the completely assembled valve, both before and after repairs, should be avoided. Excessive back pressure should not be applied to a bellows-type valve. The rating should first be checked.

16.5.8.3 During Installation

Rough handling of a pressure-relief valve by refinery personnel while installing the valve on the refinery unit may

cause poor valve performance in service, just as rough handling during shipment damages the valve. Bumping or dropping the valve during installation should be carefully avoided. The repaired valves shown in Figure 34 were dropped from the bed of a truck. As a result, they leaked when they were installed.

When performing hydrostatic testing of discharge piping, it is necessary to install blinds. Otherwise, the bellows will be damaged from excessive back pressure.

16.5.9 IMPROPER DIFFERENTIAL BETWEEN OPERATING AND SET PRESSURES

The differential between operating and set pressures provides seat loading to keep the pressure-relief valve closed tightly.

Due to a variety of service conditions and valve designs, only general guidelines can be given for designing a system. The *National Board Inspection Code* and Sections VI and VII of the *ASME Boiler and Pressure Vessel Code* are useful references. However, individual applications and experience must finally govern. Greater differentials promote more trouble-free operation but may increase the cost of the equipment. The inspection function should include feedback to recorded experience for future design use or remedial action.

16.6 Frequency and Time of Inspection

16.6.1 INSPECTION FREQUENCY

To ensure proper performance, a definite time interval between inspections should be established for every pressure-relieving device on operating equipment. This interval may vary from one installation to another, depending on operating experiences. The time interval should be sufficiently firm to ensure that the inspection is made, but it should also be flexible enough to permit revision and temporary waiving where circumstances justify. In evaluating inspection intervals, safety considerations are paramount and should supersede economic considerations.

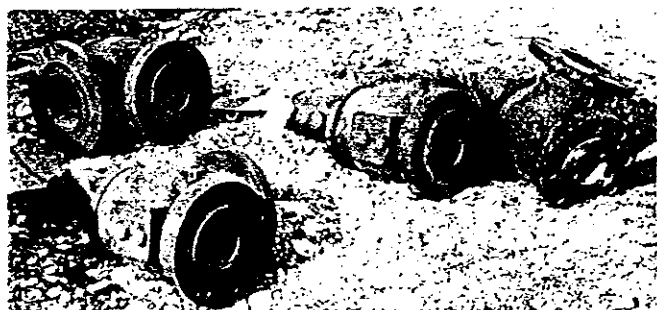


Figure 34—Rough Handling of Valves Should Be Avoided

16.6.1.1 Normal Basis

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

Where an adequate inspection history extending over a long period of time reflects consistent "as-received" test results that coincide with the set pressure (see 16.8.2.2), and where no change in service is to be made, an increase in the test interval may be considered. Conversely, if the as-received test results are erratic or vary significantly from the set pressure, the inspection interval may be decreased until satisfactory operation is assured. If a valve fails to operate on the test block at the set pressure, it can be assumed that it would have failed to operate on the unit during an emergency.

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

16.6.1.2 Manufacturer's Basis

Manufacturers of pressure-relieving devices are sometimes in a position 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 different from those required for conventional pressure-relief valves. Rupture disks and bellows-type valves may also require special consideration because manufacturers are familiar with the nature of the loading, stress levels, and operating limitations of their design, and they are able to suggest inspection intervals appropriate for their equipment.

16.6.1.3 Other Bases

In some instances, the frequency of inspecting and testing pressure-relieving devices is established by regulatory bodies. This point should be investigated for each locality to

avoid any possible conflict between such regulations and frequencies considered satisfactory.

16.6.2 TIME OF INSPECTION

Efforts should be made to inspect and test pressure-relieving devices according to schedules previously established, assuming the equipment has been in continuous operation except for normal shutdown interruptions.

Pressure and vacuum vents on atmospheric storage tanks should be inspected after installation but before the tank is hydrostatically tested or put into service. The items to check are covered in 16.8.3.2.

16.6.2.1 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. This inspection is used to determine any damage or changes in factory adjustment because of shipping, confirm set pressure, and initiate appropriate records. Records should include a complete specification record (see 16.9.4), the assignment of a company number, and the installation of a metal company identification tag on the valve. The tag shown in Figure 35 includes the company number, valve location, set pressure, and date of test.

Pressure and vacuum vents on atmospheric storage tanks should be inspected after installation but before the tank is hydrostatically tested or put into service. The items to check are covered in 16.8.3.2.

16.6.2.2 Unscheduled Inspection

An inspection of a pressure-relieving device is considered on schedule when it occurs within 10 percent of the established inspection interval. Any other inspections should be approved by the inspector or by a person responsible for equipment safety. In allowing deviations from the schedule, the following points should be considered:

1. Service experience. Review historical records to see whether safety would be compromised.
2. Presence of block valves to permit removal during operation.
3. Relation of schedule to planned unit shutdown.
4. Coordination with operations and with other work. Where safety is not impaired, economic considerations will be the controlling factor.

Inspection schedules should be expected to have deviations to correct observed malfunctioning of pressure-relief valves in service. If a valve fails to open at the set pressure,

it certainly requires immediate attention. If it opens at the set pressure but fails to reseat properly, the urgency of inspection and repairs will depend upon the amount of leakage and upon the fouling characteristics of the leaking fluid.

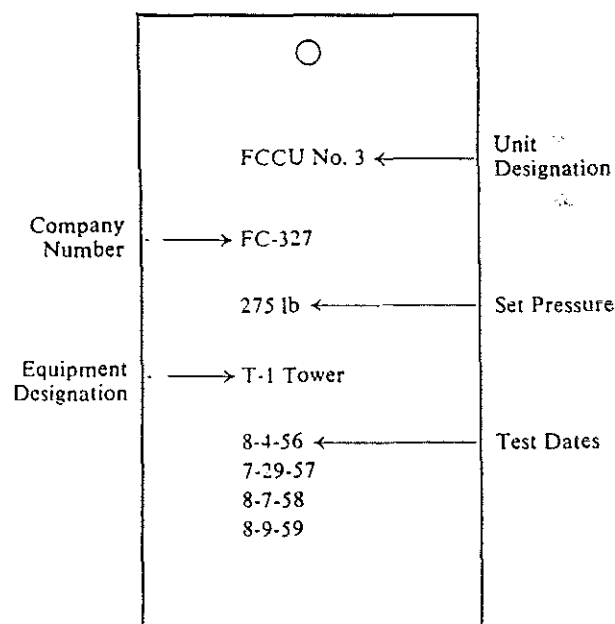
The date of a nonscheduled inspection and repair may be used as a starting point in scheduling subsequent inspections.

16.6.2.3 Inspection During Planned Shutdowns

The ideal time to inspect pressure-relief valves is when the inspection least interferes with the process and when maintenance manpower is readily available. These conditions prevail during planned shutdowns. All relief devices not equipped with block valves should be inspected at this time if an inspection becomes due before a subsequent shutdown. Even where block valves are used, the relief devices should be inspected at this time. This will minimize process interruptions and avoid the increased risk of performing this work on equipment in operation.

16.6.2.4 Inspection After Extended Shutdowns

Pressure-relief valves left on a unit during an extended shutdown period should be inspected and tested before resuming operation. This inspection is considered necessary to ascertain that corrosion, fouling, tampering, or other conditions or acts that would prevent the device from perform-



NOTE: Tag is 3 inches $\times$ 1½ inches $\times$ ¼ inch, preferably aluminum for corrosion resistance and ease of stenciling.

Figure 35—Identification Tag for Pressure-Relieving Device

ing properly have not occurred. Where a change in operating conditions follows the shutdown period, the inspection interval should be reviewed.

16.6.2.5 Visual Onstream Inspection

A visual onstream inspection is more like a survey and may be considered a control measure. It includes obvious points such as ascertaining that:

1. The correct relief device was installed.
2. The company identification tag shows the proper pressure setting for the equipment protected.
3. The established test interval has not been exceeded, if this is not clear from the records.
4. Gags, blinds, closed valves, or piping obstructions do not exist.
5. Seals protecting the spring setting have not been broken.
6. 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 prevents fouling and subsequent sticking of the valve. If the valve is a bellows type, leakage from the bellows vent should be checked.
7. Bellows vents are routed to a safe location.
8. Block valves upstream and downstream are locked or car-sealed in proper position.
9. Small nipples are properly supported to avoid breakage or leakage. Inadequately supported or anchored nipples can be damaged during maintenance or by vibration.

Although the interval selected for onstream inspection will vary with circumstances and experience, a visual inspection, including a check for leakage or vibration damage, should follow each operation of pressure-relief valves. Operating personnel assigned to the process unit could make these inspections providing they are sufficiently experienced to recognize these conditions.

16.7 Preparatory Work, Tools, and Equipment

16.7.1 PREPARATORY WORK

16.7.1.1 Equipment Checked for Safety

The general safety precautions outlined in Chapter V of this guide, "Preparation of Equipment for Safe Entry and Work," should be observed prior to working on pressure-relieving devices. This is particularly important if the equipment is in operation. When this is done, unit operations should be normal, and proper authority and permits should be obtained for the work.

When relief lines are opened to the atmosphere, precautions should be taken to avoid the release of hydrogen sulfide, hydrocarbons, or other hazardous materials that may flow out through this opening from other portions of the system. Proper care should also be taken to avoid fires and explosions that can occur when iron sulfide deposits in the piping are exposed to air.

In some cases a spool piece can be installed in place of the safety valve so that excessive pressure can be safely released. A bypass around the safety valve is sometimes used for depressuring when the safety valve is out of service. In both cases, an authorized person must remain stationed at the block valve in order to open it, if necessary, to protect the equipment from excessive pressure while the safety valve is removed. A pressure gage must be readily visible from this standby location.

When repairing a pressure-relief valve in place or removing it while equipment is in operation, the following precautions should be observed:

1. Isolate the relief device by closing any block valves upstream or downstream. This should be done only by an authorized person.
2. Vent to a safe location the space between the relief device and the block valve to release entrapped lading fluid and to determine if the block valves are holding.
3. If no block valve is installed on the downstream side of a relief device discharging into a common header, blinds, or other suitable means, should be provided to prevent discharge through the open outlet pipe in the event one of the other relief devices opens.
4. When repairs to a pressure-relief valve are to be made in place, a blind should be inserted between the pressure-relief valve and the upstream block valve. If the pressure-relief valve is tied into a common discharge header, a blind should also be installed between the relief valve and the header.
5. After repairs are completed, or after the relief device is reinstalled, all blinds should be removed. The block valves on the inlet and outlet should be opened and locked or sealed in that position. Figure 36 shows a safety relief valve installation with the block valves sealed open. It is recommended that these block valves have full pipe area.

If the equipment protected is out of service and open for other work, there should be no special safety precautions necessary other than to blind the discharge side properly if the valve is connected to a common discharge header that remains in service.

16.7.1.2 Identification of Valve Checked

Pressure-relief valves in service should carry an identifying tag or plate that shows the company equipment num-

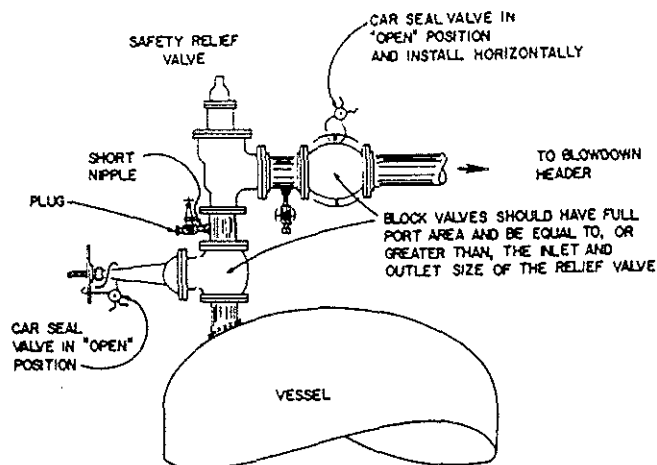


Figure 36—Block Valves on Inlet and Outlet Sealed Open and Bleeders to Depressure Safety Relief Valve Inlet and Outlet

ber, unit, location of pressure-relief valve on the equipment, set pressure, and date of last test (see Figure 35). If this information is not on the valve, it should be obtained from a master file and the valve tagged accordingly before it is removed from the equipment.

This identification is necessary to minimize errors in the testing and handling of pressure-relief valves (see 16.9).

16.7.1.3 Operating Conditions Noted

If possible, a complete operating history of the pressure-relief valve from the time of the last inspection should be obtained from the operators. This information should include:

1. Average operating conditions.
2. Number and severity of upsets and their effect on the pressure-relief valve.
3. Extent of any leakage.
4. Any other evidences of possible malfunctioning.

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

16.7.1.4 Valve Removed from System

The removal of a pressure-relief valve from equipment in operation should be planned to minimize outage time of the safety equipment. The precautionary steps outlined in 16.7.1.1 should also be followed.

Before removing the valve, the proper tools, such as wrenches and hoists, should be accumulated. Do not handle the valves roughly or hammer on the bolting of body flanges. Such treatment may affect the valve setting so that testing and inspection results will not give a true picture of valve performance. In the case of rupture disks, the outlet pipe and the flanges holding the disk may be the only parts that need to be removed.

In some cases, the connecting pipe may have to be sprung. Vent stacks and outlet piping should be adequately supported before removing the valves from the system.

16.7.2 SHOP TEST BLOCK

16.7.2.1 Need and Function of Test Block

After a pressure-relief valve is removed from service, it is usually taken to the shop for inspection and repair. An important phase of the maintenance routine is testing to determine set pressure and tightness of the valve, both in the as-received condition and after overhauling. Testing is usually performed on a testing block that has facilities for applying pressure to a valve and indicating this pressure. 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 also be used to advantage, especially for high-pressure valves.

Refer to ASME *Boiler and Pressure Vessel Code* Sections I, IV, and VIII for requirements for setting safety valves and safety relief valves in steam service.

The test block and supporting facilities are necessities in 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. For example, the amount of liquid or gas that can be discharged is limited, and it is not generally practical to measure relieving capacity or blowdown. However, the shop test block gives a good indication of the pressure at which the valve will open and can also be used to determine the tightness of the valve.

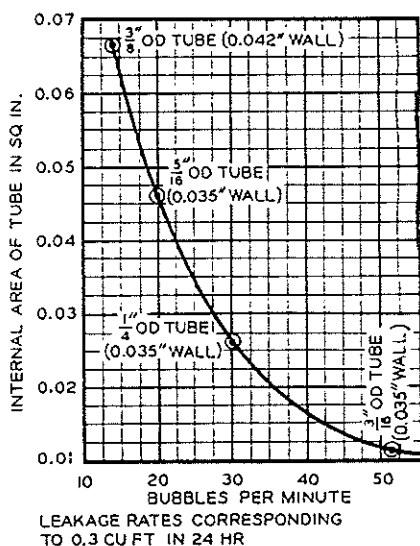
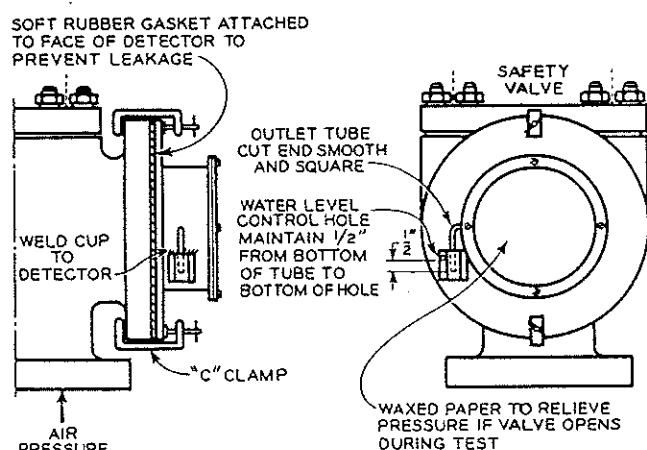
Safety considerations dictate that the valve discharge nozzle be positioned to prevent exposure of personnel to a sudden blast of air, water, or projectiles from within the valve. Ear protection may also be required for personnel working in the test area.

16.7.2.2 Testing with Air

Most test blocks are designed to test pressure-relief valves with air because it is a safe and readily available medium. Air is compressible and causes reaction-type valves to relieve with a short pop action and closely approximates operating conditions for pressure-relief valves in hydrocarbon

or other gas services. The air test is generally used to test safety, relief, and safety relief valves for set pressure and valve tightness.

The arrangement to detect leakage during the air test depends upon the construction of the valve. Blinding 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 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 37



NOTES:

1. When using this detector, all other valve outlets must be closed.
2. Test for leakage at 90 percent set pressure.
3. Count bubbles after they appear at uniform rate.

Figure 37—Safety-Valve and Relief-Valve Leak Detector

shows the standard equipment used in ANSI/API Standard 527 for determining leakage rates. Leaks can also be detected with ultrasonic equipment.

16.7.2.3 Testing with Water

Test blocks may be designed to include facilities for testing relief valves with a liquid test medium such as water, which is safe, inexpensive, and may closely simulate operating conditions. This test is usually limited to measuring the set pressure because very small water leakage is not readily detected. Leakage or tightness tests are usually made with air, as discussed in 16.7.2.2.

16.7.2.4 Description of Test Block

The test block, which may be defined as the assembled equipment required to give set pressure and tightness tests to pressure-relief valves, 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 38 shows the essential elements of a test block using air as the testing medium and instructions for its use. Hydraulic systems may also be used for testing relief valves where air pressure is unavailable.

The air system 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, pressure gages, piping, and the necessary instrumentation and valves to control the tests. Small installations with hand-operated pumps are also available.

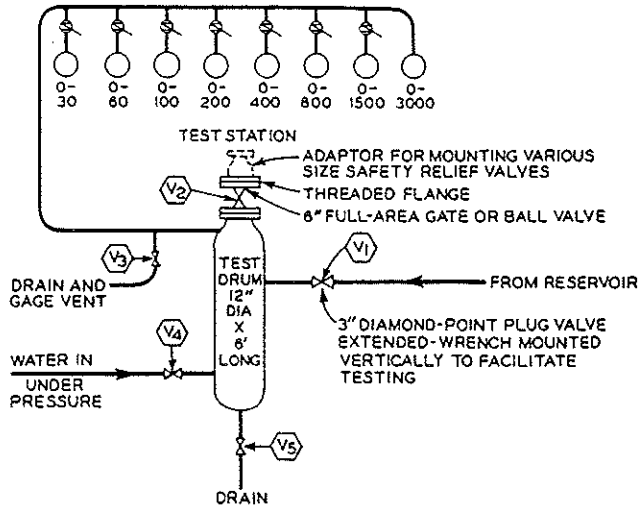
The hydraulic system usually includes a positive-displacement pump that will develop high pressures with a reasonable flow of water and suitable piping and valves to control the tests. Usually, a common manifold is used for both the air and water systems. The range of various flange sizes of a manifold allow it to be used for testing many different valves. Similarly, several calibrated precision pressure gages are connected to the manifold to accurately cover the wide range of pressures usually required to test pressure-relief valves in a refinery.

16.7.3 TOOLS AND REPAIR PARTS

16.7.3.1 Tools Required

In addition to the test block and bubble-test facilities previously discussed, the following tools required for testing and repairing pressure-relief valves will be found in a well-equipped machine shop:

1. Wrenches.
2. Manufacturers' special tools.



Construction

1. This layout uses the available air supply to the highest pressure possible. Then, if required, the pressure can be raised higher by inserting water 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

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 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 V2 valve.
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 under pressure until safety relief valve pops. 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 pops at the required set pressure.
8. Vent the test drum to 90 percent of the set pressure.
9. Test safety relief valve for leakage.
10. After satisfactory test, close V2 valve.
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 percent of set pressure of the next valve to be tested. Repeat operations 4 through 11.
13. If another valve is not to be tested immediately, leave test station as specified in operation 1.

Figure 38—Typical Safety-Valve and Relief-Valve Test Block Using Air as the Test Medium

3. Quick-coupling devices for connecting the valves to the test block.
4. Lapping and grinding equipment.
5. Nozzle and seat wrenches.
6. Lapping compounds.
7. Complete set of seat gages.
8. Calibrated precision test gages.
9. Calibrating equipment for the pressure gages.
10. Manufacturers' catalogs and maintenance procedures.

16.7.3.2 Repair Parts

Sufficient repair parts should be kept on hand or made readily available to repair all valves in service. Repair parts lists should be determined from past experience with valve performance, manufacturers' recommendations, and possibly contractors' recommendations regarding a spare parts inventory. A typical repair parts inventory should include:

1. Springs.

2. Gaskets.
3. Disks.
4. Nozzles.
5. Bolts.
6. Bellows.
7. Frangible disks.
8. Nonmetallic diaphragms.
9. Complete relief valves of most commonly used sizes.
10. Pilot kits.
11. O-rings.

Repair parts should also be identified correctly and properly protected against damage from rough handling or corrosion.

16.8 Inspection and Test Procedures

16.8.1 INSPECTION OF PRESSURE-RELIEF VALVES BEFORE REMOVAL TO THE SHOP

16.8.1.1 Inspection for Obstructions or Deposits in Valve

A visual inspection of pressure-relief valves should be made when the valves are first removed from the system. Many types of deposits or corrosion products may be loose and may drop out from the pressure-relief valve during transportation to the shop. Figure 39 shows sulfur deposits in a valve. When fouling is a frequent problem, it may be desirable to collect samples for further testing and to make notes regarding deposit location and appearance. Any obstructions in the valve should be noted and corrected.

Valves that might contain pyrophoric materials should be kept wet to prevent ignition. Valves in hydrofluoric acid and other similar service must be neutralized immediately after removal.

16.8.1.2 Inspection of Inlet and Outlet Piping

When a pressure-relief valve is removed from service, the upstream and downstream piping is often open and available for inspection. However, where it is the practice to remove relief devices from equipment during operation by closing block valves, it is usually not possible to make an inspection of this pipe. Such inspection should be made when the operating equipment is out of service.

Inspection of the piping at the pressure-relief valve will often indicate the condition of other process piping that is unavailable for inspection. Piping should be checked for corrosion, indications of thinning, and deposits that could interfere with valve operation. The character of the deposits may supply clues regarding any leakage from the pressure-relief valve in a closed system. Figures 29 through 33 and Figure 39 show examples of fouling deposits in pressure-relief valves.

16.8.1.3 Handling Precautions

After the pressure-relief valve is removed from the installation, it should be transported to the shop for inspection, testing, maintenance, and resetting. Careful handling in transit is important since rough handling can change the pressure setting or deform the pressure-relief valve parts so they cannot be set properly. Flanges on the piping and flange faces on the valve should be protected so that gasket faces are not damaged. Large valves should be handled with suitable rigging equipment to prevent them from being dropped or roughly handled. Relief devices should not be stocked in a careless manner. Where practical, they should be segregated and stored away from heavy pipe fittings or other types of valves. Pressure-relief valves should be treated as delicate instruments because their accurate functioning is very important to safe plant operation.

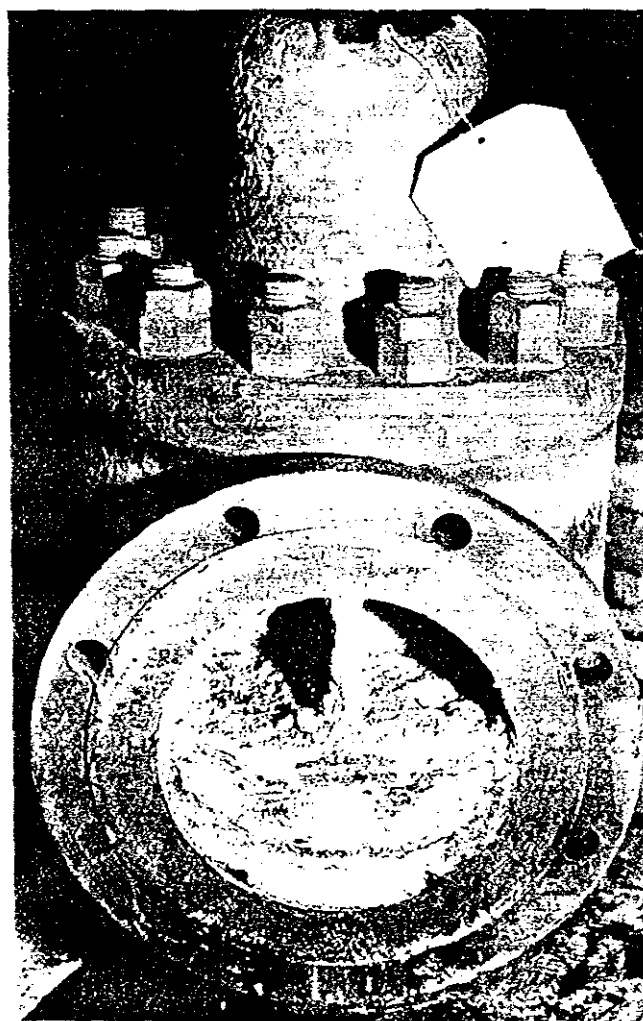


Figure 39—Sulfur Deposits in Body of Valve on Way to Repair Shop

16.8.2 INSPECTION OF PRESSURE-RELIEF VALVES IN THE SHOP

16.8.2.1 Visual Inspection

When a valve is first received in the shop, it should be given a visual inspection to note its condition when removed from service. Caution should be exercised during the inspection if the pressure-relief valve is from equipment handling hazardous materials. The results of this inspection should be noted on appropriate forms.

Points that should be checked during dismantling include:

1. Condition of flanges, including evidence of pitting, roughening, and decrease in width of seating surface.
2. Springs, for evidence of corrosion or cracking and for correctness at the valve's operation pressure and temperature.
3. Bellows, if the valve is of the bellows type.
4. Position of the set screws and openings in the bonnet.
5. Inlet and outlet nozzles, for evidence of deposits of foreign material and for corrosion.
6. Condition of the external surfaces, for any indication of a corrosive atmosphere or evidence of mechanical damage.
7. Body wall thickness.
8. Valve components and materials, to check against identification tag and specification card.
9. Pilots and associated parts.

16.8.2.2 Determining As-Received Relieving Pressure

Before the valve is dismantled, it is generally considered important to determine the pop pressure of the valve when removed from service. Although procedures for determining relieving pressures vary with local plant practices, this test is generally done by mounting the pressure-relief valve on the test block and slowly increasing the pressure on the valve. The operator determines relieving pressure by watching a pressure gage and noting the point at which the valve pops or relieves.

If the valve opens at the set pressure, no further testing to determine the as-received relieving pressure is needed. If the initial pop is higher than the set pressure, it is advisable to test a second time. If the valve then pops at approximately the set pressure, this indicates that the valve was probably stuck because of deposits. If the valve does not pop near the set pressure, this indicates that the valve setting was either in error originally or may have been changed during operation. A low initial pop indicates that the spring has either become weakened or that the setting was changed during operation.

The "as-is" test pressure should be recorded for review and facilitation of any necessary corrective action.

16.8.2.3 Dismantling of Valve

After the valve is received and checked, it is then ready for thorough shop inspection and repair. The valve should be carefully dismantled in accordance with the manufacturer's manuals and recommendations. Valves in light hydrocarbon service should be cleaned thoroughly before dismantling to avoid the possibility of a flash as a result of sparks created by the dismantling operations. This can be accomplished by using the solution recommended by chemical cleaning agencies. Proper facilities should be available for segregating 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-type valves should be checked for cracks or other failures that may affect performance (see Figure 22).

16.8.2.4 Cleaning and Checking of Parts

The valve parts should be properly marked and segregated to keep the parts of each valve separate. At this point, the valve parts should be cleaned thoroughly and inspected.

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 or wire brushing or should be carefully scraped.

The dismantled parts should be checked carefully at this time for wear and corrosion. Seating surfaces on the disk and nozzle should be inspected for roughness or damage (see Figures 25 and 26), which might result in valve leakage. They should also be checked with applicable seat gages. Seat flatness can be checked with suitable lap rings recommended by the manufacturer or by optical flats or other suitable inspection devices. If equipment is available, the spring force should be checked. The springs should also be checked for evidence of 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 warpage. Bellows should be checked for leaks, cracks, or thin spots that may develop into leaks. In addition, if the bellows is found collapsed, this is usually an indication of back pressure in excess of the design of the bellows. High back pressure can be a result of downstream flare piping restrictions created by deposits, or it may indicate higher relief flows than used in the original design. The cause should be found and corrective action taken.

Checking of the valve components is important. It should be done carefully with the proper equipment for measuring valve dimensions and with frequent reference to the proper drawings and literature.

16.8.2.5 Reconditioning and Replacing of Parts as Required

Parts that are worn or damaged should be replaced or reconditioned. Damaged springs or damaged bellows should be replaced. Replacement parts may be obtained from the manufacturer of the particular pressure-relief valve.

The seating surfaces of the disk and nozzle may be machined (see Figure 19) or lapped if evidence of wear or damage is found. Reference should be made to the manufacturer's recommendations for lapping seats.

The valve body and bonnet may be reconditioned by means considered suitable for repairs to other pressure-containing parts of similar material.

16.8.2.6 Reassembly of Valve

After the valve has been inspected and reconditioned, it should be reassembled in accordance with the manufacturer's instructions. Clearances between assembled parts should be checked. The spring adjustment should be made, in accordance with the manufacturer's instructions, as close as possible to the desired set pressure. The adjustment for blowdown should also be made at this time. Because the actual blowdown usually cannot be measured on a test block, past performance should be evaluated and any necessary adjustment should be made. Blowdown rings should be set carefully and accurately in accordance with the manufacturer's recommendations for both vapor and liquid services.

16.8.2.7 Setting of Valve to Required Pop Pressure

After the valve has been reconditioned and reassembled, it is ready for a final spring adjustment to ensure the required pop pressure. Again, test procedures will vary with local plant practice, but generally the valve is mounted on the test block and air pressure increased slowly until the valve pops. The manufacturer's recommendations should be used as a guide in adjusting 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. It may be necessary to provide a different spring.

After the final adjustment is made, the valve should be popped at least once to prove the accuracy of the setting. The final pop should be within $\pm 1/2$ percent of the required cold set pressure before the valve is approved for service. Allowance for hot setting should be made in accordance with the manufacturer's data.

When testing is done with water, the pressure should be raised slowly to the required setting. The discharge should be observed for evidence of leakage, or the test gage should be observed for a momentary drop in pressure. The pressure

at which the valve releases should be within $\pm 1/2$ percent of the specified set pressure before the valve is approved for service.

16.8.2.8 Checking of Valve for Tightness

After the valve is satisfactorily checked for set pressure, it is then desirable to check the valve for leakage. It is important to minimize leakage from pressure-relief valves because excessive leakage could be hazardous to personnel and equipment, in addition to leading to fouled and inoperable valves and serious product loss.

The valve can be tested for tightness on the test block by increasing the pressure on the valve to 90 percent of the set pressure and observing the discharge side of the valve for evidence of leakage. Methods of determining leakage are covered in 16.7.2.2 and in Figure 37.

16.8.2.9 Completion of Necessary Records

All necessary records should be completed before the valve goes back into service. The records are important for effective future use of the valve. They will provide some guidance as to when to retire valves and replace components as well as providing the historical record of the conditions and services under which the valve operated.

16.8.3 INSPECTION OF PRESSURE-RELIEF VALVES ON EQUIPMENT

16.8.3.1 Process Units

It is generally more economical and more effective to send valves to the shop for inspection and testing at the required intervals. However, when valves are operating in clean, low-temperature, and low-pressure services, experience may indicate that inspection on the equipment is a safe and suitable practice. When the block valve ahead of the relief device holds tight, as verified by checking a bleeder between the two, the bonnet of the pressure-relief valve may be removed for inspection and repairs. When sizable repairs are indicated, the valve should be sent to the shop.

Testing the valve for set pressure and leakage may be accomplished with an inert gas-testing medium through the bleeder. Admittedly, this testing procedure is inferior to the test block procedure discussed in 16.7.2, but it may be applicable in some services.

Reverse-buckling rupture disks may be used for onstream testing of pressure-relief valves to facilitate testing and allow more frequent testing. For such testing, the section between the rupture disk and the pressure-relief valve is generally pressured with an inert gas testing medium. Since visual inspection and testing is not carried out in the shop when using this procedure, the rupture disk must be inspected and replaced on a regular basis.

16.8.3.2 Storage Tanks

The relieving devices on tanks may be separated into equipment for pressure and vacuum relief on atmospheric tanks and pressure-relief valves on pressure storage vessels. These devices are usually inspected while the equipment is in service.

Pressure and vacuum vents 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. These devices are usually weight-loaded.

Inspection in place should include checking discharge openings for obstructions. The top 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 there is a flame arrestor on the inlet nozzle, it should be inspected for evidence of excessive fouling or plugging. If necessary, the element should be removed for cleaning. Inspection of this item in service is important because any malfunction may result in the loss of expensive equipment. Because the pressure and vacuum vents are in continuous service, they are prone to failure by sticking unless examined periodically. Icing may occur in northern climates.

Inspection of relieving devices for pressure storage tanks is similar in procedure to the inspection of pressure-relief valves for use on process equipment, as described in previous paragraphs.

16.8.3.3 Boilers

Although steam safety valves on steam boilers are similar in construction and operation to relieving devices on process equipment, they are often designed and installed in accordance with local regulations and power codes. Inspection of these devices should be in accordance with local regulatory requirements as well as manufacturers' recommendations and company practice.

Because Section I of the ASME *Boiler and Pressure Vessel Code* does not permit block valves under boiler safety valves, testing on the equipment must be done by periodically raising the steam pressure to pop the valves. Precision-calibrated pressure gages should be used during the test procedure. The accumulation and blowdown should also be noted. The code also requires that boiler safety valves have a substantial lifting device by which the valve disk may be lifted from its seat when there is at least 75-percent full working pressure on the boiler. This permits checking to ensure that moving parts are free to operate.

16.8.4 INSPECTION OF PILOT-OPERATED SAFETY RELIEF VALVES

There are many types of valves that operate with pilots, but the basic principle involves the use of some mechanism,

separate from the main relief valve and actuated by pressure in the system, to open the valve to full capacity. Pilots are usually smaller spring-loaded pressure valves that act to unload pressure above the main valve diaphragm. Separate air or electrically operated pilots are not considered sufficiently reliable to be used as pressure-relieving devices.

Inspection of pilot-operated valves may be divided into two separate phases: the pilot mechanism and the main valve. On some types of valves, the pilot can be blocked off from the vessel for inspection and testing while the spring-loaded main valve continues to protect the vessel (see Figure 7). The diaphragms in both the pilot and the main valves of some designs can be inspected and replaced, if necessary, with the main valve in service. Manufacturers frequently recommend semiannual inspection of these diaphragms and other components. If there is no block valve under the main valve, inspection and repairs can be made only with the vessel out of service. Because of the many types of pilot-operated valves available, the manufacturer's recommendations for inspection and repairs should be consulted and followed carefully.

16.8.5 INSPECTION OF RUPTURE DISKS

Rupture disks are used in services where a large relieving capacity is required to give a rapid drop in pressure. The disks are made from a wide variety of material, both metallic and nonmetallic. Rupture disks may be inspected visually. Inspection should include a check of flanges for leakage and the disk for evidence of fatigue, corrosion, or failure. Disks should also be checked for buildup of coke or other foreign material that could adversely affect the performance of the disk.

Disks for which manufacturers specify a limited bolting torque procedure should not be reused after removal for visual inspection. Once the bolting has been loosened, it is unlikely the disk can be reseated in the exact previously installed position and condition.

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, this valve should be locked open during operation. If replacement of the disk is necessary, it should be locked closed until disk installation has been accomplished.

Rupture disks are also used to protect other pressure-relieving devices from corrosion. When used for this purpose, rupture disks cannot be inspected without removing the valve. Therefore, inspection of the disk should be part of the routine developed for inspection of the pressure-relief valve. Rupture disks in these services are usually set to fail at some pressure less than the set pressure of the pressure-relief valve. In this case, the space between the rupture disk

and relief valve should be vented *safely* to avoid a pressure buildup resulting from a pinhole or small leak in the disk. (Refer to Section VIII of the ASME *Boiler and Pressure Vessel Code* for venting requirements.)

16.9 Records and Reports

A suitable system of keeping records and making reports is essential for 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.

16.9.1 OBJECTIVE

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

16.9.2 NEED FOR KEEPING RECORDS

A complete permanent record should be kept for each pressure-relieving device in service. The record should provide specification data for the device and a history of inspection and test results.

The specification record is needed to provide basic information to evaluate the adequacy of the device for a given installation, to determine its adequacy for a contemplated change in operating conditions, and to furnish correct dimensional and material information to minimize shop errors and expedite repairs. It provides design information necessary to facilitate purchase of a similar device or for the assembly of an identical device from an inventory of spare parts. This allows a pressure-relieving device to be assembled, tested, and exchanged with an identical device on the unit to accomplish a scheduled inspection with minimum unprotected time for the equipment.

Historical records showing dates and results of inspections of pressure-relieving devices are necessary for the follow-up or control phase of the program. They enable periodic reviews to be made to determine adherence to the established test intervals. They also provide performance data that can be evaluated to determine the suitability of the device for the particular service. This data could indicate problems in design, materials, or even misapplication of the device. Probably one of the most important reasons for keeping service records is that they provide a practical and realistic basis for establishing and keeping safe and economical inspection intervals up to date.

16.9.3 RESPONSIBILITIES

The duty and responsibility for the various facets of an inspection and testing program of pressure-relieving devices must be clearly defined to avoid confusion and must be expressly assigned to assure compliance. Some companies have assigned this task to equipment inspectors. Others have process-unit operators follow up on a previously established program and proceed under the guidance of engineering or inspection groups.

Although it is not the intention of this section to suggest specific individual responsibilities, the following outline of duties is listed primarily for the purpose of understanding the sample record and report forms provided in the appendixes. These duties might be typical for a large process industry.

The specific responsibilities of engineering personnel might include an assignment to:

1. Furnish specifications.
2. Determine allowable pressure settings.
3. Specify test intervals.
4. Record service data.
5. Prepare monthly lists of devices due for inspections.
6. Review performance data and furnish engineering services.

The specific responsibilities of process-unit operators might include an assignment to:

1. Initiate work requests.
2. See that devices are reinstalled in their proper location.
3. Prepare in-service reports.

The specific responsibilities of craftsmen might include an assignment to:

1. Perform mechanical work required to repair, test, and reinstall the devices and attach identification tags.
2. Maintain a duplicate set of specification records to facilitate repairs.
3. Furnish test reports.

16.9.4 SAMPLE RECORD AND REPORT SYSTEM

The precise recording and reporting format is a matter of individual choice. Appendix A is a typical permanent card-form record showing the specification for a pressure-relief valve. The card form provides convenience in handling, filing, and reviewing. This record includes the basic information needed to properly repair or replace the valve. Appendix B is a permanent card-form service record showing the dates and results of periodic inspections and tests. The information shown forms a basis for determining test intervals and design changes.

In the record and report system being reviewed, the engineering inspection group maintains the records and each month informs the process group of the due date for inspecting pressure-relief valves. A form report, such as that shown in Appendix C, is a simple and effective means for initiating work. Its return serves as a follow-up that action has been taken. Such forms could list all the valves at a given unit, thus preventing oversights and at the same time minimizing clerical work. (With the availability of computers, much of the report writing, record keeping, and inspection scheduling can be handled by a properly programmed system). Because the process group must coordinate the removal of a pressure-relief valve with operations, it is proper that they prepare the work order.

When the valve is sent to the shop for inspection, it is tested in the as-received condition. A report showing the

results of this inspection and test is sent to the engineering department (see Appendix D).

Pertinent information from this report is transferred to the permanent history record. When a pressure-relief valve has been assembled from an inventory of spare parts, a test report is prepared showing this fact as well as other basic information on the form. This report will be followed within a few days by an as-received test report of the valve being replaced.

After a pressure-relief valve has been returned to the process unit and installed, an in-service report, as shown in Appendix E, is prepared by the process group. This report is sent to the engineering department and certifies that the valve has been reinstalled in its proper location. In addition to being an independent check on earlier steps, this report serves as the final closeout on the job.

APPENDIX A

SPECIFICATION RECORD

Make _____	Style _____	Remarks _____
Body and bonnet material _____		_____
Nozzle and disk material _____		_____
Trim material _____		_____
<i>Spring Material</i>	<i>Spring No.</i>	
Carbon steel _____	_____	_____
Alloy _____	_____	_____
Inlet _____	Outlet _____	_____
Flange size	Flange size	
Orifice _____	Back pressure _____	_____
Spring set pressure _____		_____
Relieving Pressure _____		_____
Normal operating temperature _____		Maintenance engineer's phone _____
No. _____	Unit _____	Location _____
_____	_____	_____

Date Tested	Popped	Reset	Disposition	Condition	Repairs	Remarks
No.	Unit		Location		Set	Test Interval

APPENDIX C

DUE LIST FOR PRESSURE-RELIEVING DEVICES

To _____
Unit _____

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" column by "X." Please prepare a work request to cover the inspection and repair to the devices indicated, and return this sheet to the engineering department by _____

Due	Location No.	Location Description	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 pumpout	
	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 _____

APPENDIX D

TEST REPORT FOR SAFETY-RELIEVING DEVICES

Fill in this report for each device tested and send to the engineering department.

Date tested: _____	Type: _____
Device no.: _____	Make _____
Unit: _____	Style _____
Location: _____	Material: _____
Size: _____	Special Material: _____
Inlet _____	Body _____
Orifice _____	Trim _____
Outlet _____	

From unit (fill in one side only)

Date last tested: _____
Popped at: _____
Set pressure: _____
Check pressure: _____

New set pressure,

If changed: _____

Test Used:

Standard _____
Dry Seal _____

Disposition:

To Unit _____
To Spare _____
To Junk _____

Condition: Leaking _____
Stuck _____
Fouled _____
Corroded _____

Tested by: _____

From Spare Stock (fill in one side only)

Set pressure: _____
Check pressure: _____

APPENDIX E
IN-SERVICE REPORT FOR SAFETY DEVICES

Safety Device No. _____ Unit: _____
Date Tested: _____ Location: _____
Date Installed: _____

Insert completed form in special envelope and return to engineering department.

