PRESSURE RELIEF DEVICES

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1.0 SCOPE

This data sheet provides recommendations for overpressure protection of boilers, pressure vessels, piping systems and vented vessels not specifically addressed in other FM Global loss prevention data sheets.

For pressure vessels where a chemical reaction is conducted or could unintentionally occur such that pressure could be developed by an uncontrolled reaction, refer to Data Sheet 7-49, *Emergency Venting of Vessels.*

1.1 Changes

October 2013. Section 1.0 was expanded to include a specific resource for a common application of pressure relief devices.

1.2 Superseded Information

The May 2003 edition of this data sheet is superceded.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Equipment and Processes

2.1.1 Provide direct spring-loaded reclosing overpressure protection devices for steam power boilers. These devices are generally known as safety valves and are characterized by a “pop action.” Provide direct spring-loaded reclosing safety relief valves for high-temperature water boilers. Safety and safety relief valves are sealed by the agency certifying the set pressure and capacity of the valve. Use safety and safety relief valves as described in Section I, Rules for the Construction of Power Boilers, ASME Boiler and Pressure Vessel Code. Direct spring-loaded safety and safety relief valves conforming to other recognized codes are also acceptable. Do not use dead-weighted or weighted-lever valves.

2.1.2 Protect all steam heating, hot water heating, and hot water supply systems from overpressure and excessively high temperature with direct spring-loaded safety, safety relief, or temperature and pressure safety relief valves as appropriate for the medium (vapor or liquid) and service (steam heating, hot water heating, or hot water supply). Safety, safety relief, and temperature and pressure safety relief valves are sealed by the agency certifying the set pressure and capacity of the valve. Safety, safety relief, and temperature and pressure safety relief valves acceptable to FM Global are described in Section IV, Rules for Construction of Heating Boilers, ASME Boiler and Pressure Vessel Code. Direct spring-loaded safety, safety relief, and temperature and pressure safety relief valves conforming to other recognized codes are also acceptable. Dead-weighted and weighted-lever valves are not acceptable. Valve installation examples are shown in Figures 1 through 5.

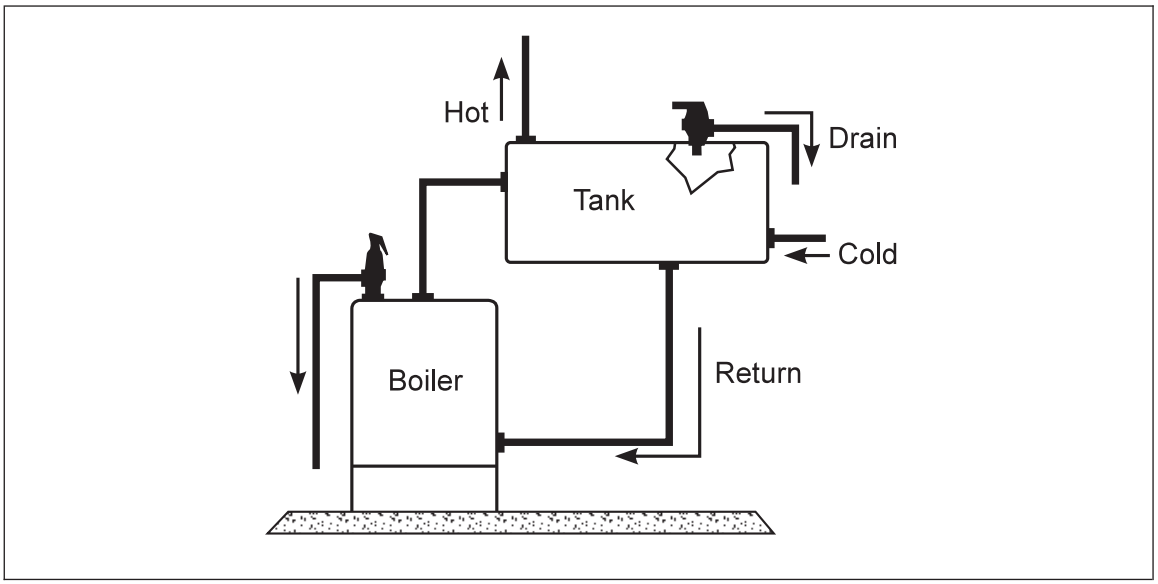

Fig. 1. Hot water supply system with both safety relief valve (on boiler) and temperature relief valve (on tank)

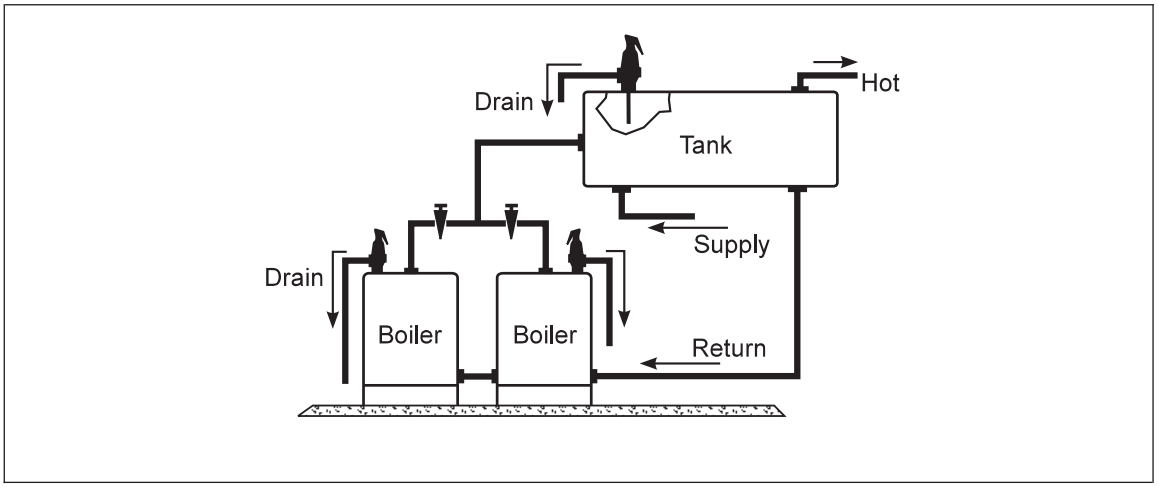

Fig. 2. Multi-boiler hot water supply system with a pressure relief valve on each boiler and a pressure-temperature relief valve on tank

2.1.3 Provide overpressure protection for pressure vessels and piping systems. Use direct-acting spring loaded safety, safety relief, relief, or pilot-operated relief valves (reclosing devices) or rupture disks, breaking-pin devices, buckling-pin devices or spring-loaded non-reclosing pressure relief devices as described in Section VIII, Divisions 1, 2, and 3, Rules for Construction of Pressure Vessels, ASME Boiler and Pressure Vessel Code. Safety, safety relief, relief, and pilot-operated relief valves are sealed by the agency certifying the set pressure and capacity of the valve. Similar devices conforming to other recognized codes are also acceptable. Do not use dead-weighted or weighted-lever valves. Provide vacuum relief protection for vessels not designed for full vacuum if the vessels may be subjected to vacuum.

2.1.4 Provide overpressure protection on all reduced-pressure systems. Use direct-acting spring-loaded safety, safety relief, relief, or pilot-operated relief valves (reclosing devices) or rupture disks, breaking-pin devices, buckling-pin devices, or spring-loaded nonreclosing pressure relief devices as described in Section VIII, Divisions 1, 2, and 3, Rules for Construction of Pressure Vessels, ASME Boiler and Pressure Vessel Code. Safety, safety relief, relief, and pilot operated relief valves are sealed by the agency certifying the set pressure and capacity of the valve. Similar devices conforming to other recognized codes are also acceptable. Do not use dead-weighted or weighted-lever valves.

An example of relief valves on the low-pressure side of a reduced-pressure system is shown in Figure 6.

Caution: Pressure reducing valves are frequently provided with a bypass, in some cases larger than the reducing valve inlet (Fig. 7). When this is the case, the required overpressure relieving capacity is based on the size of the bypass rather than the size of the reducing valve inlet.

2.1.5 Design and construction of acceptable direct-acting spring-loaded safety, safety relief, relief, and pilot operated relief valves:

FM Global has adopted and continues to endorse application of the ASME Boiler and Pressure Vessel Code. When there is no comparable boiler and pressure vessel code for a country or jurisdiction, provide overpressure protection meeting the intent of the ASME Boiler and Pressure Vessel Code.

2.1.6 For specific processes, such as vessels containing combustible mixtures, follow the overpressure protection recommendations in the data sheets listed in Section 4.0, References.

2.1.7 Provide a vent of sufficient size to prevent the buildup of any appreciable pressure within vessels (e.g., process tanks and silos) designed for atmospheric pressure only. For vessels not designed for full vacuum, provide a properly sized vent or vacuum breaker to prevent implosion or collapse.

2.1.7.1 Provide boiler blowoff tanks with vapor vent and water drain pipe sizes in accordance with *National Board Rules and Recommendations for the Design and Construction of Boiler Blowoff Systems, NB-27* or a similar accepted standard.

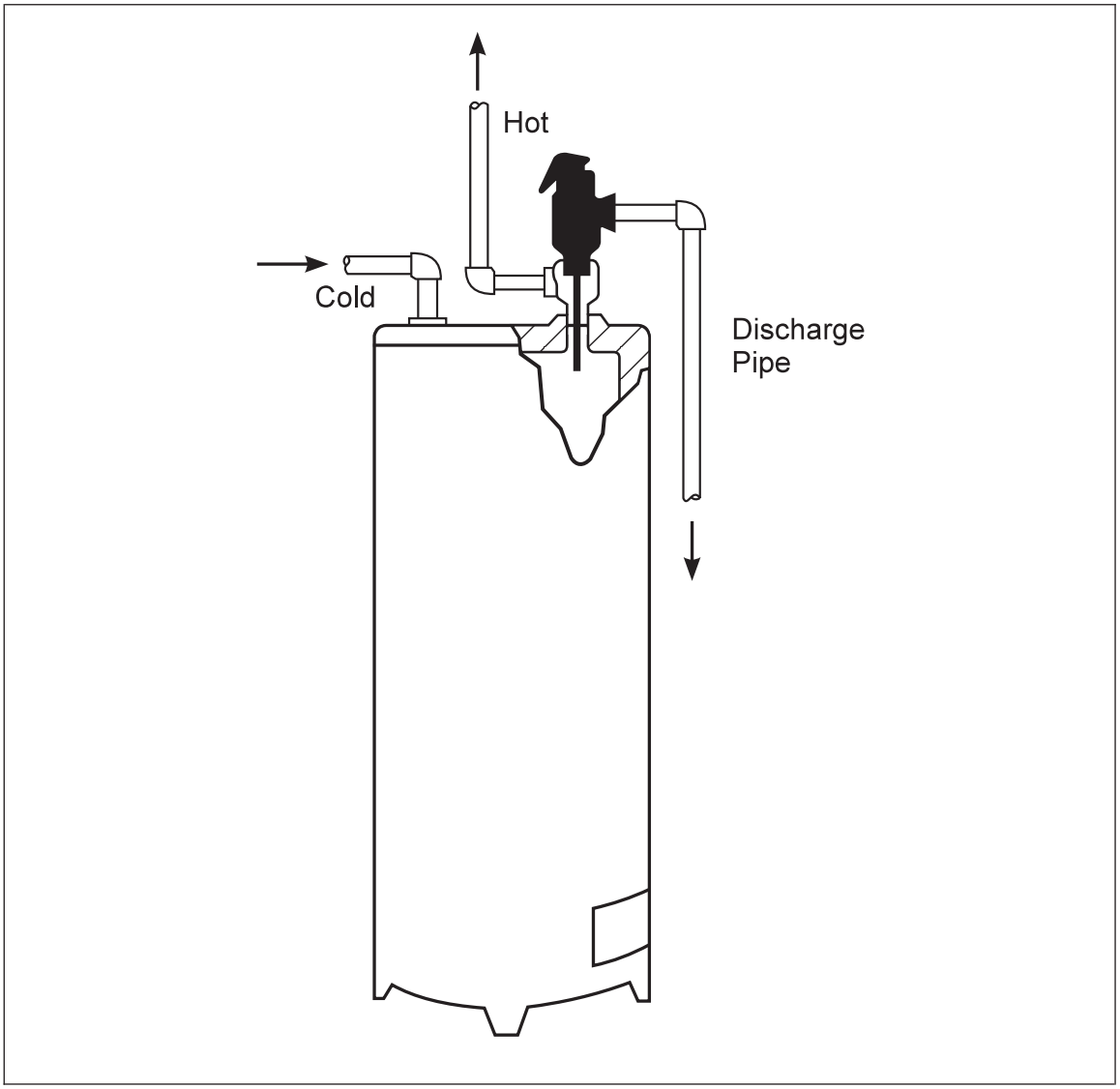

Fig. 3. Water heater relief valve protection for storage water heater

2.1.7.2 Provide condensate receivers with properly sized vents that are short, straight (no pockets to accumulate condensation), and of uniform or increasing pipe size (no restrictions between vent and atmosphere).

2.2 Operation and Maintenance

2.2.1 Maintain and operate overpressure protection devices as required by the code of construction (e.g., in North America, the ASME Code, Sections I, IV, VI, VII, and VIII, and as required by the National Board Inspection Code).

2.2.2 Permit only personnel properly trained in overpressure protection device maintenance to adjust the devices. All settings and repairs must be made by the manufacturer, manufacturer's representative, or firms having authorization and certification (e.g., in North America firms holding the VR stamp issued by the National Board) to perform repairs and reseal the device.

2.2.3 Connect power boiler safety valves to the boiler independently of any other connection, and attach them as closely as possible to the boiler, without any unnecessary intervening pipe or fitting. Always mount power boiler safety valves in a vertical position directly on nozzles having well-rounded approaches providing

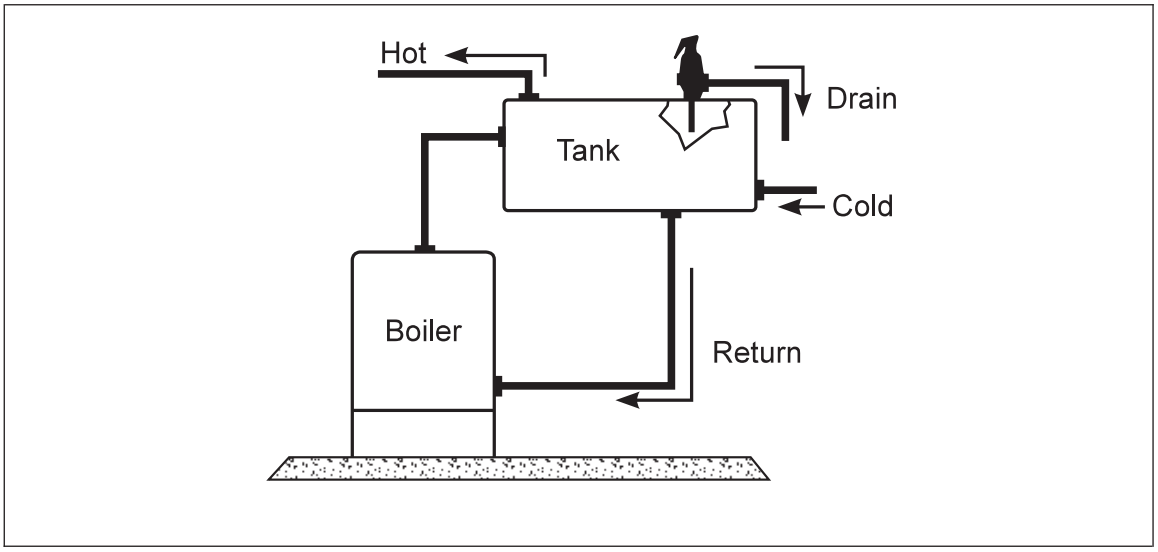

Fig. 4. Location of combination pressure- and temperature-actuated relief valve, with no stop valves between boiler and storage tank

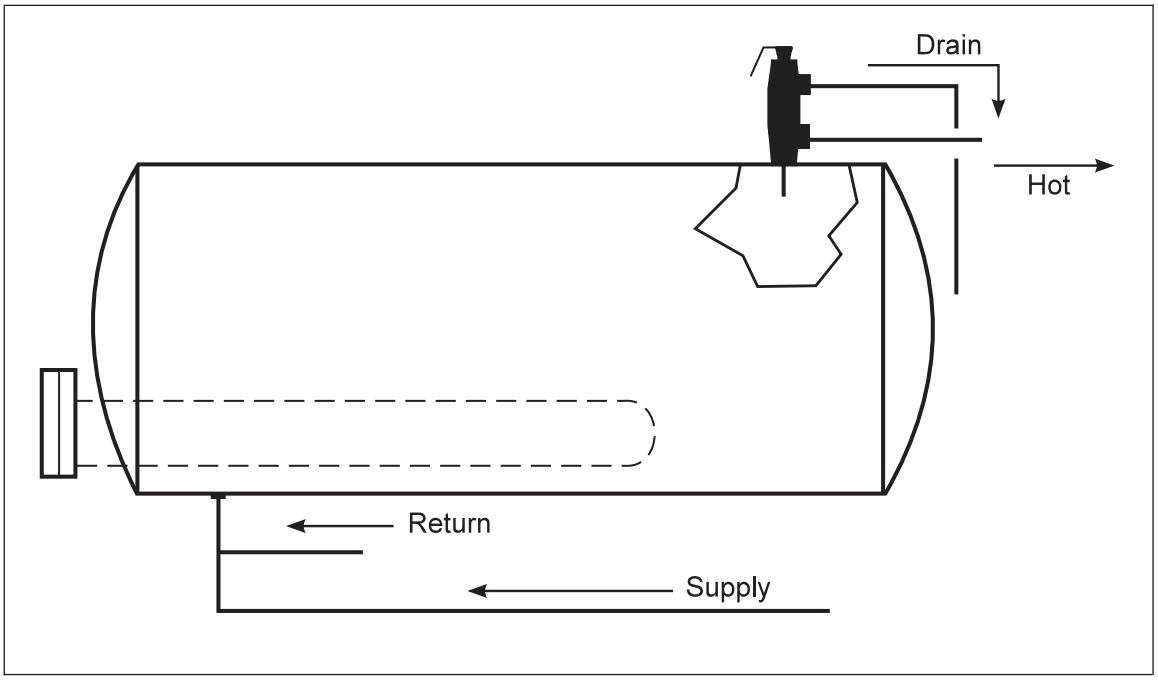

Fig. 5. Steam-coil-heated storage tank with pressure-temperature valve, maximum temperature 250°F (127°C) and maximum pressure 160 psi (1102 kPa)

smooth, unobstructed flow from the drum to the valve. Never install a power boiler safety valve on a fitting that has an inside diameter smaller than the inlet connection to the valve, since this will restrict the flow and cause faulty operation.

2.2.4 When unavoidable, use a riser (i.e., intervening pipe or fitting) as short as possible, and in no case longer than the face-to-face dimension of the corresponding tee fitting, of the same diameter and pressure rating under the applicable piping standard (e.g., American National Standard) to install a power boiler safety valve.

2.2.5 Properly clean connections before installing overpressure protective devices.

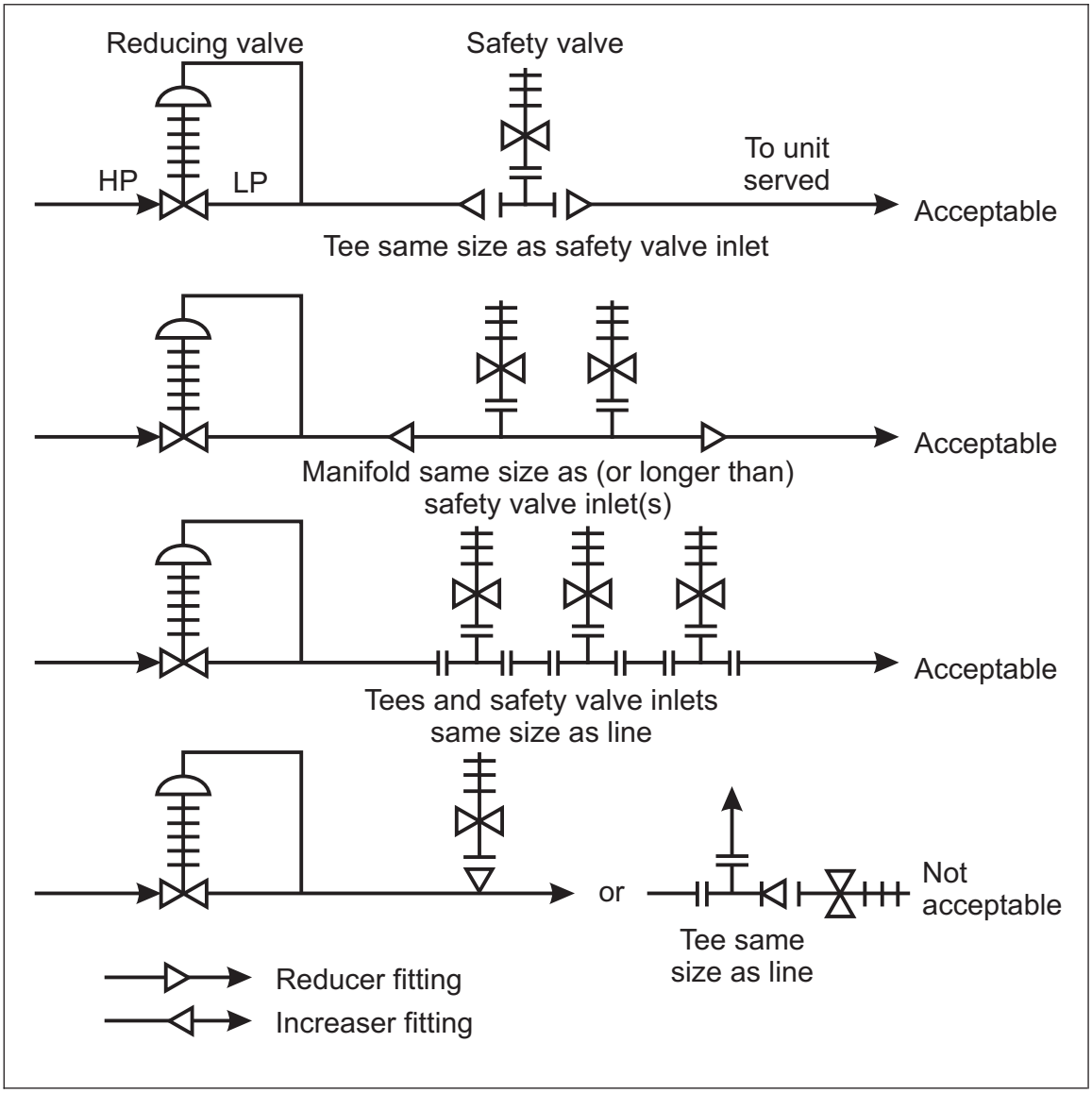

Fig. 6. Methods of installing safety valve(s) on low-pressure side of reducing valve. Note: Sum of discharge capacities equals (or exceeds) required capacity as determined by the National Board Inspection Code Sections A-403, and Table A-1, or the reducing valve rating.

2.2.6 Select overpressure protection device materials of construction appropriate for the fluids in the particular system to be protected and the installation environment.

2.2.7 When a combination rupture disk and reclosing relief device is provided, monitor or vent the piping between the rupture disk and the relief device.

2.2.8 Discharge or vent piping for overpressure protection devices must be of ample size to handle the expected relief flow. Individual lines from each device are preferred.

2.2.9 Ensure overpressure protection device discharge piping is as simple and direct as possible. The inside diameter of the discharge line must never be less than that of the valve outlet. Broken connections with generous clearance like those in Figure 8 are preferred. If fixed piping is necessary, a separate discharge line from each valve is preferable to the manifold type. If a manifold vent arrangement is used, size the manifold for at least the combined areas of all valves connected to it.

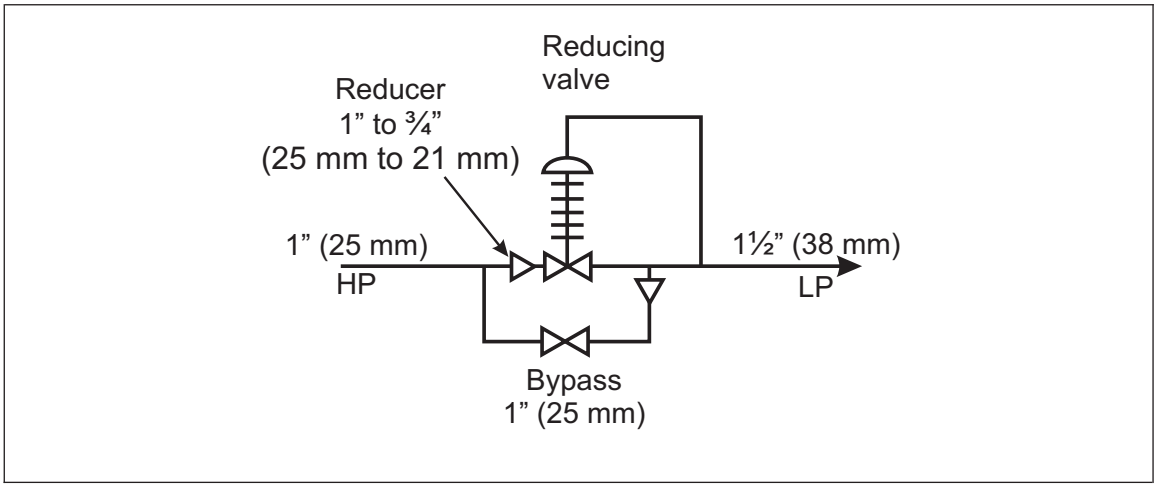

Fig. 7. Bypass larger than reducing valve inlet

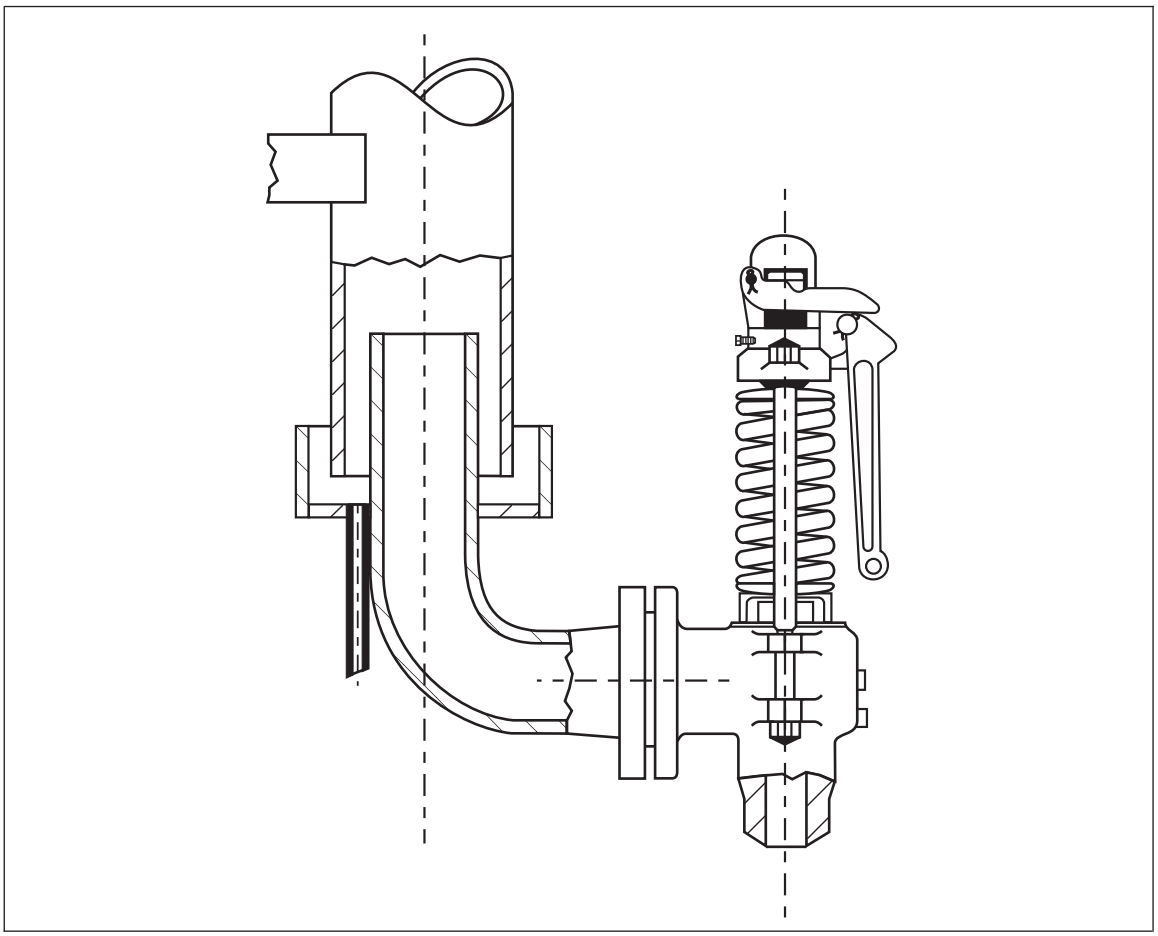

Fig. 8. Discharge pipes of safety valves are kept as short as possible and must be adequately braced

2.2.10 Remove plugs from drains in reclosing valve bodies and provide drain piping to an appropriate location.

2.2.11 Test all reclosing-type overpressure protection devices at the time of installation to ensure they operate. Reclosing valves are tested and carefully adjusted at the factory, but the valve may have been damaged during shipment or installation.

2.2.12 Avoid damaging reclosing devices when hydrostatic testing a boiler or pressure vessel by following the device manufacturer's recommendations on removing or applying a gag to the device. In either case, have a system in place to ensure the relief device is properly restored to operation upon completion of the testing. See Figure 9 for example of gag application.

2.2.13 Take every precaution while acid-cleaning a boiler or pressure vessel to protect the internal parts of safety, safety relief, or relief valves from damage. Remove the valves and use blanks during the cleaning operation, or use internal plugs. Whichever method is used, be sure the blanks or plugs have been removed, and the valves are in place and in operating condition before returning the boiler or pressure vessel to service.

2.2.14 Inspection and Testing of Safety, Safety Relief, and Relief Valves

For most boiler, pressure vessel, and piping applications, follow the guidance in RB-8000, *Inspection of Pressure Relief Devices*, 2004 National Board Inspection Code.

FM Global has adopted and continues to endorse application of the National Board Inspection Code. Recommended inspection and test frequencies are as follows:

- Power boilers, pressure less than 400 psi (3000 kPa) — Manual check every six months, pressure test to verify set pressure annually or as determined by operating experience and demonstrated by testing history.
- Power boilers, pressure 400 psi (3000 kPa) and greater — Pressure test every three years to verify set pressure or as determined by operating experience and demonstrated by testing history.
- High-temperature hot water boilers — Pressure test annually to verify set pressure (testing off the boiler is recommended for safety) or as determined by operating experience and demonstrated by testing history.
- Low-pressure steam heating boilers — Manual test quarterly, pressure test annually to verify set pressure.
- Hot water heating boilers — Manual test quarterly, pressure test annually to verify set pressure.
- Pressure vessels, steam service — Annual inspection or as determined by operating experience and demonstrated by testing history.
- Pressure vessels, air & clean dry gases — Three years or as determined by operating experience and demonstrated by testing history.
- Pressure vessels, propane & refrigerant — Five years or as determined by operating experience and demonstrated by testing history.

2.2.15 Maintain a differential between expected maximum operating pressure and overpressure protection device set pressure as recommended by the device manufacturer or the 2004 National Board Inspection Code, Appendix F.

2.2.16 Replace rupture disks on a regular basis. The frequency of replacement is governed by the disk manufacturer's recommendation, based on operating conditions such as amplitude and frequency of pressure cycling, operating temperature, and corrosive characteristics of contained material.

2.2.17 Periodically check traps on the return lines leading to vented condensate receivers to ensure the lines are in proper working order.

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3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Overpressure Protection Devices

The function of overpressure protection devices is to protect the boilers, pressure vessels and piping on which they are installed by opening and releasing pressure when the vessel or system reaches a predetermined pressure. These devices are not intended for pressure regulation. Their only function is to prevent pressure from exceeding the maximum allowable pressure when operating controls and pressure-limiting devices malfunction.

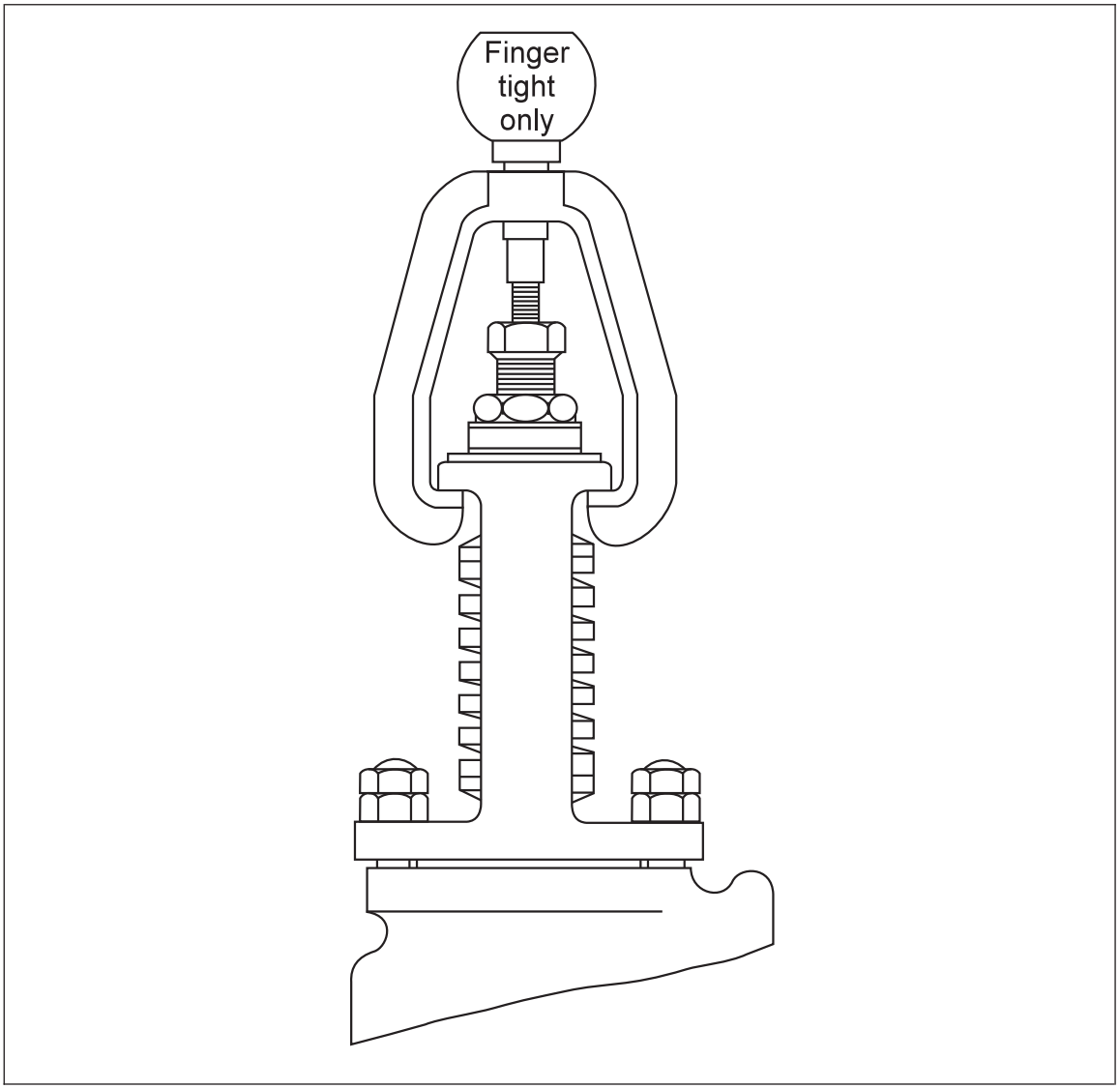

Fig. 9. Gag screw in position for hydrostatic test

3.1.1 Direct Spring-Loaded Reclosing-Type Devices

Direct spring-loaded reclosing devices (valves) are one of the most vital protection devices against overpressure explosion in boilers, vessels, and piping, and usually serve as the last line of defense. Still, disasters continue to occur because the valves have not been properly tested and maintained and therefore do not function.

3.1.2 Code Requirements

Many construction codes and some in-service inspection codes have requirements for overpressure protection device construction, installation, and maintenance. As an example, in North America, the ASME Boiler and Pressure Vessel Code is typically followed for new device construction, and the NBIC is followed for device repairs.

3.1.3 Hazards

Sticking or seizing corrosive attack on the seating surfaces due to water conditions. Seating surfaces of the valves may be affected by a particular chemical treatment of the water, which causes a thin adhesive film to form between the seating surfaces, resulting in a popping pressure higher than normal.

3.1.4 Installation

Construction standards, such as the ASME Boiler and Pressure Vessel Code, address location, mounting, quantity, operation, and relieving capacity of overpressure protection devices required on boilers and pressure vessels.

3.1.5 Recommended Maintenance Practices

The amount and type of maintenance required for overpressure protection devices depends on the size, type of construction, and application. Problems encountered with the devices often vitally affect their life, operation, and efficiency. The device manufacturer is the best resource for these practices.

3.1.6 Testing Frequencies

Periodic testing of overpressure protection devices of the reclosing type is necessary. They are expected to function properly. For boilers, the most positive test is to gradually increase boiler pressure until the valve opens.

The testing frequency will vary from facility to facility depending on operating conditions. In all cases, the testing interval must not exceed what is necessary to keep the valves in satisfactory condition based on operating experience. Valve testing requirements of jurisdictional regulatory bodies that are more stringent than recommendations in this data sheet take precedence.

3.1.7 Rupture Disks

Rupture disks, sometimes referred to as safety heads or rupture diaphragms, are membranes of metal, plastic, graphite, or other materials designed and tested to hold pressure up to a specified predictable point and then break to release that pressure. They are widely used for the protection of pressure vessels and systems, especially in the chemical and petroleum industries. Rupture disks range in size from about 3⁄16 in. (5 mm) to about 4 ft (1.25 m) in diameter and can be obtained with rupture-pressure ratings of a few ounces up to 100,000 psi (689,400 kPa).

3.1.8 Emergency Venting

Venting requirements for chemical reactions and unstable materials present complex problems. For recommendations in this area, refer to Data Sheet 7-49, *Emergency Venting of Vessels.*

3.1.9 Other Vented Vessels

There are many other types of vessels that are vented to atmosphere. Storage vessels under static head that are drained or pumped out must be protected by a vent of proper size or a vacuum breaker. Although the collapse of a vessel under vacuum or external pressure usually presents little damage other than to the vessel itself, the tank usually must be replaced or extensively repaired. In addition, serious interruption to facility production often occurs.

4.0 REFERENCES

4.1 FM Global

Data Sheet 1-25, *Process Tanks and Silos*
Data Sheet 3-2, *Water Tanks for Fire Protection*
Data Sheet 3-11, *Pressure Reducing Valves for Fire Protection Service*
Data Sheet 6-21, *Chemical Recovery Boilers*
Data Sheet 6-22, *Firetube Boilers*
Data Sheet 6-23, *Watertube Boilers*
Data Sheet 7-13, *Mechanical Refrigeration*
Data Sheet 7-46, *Chemical Reactors and Reactions*
Data Sheet 7-49, *Emergency Venting of Vessels*
Data Sheet 7-51, *Acetylene*
Data Sheet 7-52, *Oxygen*
Data Sheet 7-55, *Liquefied Petroleum Gas*
Data Sheet 7-84, *Hydrogen Peroxide*
Data Sheet 7-88, *Storage Tanks for Ignitable Liquids*

Data Sheet 7-92, *Ethylene Oxide*
Data Sheet 7-99, *Heat Transfer by Organic and Synthetic Fluids*
Data Sheet 12-3, *Continuous Digesters*
Data Sheet 12-6, *Batch Digesters.*
Data Sheet 12-53, *Absorption Refrigeration Systems*
Data Sheet 12-61, *Mechanical Refrigeration*

4.2 Other

American Society of Mechanical Engineers (ASME), 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300, www.asme.org

Boiler and Pressure Vessel (B&PV) Code —

Section I, Rules for Construction of Power Boilers
Section IV, Rules for Construction of Heating Boilers
Section VI, Recommended Rules for Care and Operation of Heating Boilers
Section VII, Recommended Guidelines for the Care of Power Boilers
Section VIII, Rules for the Construction of Pressure Vessels

Performance Test Codes —

PTC 25-2001 Pressure Relief Devices

The National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, OH 43229, www.nationalboard.org

NB-23, National Board Inspection Code (NBIC)
NB-27, A Guide for Boiler Blowoff Vessels

APPENDIX A GLOSSARY OF TERMS

Action, Popping or Pop: The action of a safety or safety relief valve when it opens under steam, gas pressure, or vapor pressure. The disk of the valve is designed so the force of the steam lifting the disk is increased when the disk is lifted slightly off its seat. The increase in force accelerates the rising action of the disk to the wide open position at or near the opening pressure. See definitions of safety valve and relief valve.

Blowdown (Blowback): The difference between the actual popping pressure of a pressure relief valve and the actual repeating pressure, expressed as a percentage of set pressure or in pressure units.

Boiler, High-Pressure: A boiler furnishing steam at a pressure in excess of 15 pounds per square inch (psi) (100 kPa), or hot water at a temperature in excess of 250°F (120°C) or at a pressure in excess of 160 psi (1,100 kPa).

Boiler, Low-Pressure Heating: See Boiler, Low-Pressure Hot-Water and Low-Pressure Steam.

Boiler, Low-Pressure Hot-Water and Low-Pressure Steam: A boiler furnishing hot water at pressures not exceeding 160 psi (1,100 kPa) or at temperatures not exceeding 250°F (120°C), or steam at pressure not exceeding 15 psi (100 kPa).

Boiler, Power: Same as Boiler, High-Pressure.

Breaking Pin: The load-carrying element of a breaking-pin device.

Device, Breaking-Pin: A non-reclosing pressure relief device actuated by inlet static pressure, and designed to function by the breakage of a load-carrying section of a pin which supports a pressure-containing member.

Device, Buckling-Pin: A non-reclosing pressure relief device actuated by inlet static pressure, and designed to function by the buckling of a load-carrying section of a pin that supports a pressure-containing member.

Device, Non-Reclosing Pressure Relief: A pressure relief device designed to remain open after operation. Generally refers to a rupture disk or breaking-pin device.

Device, Primary Pressure Relief: Devices required by Code and set to open below, at, or near the maximum allowable working pressure of a vessel.

Device, Rupture Disk: A non-reclosing pressure relief device actuated by inlet static pressure, and designed to function by the bursting of a pressure-containing disk.

Device, Secondary Pressure Relief: Devices not required by code. May be set above vessel MAWP to protect vessels and systems in case of unexpected, potentially hazardous pressures or may be set below MAWP to avoid operation of primary protection device.

Gag, Safety Valve: A clamp designed to prevent a safety valve from opening (lifting) when applying a hydrostatic pressure test at a higher pressure than the safety valve setting. See Figure 9.

Holder, Rupture Disk: The structure that encloses and clamps the rupture disk in position. The material of the rupture disk holder is a material permitted by the vessel construction code (in North America, Section II of the ASME B&PV Code).

Housing, Breaking Pin or Buckling Pin: The structure that encloses the breaking or buckling pin mechanism. The material of the housing is a material permitted by the vessel construction code (in North America, Section II of the ASME B&PV Code).

Rated, Officially: Pertains to a safety, safety relief, or relief valve that has been certified, by a recognized authority such as the National Board of Boiler and Pressure Vessel Inspectors, as having been tested and capacity rated by a testing facility accredited by a recognized authority, such as the ASME Boiler and Pressure Vessel Code Committee. Valves certified by the National Board are published in Safety Valve and Safety Relief Valve Relieving Capacities. This publication may be obtained from the National Board of Boiler and Pressure Vessel Inspectors, www.nationalboard.org.

Rupture Disk: The pressure-retaining and pressure-sensitive element of a rupture disk device.

Rupture Disk, Manufacturing Design Range of: A range of pressure within which the average burst pressure of test disks must fall in order to be acceptable for a particular requirement as agreed upon between the rupture disk manufacturer and the user or his agent.

Rupture Disk, Minimum Flow Area of: The calculated net area after a complete burst of the disk with appropriate allowance for any structural members that may reduce the net area through the rupture disk device.

Valve, Power-Actuated Relief: A pressure-relieving device whose movements to open or close are fully controlled by a source of power (electricity, air, steam, or hydraulic).

Valve, Pressure-Temperature Relief: An automatic relief device actuated by the static pressure upstream of the valve or by the temperature of the fluid. The maximum temperature setting is usually 210°F (100°C). It is used primarily for liquid service.

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

Valve, Safety: An automatic pressure relief device actuated by the static pressure upstream of the valve and characterized by full opening pop action. It is used for steam, gas, or vapor service.

Valve, Safety, Lift of: The movement of the disk off the seat of a safety, safety relief, or relief valve when the valve is opened. It normally refers to the amount of movement of the disk off the seat when the valve is discharging at rated capacity.

Valve, Safety Relief: An automatic pressure-actuated relief device that may be configured for use as either a safety valve (vapor) or relief valve (liquid), depending on application. A safety relief valve configured for vapor relief will not be suitable for liquid relief and the reverse.

For additional definitions refer to ASME PTC 25-2001, *Pressure Relief Devices.*

APPENDIX B DOCUMENT REVISION HISTORY

October 2013. The Scope was expanded to include a specific resource for a common application of pressure relief devices.

January 2007. Clarification was made to the recommendation 2.2.14.

February 2006. Recommendations and support material have been revised to clearly limit reclosing-type overpressure protection devices to direct spring-loaded valves that cannot be adjusted without breaking a seal.

May 2003. Test frequency for reclosing overpressure protection devices revised for consistency with current industry practice (2.2.15 and deletion of 2.2.16). Also deleted section ‘‘3.2 Illustrative Losses’’.

September 2000. The document was reorganized to provide a consistent format.

1998 — Reformatted

1983 — Original Draft