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Liquid applications for ASME Section I service

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Extensive guidance is available for relief protection of American Society of Mechanical Engineers (ASME) Boiler & Pressure Vessel Code (B&PVC) Section VIII process equipment for scores of applications, such as run-away reactions, distillation and heat exchangers. Sources include ASME, American Petroleum Institute (API) and the Design Institute for Emergency Relief Systems (DIERS), among others.

Vapor/steam relief protection from overpressure for fired boilers is covered thoroughly in ASME Section I. However, there is little-to-no guidance for sub-cooled or saturated/flashing liquid relief protection for ASME Section I fired boilers and associated equipment.

This article will discuss applications that require liquid or flashing liquid relief protection for ASME Section I equipment, along with applicable code references and relief equipment used for such protection. Applications discussed include economizers, low-quality steam generators and liquid overfill of steam drums.

National Board "Redbook." Relief equipment is certified for protection of ASME code equipment by the National Board of Boiler and Pressure Vessel Inspectors (National Board). The National Board certifies the device's operation and capacity follow the performance requirements defined by the construction code. All issued certifications are listed within the published NB-18 "Redbook"¹ listing the applicable ASME Code Section to which the device is certified. An example of a partial listing from NB-18 is shown in

FIG. 1.

Design Name:	6400/6600 (previously 2500 & 4600)	NBCert #	57046
Manufacturer/Assembler	Code Sections	Expiration Date	
Assembler	I, VIII Div. 1	05/26/2026	

Design Type

[Safety Valve] 6400/6600 (previously 2500 & 4600)
Capacity Tests: Sec. I, VIII Div. 1 at Ohio State University (Robinson Laboratory) on January 28, 1972
Method of Establishing Relieving Capacity: Flow Capacity, K
Certified Value: 0.858 Unitless
Media - Test: Steam; Certified: Air, Gas, Steam
Set Pressure Definition: Pop
Blowdown Characteristics: Adjustable (Dual Ring)
Designed by: Farris Engineering {TFO}

Inlet Size	Outlet Size	Flow Area	Orifice [designator] dia.	Lift	Set Pressure Range	Media	Code Section
1-1.5 NPS	2 - 3 NPS	0.15 in ²	[D] 0.437 in	0.109 in	15-2900 psi	Air	VIII Div. 1
1-1.5 NPS	2 - 3 NPS	0.15 in ²	[D] 0.437 in	0.109 in	15-2900 psi	Steam	I
1-1.5 NPS	2 - 3 NPS	0.15 in ²	[D] 0.437 in	0.109 in	15-2900 psi	Steam	VIII Div. 1
1-1.5 NPS	2 - 3 NPS	0.225 in ²	[E] 0.535 in	0.134 in	15-2900 psi	Air	VIII Div. 1
1-1.5 NPS	2 - 3 NPS	0.225 in ²	[E] 0.535 in	0.134 in	15-2900 psi	Steam	I
1-1.5 NPS	2 - 3 NPS	0.225 in ²	[E] 0.535 in	0.134 in	15-2900 psi	Steam	VIII Div. 1
1.5 NPS	2 - 3 NPS	0.371 in ²	[F] 0.687 in	0.172 in	15-2900 psi	Air	VIII Div. 1
1.5 NPS	2 - 3 NPS	0.371 in ²	[F] 0.687 in	0.172 in	15-2900 psi	Steam	I
1.5 NPS	2 - 3 NPS	0.371 in ²	[F] 0.687 in	0.172 in	15-2900 psi	Steam	VIII Div. 1

FIG. 1. A partial listing from NB-18 of the National Board of Boiler and Pressure Vessel Inspectors' "Redbook."¹

A device's listing details the manufacturer, model series, Code Section, NB capacity certification number, test media, certified discharge coefficient, and ASME flow area certified according to the coefficient of discharge method. Another certification method uses a slope or flow factor to determine the relieving capacity.

RELIEF EQUIPMENT CERTIFIED FOR SECTION I APPLICATIONS

Four main different types of relief equipment are available with ASME Section I certification and are detailed in the following sections:

- A dual-blowdown ring safety valve with V-designation certified for Section I
- A single-blowdown ring safety valve with V-designation certified for Section I
- A safety relief valve certified for liquid with a UV-designation extended to Section I
- A pilot-operated safety relief valve dual-certified for steam and liquid with V-designation certified for Section I.

Dual-blowdown ring safety valve (V-designator). The dual-blowdown ring safety valve marked with V-designation is the workhorse for relief protection for ASME Section I fired boilers. Most code boilers utilize these designs, and all but the smallest boilers typically use two or more dual-ring valves certified for Section I. These valves are characterized by full lift at low overpressure (3% or 2 psi) and low blowdown (4%–6%). With the dual-blowdown rings and stiffer spring rates used to achieve these strict requirements, they typically demonstrate unstable operation when flowing liquid. These valves are only certified under vapor/steam flowing conditions and are not expected to achieve full lift at 10% overpressure, as required for liquid certification. These safety valves are typically suitable for backpressures of up to 20% for the common open bonnet designs.

FIG. 2 illustrates a cutaway view of a dual-blowdown ring safety valve showing details of the upper and lower blowdown rings. The two rings are required to simultaneously meet the 3% overpressure requirement and the 4% blowdown requirement. These are suitable for steam/vapor operation but not liquid operation.

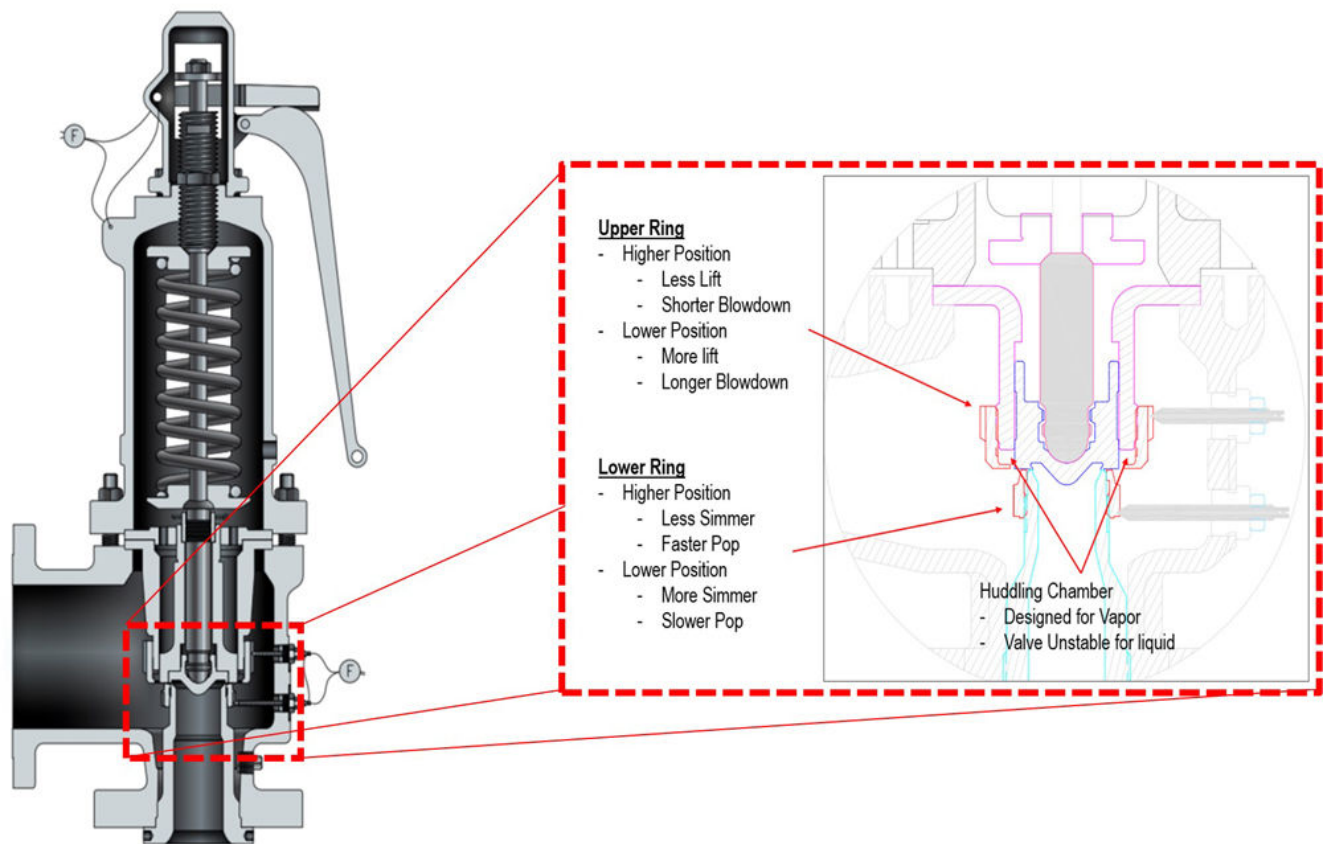


FIG. 2. A cutaway view of a dual-blowdown ring safety valve showing details of the upper and lower blowdown rings.

Single-ring safety valve (V-designator). A V-designated safety valve with a single-blowdown ring is available in accordance with ASME Section I. This valve is typically for use with Section I economizer applications and organic vaporizer service applications only. The capacity is certified for vapor/steam relief at 3% overpressure; however, the blowdown requirement of 4% is not achieved. This valve design is not intended for Section I boiler drum, superheater or reheater applications.

Dual-certified safety relief valve (UV-designator). UV-designated safety valves with dual certification in accordance with ASME Section VIII service have a single-blowdown ring design, as shown in **FIG. 3**. These valves are characterized by full lift at, or below, 10% overpressure for vapor or liquid applications and a blowdown of 7% in vapor service. Valves may be certified for vapor flow, liquid flow or dual media. While there is no direct certification for two-phase/flashing flow, a certified capacity can be determined by guidance outlined by DIERS and API. The design of the huddling chamber for the dual-certified valves results in stable operation for vapor, liquid and two-phase flowing conditions. The National

Board recently added ASME Section I certification for liquid flow at 10% overpressure. For conventional safety relief valves with a UV-designator, the amount of variable superimposed and built-up backpressure is allowed up to the allowable overpressure. For balanced bellows valves, the backpressure is limited by their backpressure capacity curves, typically extending up to 50% or higher.

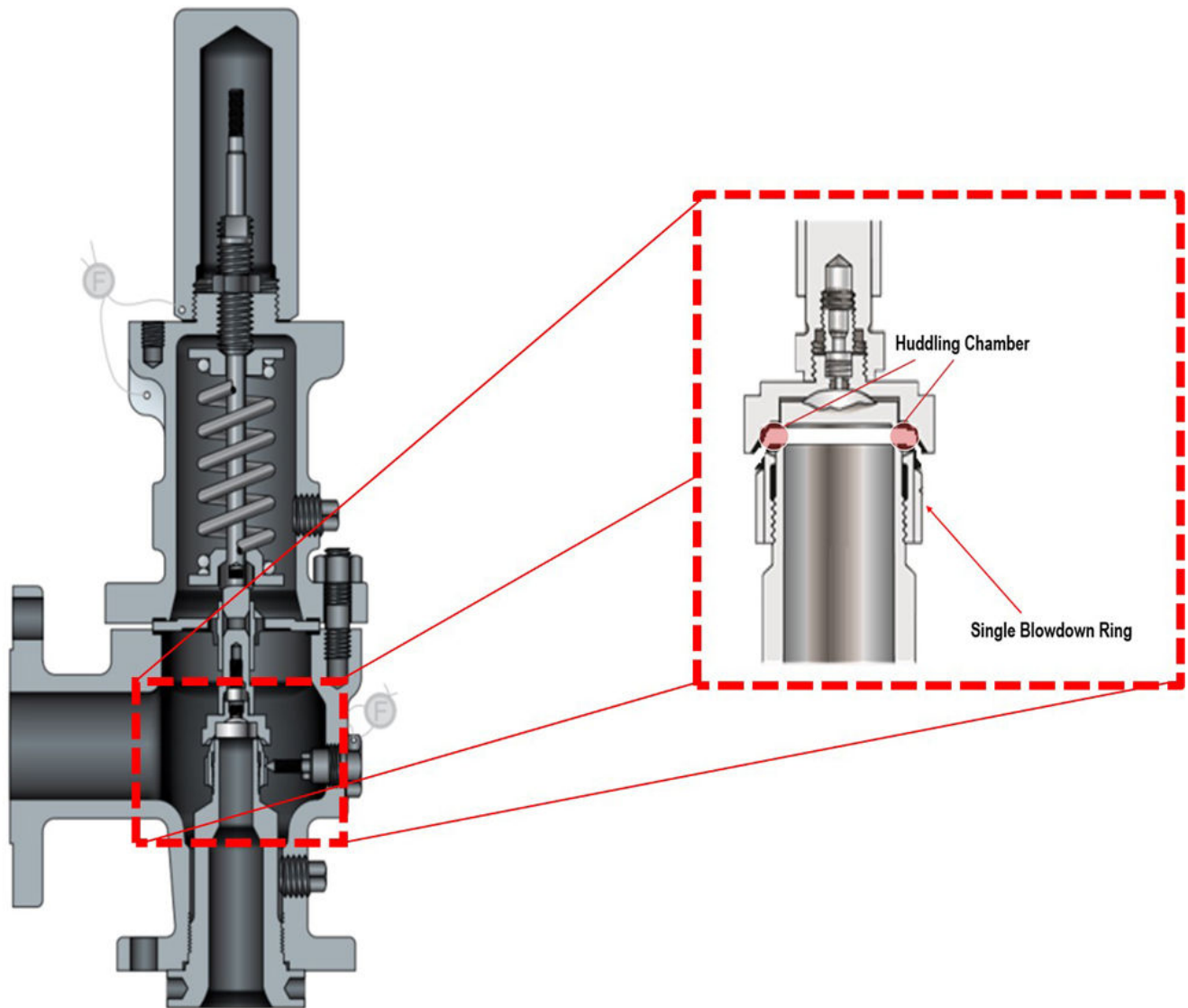


FIG. 3. A cutaway view of a single-blowdown ring safety relief valve showing a single-blowdown ring and huddling chamber.

Dual-certified pilot-operated safety relief valve (V-designator). Invoking ASME Code Case 2446 allows for a pilot-operated safety relief valve with a V-designation to be certified for dual steam and liquid service. Vapor capacities are certified at 3% overpressure and liquid capacities are certified at 10% overpressure. While there is no direct certification for two-phase/flashing flow, a certified capacity can be determined by guidance outlined by DIERS and API.

LIQUID APPLICATIONS FOR ASME SECTION I SERVICE

Application: Economizers. Economizers for ASME Section I Boilers are heat exchangers that recover heat generated from boilers and other fired equipment by preheating the boiler feedwater using the exiting hot flue gases. From the Preamble of ASME Section I, “Superheaters, *economizers*, and other pressure parts connected directly to the boiler without intervening valves shall be considered as parts of the boiler proper, and their construction shall conform to Section I rules.” When located outside the limits of a boiler’s external piping, an economizer (**FIG. 4**) is considered a fired pressure vessel.

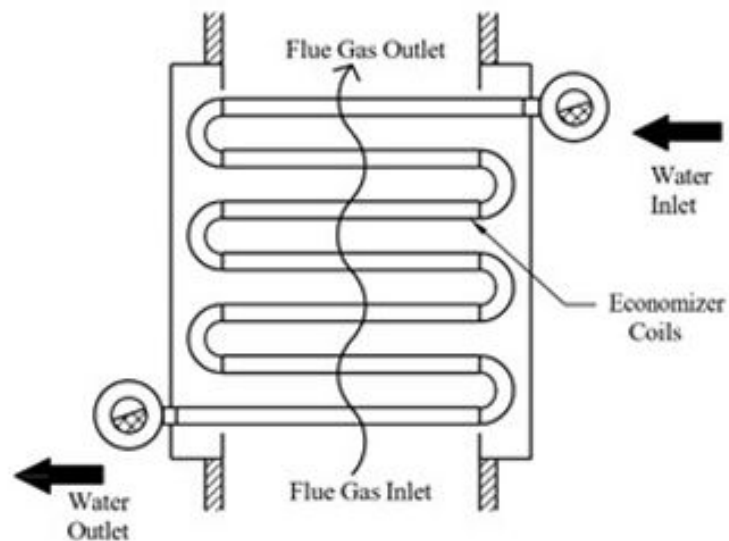


FIG. 4. Economizers for ASME Section I Boilers are heat exchangers that recover heat generated from boilers and other fired equipment by preheating the boiler feedwater using the exiting hot flue gases.

Economizers that can be partially or totally isolated from the boiler require one or more pressure relief valves sized for the discharge of saturated steam flow at a calculated capacity (lb/hr) using the economizer’s stamped duty (Btu/hr) divided by 1,000 (Btu/lb). If overpressure can occur within the economizer due to liquid, the pressure relief valve(s) are also sized to limit the overpressure to no more than 10% or 3 psi, whichever is greater.²

Partially or totally isolated economizers may be designed in accordance with rules from either ASME Section VIII, Div. 1 requirements or ASME Section I requirements (see ASME Section I, Part PFE).² Economizers constructed to ASME Section VIII shall have overpressure protection in accordance with ASME Section XIII requirements with a UV-designation.

As ASME Code does not provide direct reference to overpressure protection for ASME Section I economizers that can be partially or totally isolated, it is implied they are to follow ASME Section I

requirement.

The rules and requirements for economizers are summarized below:

- If an economizer cannot be isolated from the steam drum, it should be included as part of the boiler proper, as defined by ASME Section I.
- If an economizer can be partially or totally isolated from the boiler, it should be protected in accordance with ASME Section VIII rules if constructed to Section VIII specifications.
 - A discharge capacity (lb/hr) based on the economizer design duty (Btu/hr) divided by 1,000 (Btu/lb)
 - Liquid relief to ensure pressure does not exceed maximum allowable working pressure by more than 10%
 - Protected by a dual-certified safety valve with UV-designation
- If an economizer can be partially or totally isolated from the boiler, it should be protected in accordance with ASME Section I rules if constructed to Section I specifications.
 - A discharge capacity (lb/hr) based on economizer design duty (Btu/hr) divided by 1,000 (Btu/lb)
 - Liquid relief to ensure pressure does not exceed maximum allowable working pressure by more than 10%
 - Protected by a steam-certified safety valve with V-designation
 - Protected by a liquid-certified safety valve with UV-designation
 - Protected by a dual-certified, pilot-operated valve with V-designation and invoking CC2446.

Application: Low-quality steam generators. A second application involving ASME Section I equipment requiring liquid/two-phase relief is a low-quality steam generator (**FIG. 5**). The overpressure failure case in this situation would be a blocked outlet evaluated at the design capacity and steam quality.

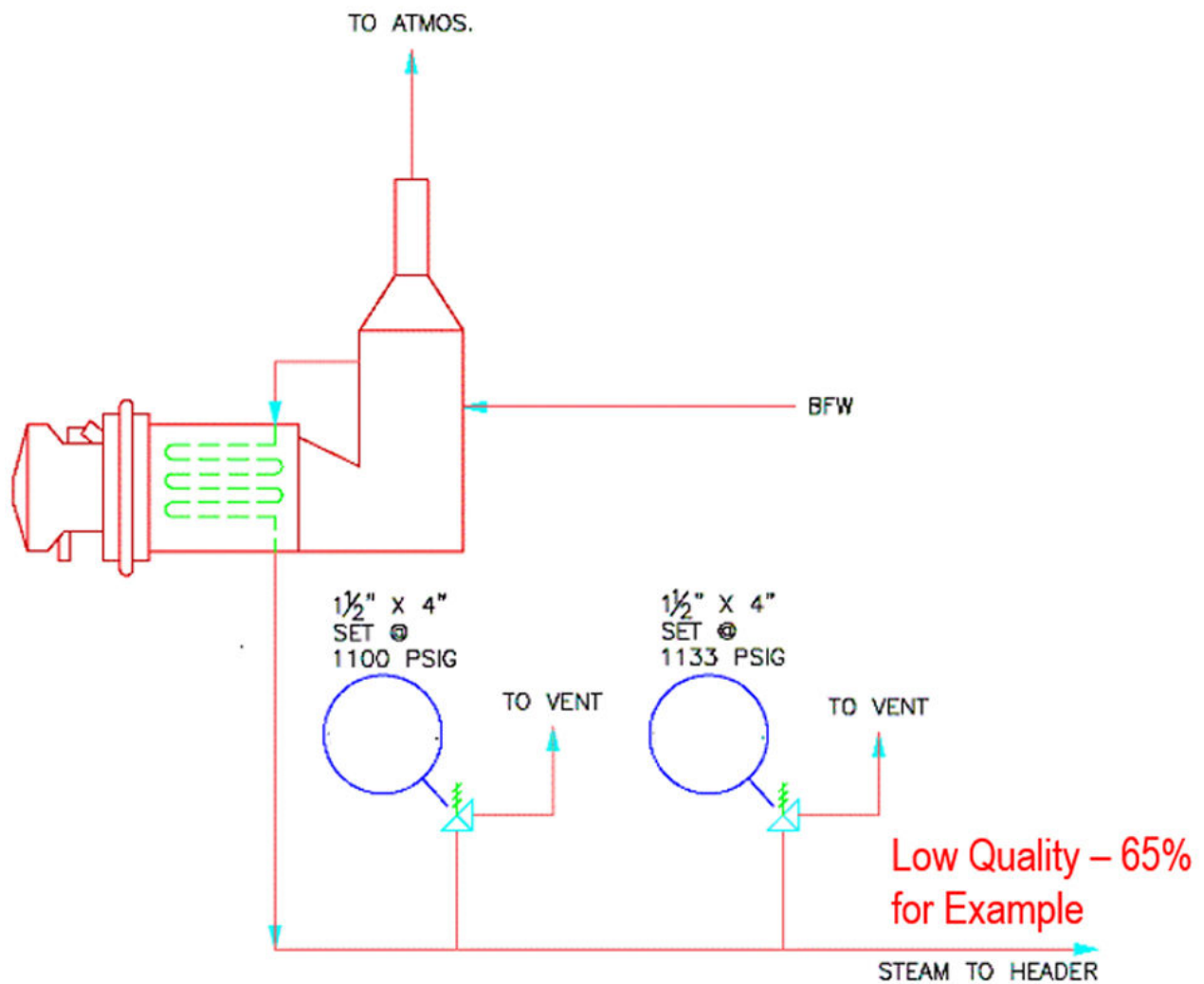


FIG. 5. A typical installation for a steam generator used in the oil and gas industry where low-quality steam (~65%) is injected “down hole” to encourage oil production.

No ASME code reference has been identified for this application. Possible relief protections to consider include:

- A dual-certified pilot valve with V-designation
- A vapor-certified safety valve with V-designation.

Note: In situations where the steam generator is designed to ASME Section VIII rules, protection may be provided by a dual-certified safety relief valve with UV-designation.

Dual-certified pilot valves with V-designation are specifically authorized for protecting Section I boiler economizers. The manufacturer must be consulted to determine if they would be approved for protecting low-quality steam generators.

Safety valves certified for ASME Section I service are specifically designed for all vapor relief and may experience stability issues if used to relieve two-phase mixtures like low-quality steam. Again, the manufacturer must be consulted to determine if satisfactory performance/stability can be expected.

Application: Fired boiler steam drum. Liquid overflow of a fired boiler is one potentially applicable relieving scenario, as illustrated in **FIG. 6**. ASME Section I PG-67 discusses relief protection requirements for fired boilers and associated equipment. However, the only reference identified for relief protection involving the boiler proper identifies a blocked outlet at design steam capacity of the boiler.

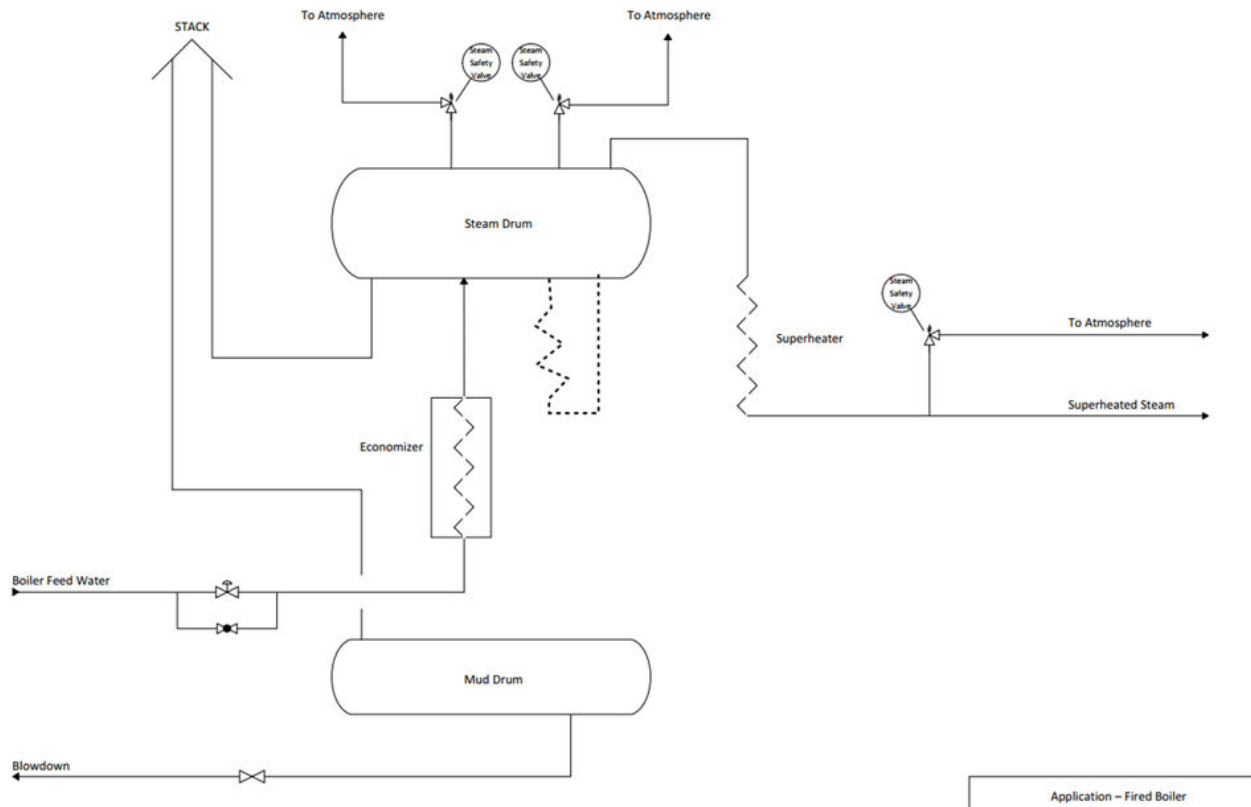


FIG. 6. Liquid overflow of a fired boiler is one potentially applicable relieving scenario.

ASME Section I boilers are typically protected by dual-blowdown ring safety valve(s) with V-designation. As discussed earlier, these safety valves do not provide stable operation when relieving liquid due to the design of the huddling chamber and stiffer spring. These dual-ring safety valves have no certified capacity for liquid flow.

As ASME only calls for steam relief associated with the boiler proper and boiler safety valves are only certified for steam/vapor flow, it is common for owner-operators to consider only the blocked outlet steam rates. Dual-certified pilot valves with V-designation might be used to relieve credible liquid scenarios for the boiler but are not certified to protect the boiler proper for the steam blocked outlet scenario. Many safety relief valves in the market are certified for liquid flow in ASME Section VIII applications and are also certified for Section I liquid applications with a V-designator. These can also be used to relieve the liquid overpressure scenarios for ASME Section I boilers, but not for a steam blocked outlet case.

Takeaways. Four different designs of relief protection equipment have been discussed, detailing characteristics and their applicability for liquid relief protection for ASME Section I applications.

- Dual-blowdown ring safety valve (V-designator)
 - Steam relief for boiler proper
 - Not certified for liquid or two-phase flow
- Single-blowdown ring safety valve (V-designator)
 - Steam relief for economizer and organic vaporizer
 - Not designed for the boiler proper
 - Not certified for liquid or two-phase flow
- Dual-certified safety relief valve (UV-designator)
 - Liquid and dual certification available
 - Two-phase flow by DIERS and/or API methodologies
 - Several are also certified with UV-designation for liquid relief at 10% overpressure
 - Liquid relief for Section I economizers
 - Liquid and vapor relief for Section VIII economizers
- Dual-certified pilot-operated safety relief valve (V-designator)
 - Certified for liquid and vapor relief for Section I economizer
 - Two-phase flow by DIERS and/or API methodologies
 - Not designed for the boiler proper.

The only liquid overpressure scenario called out in code for ASME Section I equipment is associated with a boiler economizer that can be partially or totally isolated from the boiler proper. Economizers that can be isolated require overpressure protection for steam flow (lb/hr) at their design duty (Btu/hr) divided by 1,000 (Btu/lb). Economizers designed following ASME Section I or ASME Section VIII that can experience overpressure by liquid, require overpressure protection for liquid relief.

Section I economizers are protected at 3% accumulation for steam relief and 10% accumulation for liquid relief. For vapor relief, a dual-ring safety valve, a single-ring safety valve, or a dual-certified pilot valve are appropriate—all with a V-designation. For liquid relief, a liquid certified safety relief valve is required. This could be a liquid or dual-certified safety relief valve with both V- and UV-designation or a dual-certified pilot-operated safety relief valve with V-designation.

Section VIII economizers are protected at 10% accumulation for steam relief and liquid relief. A dual-certified relief valve with UV-designation could be used for this application.

ASME Section I does not address overpressure protection for liquid relief associated with other equipment/applications, such as low-quality steam generators or liquid overflow of steam drums.

Relief protection for a low-quality steam generator is not specifically defined. Facility owner-operators should evaluate possible options for overpressure protection, including dual ASME Section I certified pilot relief valves, a V-designated safety valve for an ASME Section I steam generator, or a UV-designated dual-certified safety relief valve if the steam generator is designed to ASME Section VIII.

Liquid relief from boiler overfill is not usually considered a creditable scenario. It might be possible to relieve the liquid case with a dual ASME Section I certified pilot relief valve, but the boiler steam blocked outlet scenario must be relieved by a dual-blowdown ring safety valve with V-designation, as the pilot valve is not certified for steam overpressure protection of the steam drum. A liquid- or dual-certified safety relief valve with UV-designation also certified for liquid on Section I equipment may also provide liquid relief protection for the boiler. **HP**

NOTES

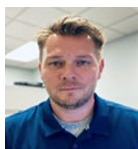
^a iPRSM[®]

LITERATURE CITED

1. National Board of Boiler and Pressure Vessel Inspectors (National Board), "Redbook: NB-18 Pressure relief device certification," online: www.nationalboard.org
2. American Society of Mechanical Engineers (ASME), "Section I, ASME Boiler and Pressure Vessel Code: PG-67.2.1.6," July 2015.



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