



# Safety Valves on Boilers

An Online Continuing Education Course for Engineers

**Course Number: M-2072**

**Credit: 2 Hours / 2 PDH / 2 CPD**

# Safety Valves on Boilers

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## Introduction

Safety valves are an important part of any boiler or pressure vessel. Some might say they are the most important part. They are the last line of defense against a catastrophic explosion due to accidental over-pressuring of a pressure vessel. The applicable codes and standards for safety valves on boilers, pressure vessels, and pressure piping are set forth by the American Society of Mechanical Engineers (ASME), the National Board of Boiler and Pressure Vessel Inspectors (National Board), and the American Petroleum Institute (API).

A boiler is any pressurized vessel designed to heat water and produce either very hot water or steam. The heat source can be electric, coal, oil, natural gas, wood, or just about any substance that can be burned to produce heat. These are referred to as fired boilers. The heat source can also be the bi-product of another process that is used to heat water. This is called a non-fired boiler.

This course will review the rules for safety valves used on boilers, which are covered by ASME Section I Code and the National Board Inspection Code. The course will discuss how to determine the capacity requirements of a boiler, how to choose the set pressures of the safety valves on a boiler, design requirements of safety valves that are used on boilers, and installation guidelines for safety valves on boilers. Set pressure tolerances, recommended operating gaps, and blowdown will also be covered.

The course also discusses recommended testing and inspection intervals and practices. Only qualified companies are authorized to work on safety valves. The course outlines what makes a company qualified to work on safety valves and provides an overview of what is involved in repairing a safety valve.

Finally, the course examines some popular safety valve designs, as well as the parts of a safety valve and how they all work together to make the valve operate correctly. The steps involved in sizing and selecting a safety valve for an application are also reviewed.

Several examples are provided in the course to better illustrate the concepts presented.

## Determining Capacity Requirements for safety valves on a boiler

Each boiler must have at least one safety valve. A boiler with more than 500 sq. ft. of bare tube water-heating surface area must have two or more safety valves. An electric boiler with a power input of more than 1100 kW must have two or more safety valves. For a boiler with a combined bare tube and extended water heating surface greater than 500 sq. ft., two or more safety valves are required only if the design steam generating capacity of the boiler exceeds 4000 lb/hr.

The minimum relieving capacity of the safety valves for all types of boilers must equal or exceed the maximum designed steaming capacity of the boiler at the Maximum Allowed Working

Pressure (MAWP) of the boiler. If more than one fuel option is allowed for the boiler, the highest heat capacity fuel option must be used in determining the steaming capacity of the boiler. If the boiler has auxiliary heat sources, such as duct burners, the minimum relieving capacity shall include all heat sources firing, as permitted by the boiler controls. The safety valves shall be sized to flow this minimum relieving capacity without allowing the pressure to rise more than 6% above the highest pressure at which any safety valve is set and no more than 6% above the MAWP of the boiler.

For a high temperature water boiler, the minimum required capacity in lb/hr steam is calculated by dividing the maximum output in BTU/hr at the boiler nozzle produced by the highest heating value fuel used by the boiler by 1000. If a boiler has an economizer that can be shut off from the boiler, thereby creating a separate fired vessel, then the economizer must have one or more safety valves installed. The minimum required capacity in lb/hr of steam is calculated by dividing the maximum expected heat absorption in BTU/hr by 1000.

For a steam generator with no fixed steam and waterline, one or more power-actuated relief valves can be used. A power-actuated relief valve, as compared to a spring-loaded relief valve, requires power to operate. This power can be in the form of an electric or pneumatic actuator. The valves must be in direct contact with the boiler controls and must receive an open command when the pressure at the superheater outlet exceeds the MAWP. The total combined capacity of the power actuated valves must be equal to or greater than 10% but not more than 30% of the maximum designed steaming capacity of the boiler. The combined relieving capacity of the power-actuated relief valves and the spring loaded safety relief valves must account for 100% or more of the maximum designed steaming capacity of the boiler. Any or all of the spring loaded valves may be set above the MAWP of the boiler section that they are connected to, but the set pressures shall be such that when all these valves are lifted, the pressure will not rise more than 20% above the MAWP of any part of the boiler except for the steam piping between the boiler and the turbine.



Spring-Loaded  
Style



Old Power Actuated  
Style



New Power Actuated  
Style

The power-actuated relief valves must be located at the superheater outlet before the steam block valve. If there are redundant power-actuated valves, an isolation valve can be installed under the power-actuated relief valves as long as the number of power-actuated valves required to meet capacity is always in service at any given time. The isolation valve port size must be at least equal to the area of the inlet of the power-actuated valves.

Every attached superheater must have one or more safety valves in the steam path between the superheater outlet and the first stop valve. The discharge capacity of the superheater safety valves can be included in the total relieving capacity of the boiler safety valves as long as there is not intervening valves between the superheater and the boiler. The superheater safety valves can account for up to 25% of the total relieving capacity of the boiler. I have seen cases of confusion with this specification. The ASME code gives the maximum allowed which is 25% but does not specify a minimum. The code only specifies that a safety valve exists. Most boilers that I have seen have the superheater safety accounting for 22% to 25% of the total relieving capacity.

Every isolatable superheater that can be shut off from the boiler and become a separate fired vessel must have one or more safety valves. The minimum required capacity is 6 lb per square foot of superheater surface measured on the side exposed to the heat source. Alternatively, the discharge capacity can be calculated by dividing the maximum expected BTU/hr heat absorption by 1000. For electric boilers, the discharge capacity is calculated based upon 3.5 lb/hr/kW input.

Every reheater shall have one or more safety valves. The total relieving capacity shall be at least equal to the maximum designed steam flow for the reheater. The capacity of the reheater safety valves is not included in the required relieving capacity for the boiler drum and superheater as the reheater section is completely separate from the main section. One or more safety valves shall be located between the reheater outlet and the first stop valve and shall account for at least 15% of the required capacity for the reheater.

Economizers that can be isolated to become a fired pressure vessel must have at least one safety valve. The discharge capacity, rated in lb/hr steam, shall be calculated from the maximum expected heat absorption rate in BTU/hr of the economizer divided by 1000. The safety valve should be mounted as close as possible to the economizer outlet.

Some examples:

1. A high temperature water boiler has a maximum expected heat absorption of 225,000 BTU/hr. For what required relieving capacity should the safety valve be sized?

Answer:  $225,000 / 1000 = 225$  lb/hr.

2. A fixed water-line boiler with attached superheater has a maximum steaming capacity of 1,500,000 lb/hr. How much of this capacity should the drum safety valves be sized for and how much should the superheater safety be sized for?

Answer: Drum capacity =  $1,500,000 \times 0.75 = 1,125,000$  lb/hr

Superheater capacity =  $1,500,000 - 1,125,000 = 375,000$  lb/hr

3. What is the required relieving capacity of an isolatable superheater section with 50,000 sqft of heating surface?

Answer:  $50,000 \times 6 = 300,000$  lb/hr



Valves on high temperature water boilers shall be closed bonnet and be capable of satisfactory operation when relieving water at saturated temperature corresponding to the set pressure. Valves for economizer service should also be closed bonnet or pilot-operated and must be capable of being certified on both water and steam without making any adjustments.

### Installation of safety valves on a boiler

Every boiler shall have outlet connections for the safety valves independent of any other outside steam connection. The PRV (pressure relief valve or safety valve) should be attached as closely as possible to the boiler or steam flow path without any intervening pipe or fittings. The safety valve should be located more than 8 ft from the boiler in steam lines or in an area of low velocity piping. The distance between the boiler and the PRV should not be longer than the face-to-face length of the valve. The diameter and pressure class of the inlet piping must be equal or greater than the diameter and pressure class of the outlet piping. The area of the inlet piping must be equal or greater than the area of the outlet piping. If the PRV is attached to one vessel connection the cross-sectional area of the inlets of the PRV must be less than the combined cross-sectional area of the outlets. If the PRV is mounted on a single connection, the relief valve must be less than 50% of the larger diameter.

No valve, other than the PRV, shall be installed in the discharge piping between the boiler and the PRV or in the discharge piping between two redundant safety valves. The PRV valve allows two safety valves to be installed in one safety valve to position where both valves are isolated from the boiler.

All PRV discharge piping shall be sized to pass trapped steam through the PRV body bowl drains. The PRV body bowl drains should tie into the steam exhaust stack and not into the drain system. When a silencer is used, the silencer should be sized so that it does not create so much back pressure as to interfere with the proper operation of the PRV or cause the discharge capacity of the PRV to be affected. A silencer shall not be used with a high temperature water boiler safety valve.

### Set Pressure tolerances for PRVs and changing the set pressure

ASME Sect I allows for tolerances in the actual set pressure versus the stamped set pressure. These tolerances are to give room for tolerances in the measuring equipment. These tolerances are not intended to purposely set a valve high hoping to get a little more outlet pressure from the boiler.

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