Chapter 3

Safety Features

There are five required safety features on every boiler

Safety valve
: Prevents overpressure by automatically releasing steam if boiler pressure exceeds the set limit.

Pressure gauge
: Indicates internal pressure so the operator can keep the boiler within its safe working range.

Fusible plug
: Last-ditch low-water protection—the core melts if the crown sheet is uncovered, dumping steam into the firebox and giving a dramatic warning.

Try cocks
: Independent check on water level—a set of test cocks at different heights to confirm gauge glass readings and detect false readings or glass failure.

Water gauge glass
: Shows actual water level in the boiler so low-water conditions can be detected before they become dangerous.

Sixth, common but not mandatory

Water column
: A remote water-level assembly that often combines a gauge glass and try cocks in one fitting, mounted off the boiler shell for better visibility and maintenance—but not strictly required by code in all cases.

3.1 Safety valve

A safety valve is an automatic, spring-loaded device fitted to the boiler shell that prevents the boiler from exceeding its maximum allowable working pressure. Steam pressure acts on a valve disc held shut by an adjustable spring. When boiler pressure reaches the valve's set pressure, the steam force overcomes the spring tension and lifts the valve, releasing steam rapidly to atmosphere. This prevents further pressure rise.

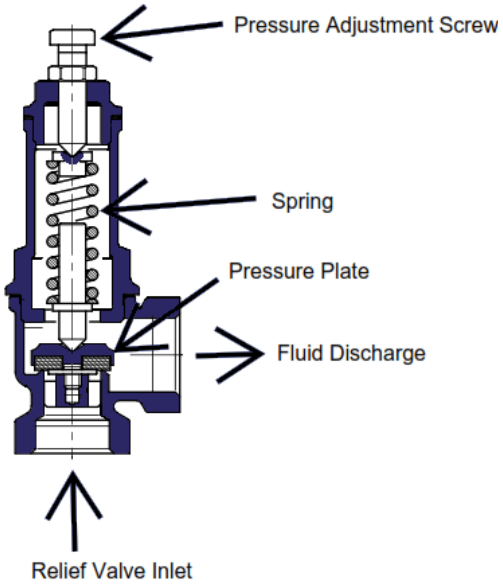

Fig. 1 Safety valve

Once pressure drops slightly below the set point (the blowdown), the spring reseats the valve and normal operation resumes.

Key characteristics:

- Spring-loaded (modern traction and portable boilers)
- Set pressure is sealed so the operator cannot adjust it
- Opens fully and quickly to prevent dangerous pressure rise
- Reseats automatically when pressure falls to safe level
- Must be sized to discharge steam faster than the boiler can generate it

3.1.1 Why a Boiler Safety Valve "Pops" Instead of Just Lifting

A boiler safety valve is designed with two effective areas, not one:

The primary seat area — the small circular area of the valve disc that steam pushes on while the valve is closed.

The secondary (huddling) chamber area — a larger annular area that becomes exposed only after the valve cracks open.

When the valve first begins to lift at the set pressure, only the small seat area is exposed to steam pressure. But the moment the disc lifts even a tiny amount, steam rushes into the huddling chamber, where it acts on a much larger surface area.

Because force = pressure × area:

Before lift: $F = P \times A_1$

After lift: $F = P \times (A_1 + A_2)$
where A_2 is the larger huddling-chamber area

This sudden increase in effective area produces a rapid, positive, self-reinforcing lift — the "pop."

The spring cannot resist this larger force, so the valve snaps fully open, releasing steam at a very high rate.

This is intentional and required by code.

3.1.2 Getting the right size

The MAWP determines the safety-valve set pressure, and the heating-surface area determines the required relieving capacity; together these specify the orifice size needed so the valve can discharge steam faster than the boiler can generate it.

A practical rule of thumb is to size the safety valve capacity at about 7–11 lb/h per square foot of heating surface. This gives a conservative capacity range for historic, hand-fired boilers. In practice, actual safety valves must be sized using the applicable boiler code and manufacturer capacity charts for the chosen set pressure.

Heating surface is the sum of all wetted boiler surfaces exposed to fire or hot gases — firebox sheets, crown sheet, tubes, and flues.

Using the capacity and the set pressure, look up the oriface in a table like the one in Table 1..

Table 1. Capacity by Oriface and Set Pressure

KUNKLE SAFETY VALVE PRODUCTS
SERIES 6000

Capacities

ASME Section I Steam (U.S., lb/h)
Flow Coefficient = 0.878

Set Pressure (psig)	Orifice Area, in^2					
	D (0.121)	E (0.216)	F (0.336)	G (0.554)	H (0.863)	J (1.414)
15	173	310	482	794	1237	2027
20	201	358	558	919	1432	2346
25	228	407	634	1045	1627	2666
30	256	456	710	1170	1822	2986
35	283	505	785	1295	2017	3306
40	310	554	861	1420	2213	3625
45	338	603	937	1546	2408	3945
50	365	651	1013	1671	2603	4265
55	392	700	1089	1796	2798	4584
60	420	749	1165	1921	2993	4904
65	447	798	1241	2047	3188	5224
70	475	848	1319	2174	3387	5550
75	503	898	1397	2303	3588	5879
80	531	948	1475	2432	3789	6208
85	559	999	1553	2561	3990	6538
90	588	1049	1632	2690	4191	6867
95	616	1099	1710	2819	4392	7196
100	644	1150	1788	2948	4593	7525
105	672	1200	1866	3077	4794	7855
110	700	1250	1945	3206	4995	8184
115	728	1300	2023	3335	5196	8513
120	757	1351	2101	3464	5397	8842
125	785	1401	2179	3593	5598	9172
130	813	1451	2258	3722	5799	9501
135	841	1502	2336	3851	6000	9830
140	869	1552	2414	3980	6201	10160
145	898	1602	2492	4109	6402	10489
150	926	1653	2571	4238	6603	10818
160	982	1753	2727	4497	7004	11477
170	1038	1854	2884	4755	7406	12135
180	1095	1954	3040	5013	7808	12794
190	1151	2055	3197	5271	8210	13452
200	1208	2156	3353	5529	8612	14111
210	1264	2256	3510	5787	9014	14769
220	1320	2357	3666	6045	9416	15428
230	1377	2457	3823	6303	9818	16087
240	1433	2558	3979	6561	10220	16745
250	1489	2659	4136	6819	10622	17404
260	1546	2759	4292	7077	11024	18062
270	1602	2860	4448	7335	11426	18721
280	1658	2960	4605	7593	11828	19379
290	1715	3061	4761	7851	12230	20038
300	1771	3162	4918	8109	12632	20696

- select the row corresponding to the set point
- select the column corresponding to the capacity
- obtain the oriface from the column heading

Then construct a model number using the oriface and inlet sizes.

Model Number/Order Guide

Model Number Position	1	2	3	4	5	6	7	7	8	9	10	11	12	13	14	15
Example	6	0	1	0	H	G	M	0	1	—	A	M	0	1	5	0

Model

6010	6130	6230
6021	6186	6933
6030	6283	6934
6182	6221	6935
6121		

Orifice

D	G
E	H
F	J

Inlet Size

C - 1/2" [12.7]	G - 1 1/2" [38.1]
D - 3/4" [19.0]	H - 2" [50.8]
E - 1" [25.4]	J - 2 1/2" [63.5]
F - 1 1/4" [31.8]	

Seat Material

M - Metal	T - Teflon® (Models 6021, 6121, 6221, 6934 only)
E - EPR	
V - Viton®	

Variation (01 to 99)

- 01 - Plain lever
- 02 - Plain lever with vibration dampener
- 03 - Plain lever with gag
- 60 - BSP Threads

Design Revision

Indicates non-interchangeable revision.
Dash [-] if original design.

Valve Service

- A - Steam ASME Section I
- K - Air/Gas ASME Section VIII
- L - Steam ASME Section VIII
- G - Steam ASME Section IV (Models 6933, 6934, 6935 only)
- P - Steam, Non-code
- N - Air, Non-code

Spring Material

M - SS

Set Pressure

0015 - 15 psig [1.0 barg] only for Models 6933, 6934, 6935

3.2 Pressure Gauge

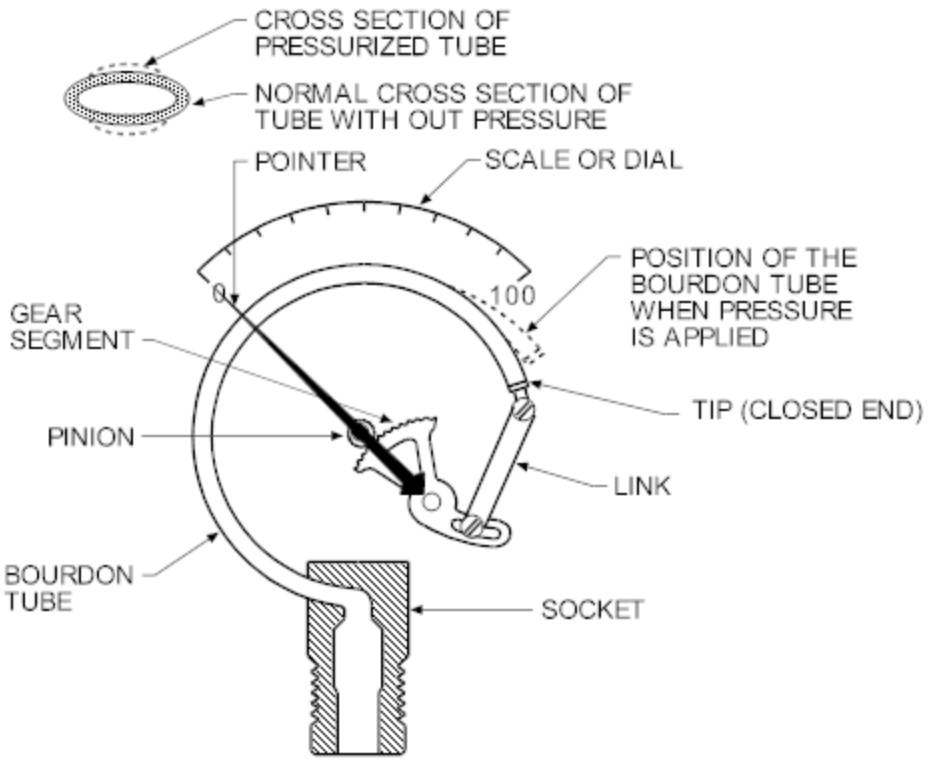

Fig. 2 Bourdon-tube gauge

Steam pressure enters a curved Bourdon tube and makes it try to straighten; this tiny motion is transmitted through a linkage and gears to rotate the needle, giving a direct reading of boiler pressure.

A siphon or pigtail forms a water seal between the boiler and the gauge; the water absorbs the steam's heat so the Bourdon tube only sees pressure, not live steam temperature, which greatly extends gauge life.

The gauge siphon is mounted above an isolation valve, typically quarter-turn style.

3.3 Fusible Plug

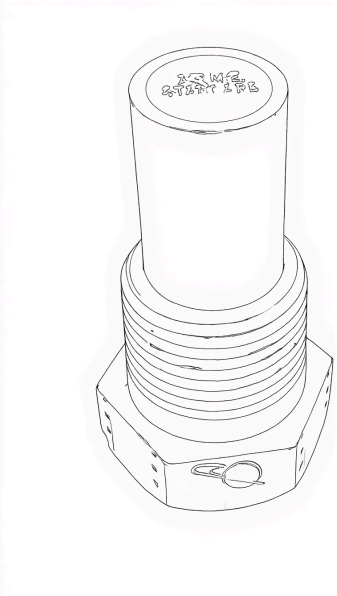

Fig. 3 Fusible Plug

A fusible plug contains a low-melting-point alloy on the water side of the crown sheet.

If the water level drops and the crown sheet overheats, the alloy melts out, creating an opening.

When it melts, it vents steam and some water into the firebox, producing a violent roar and a blast of white steam.

The discharge does not quench the fire — the amount of water/steam is far too small, and the draft usually overwhelms it.

What it does do is provide an immediate, unmistakable warning of dangerously low water and forces the operator to react.

Its real purpose is to prevent crown-sheet failure by giving a warning before the plate reaches a critical temperature.

Fusible Plug — Myth vs. Reality

Myth: A fusible plug melts and dumps water onto the fire, putting the fire out.

Reality: What comes through the plug is mostly steam, not enough water to quench a fire, and the firebox draft blows it away. What it really does is produce a violent roar and a blast of white steam — an unmistakable warning of low water or crown-sheet overheat.

Bottom line: A fusible plug is a temperature-triggered warning device, not a fire extinguisher.

3.4 Try cocks

Try cocks are installed on the boiler head at the normal waterline, with one above and one below it to verify the true water level. Mounting try cocks on a water column keeps them in the same vertical plane as the gauge glass, giving a cleaner, more stable indication and making it easier to verify the true water level without opening fittings directly on the boiler shell.

A try cock is cracked open briefly to check whether it blows steam or water, confirming the true boiler water level independently of the gauge glass.

3.4.1 Operating a Try Cock — Key Points

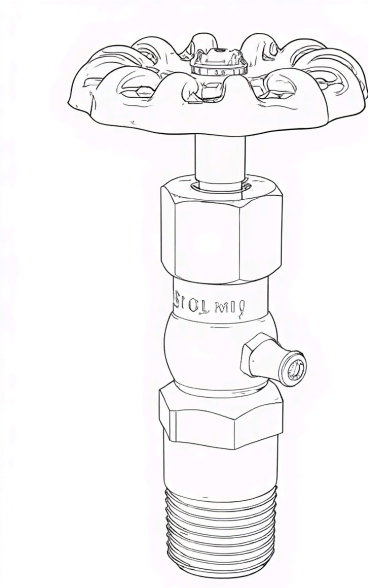

Fig. 4 Try Cock [1]

Open the top try cock first
: A steady stream of steam indicates the water level is below that cock.

Open the bottom try cock next
: A steady stream of water indicates the water level is above that cock.

The correct water level lies between the two
: If the top blows water and the bottom blows steam, the gauge glass is lying — shut down and investigate.

Crack the valve open slowly
: Try cocks discharge forcefully; opening gently prevents water hammer and avoids scalding spray.

Stand to the side
: Never directly in front of the discharge. Hot water or wet steam can eject violently.

Use short, controlled bursts
: Long openings waste water and can drop the level unnecessarily.

Try cocks are an independent check
: They confirm the gauge glass reading and detect a plugged, broken, or false-reading glass.

Two are required, three are common
: The term “tricock” is traditional, but only two are required to bracket the safe operating level.

3.5 Gauge Glass

A gauge glass is the vertical sight tube mounted on the the boiler that shows the true water level inside. It connects to the boiler through a top steam connection and a bottom water connection, so the water in the glass rises and falls to the same height as the water inside the boiler. Because the glass is open to boiler pressure at both ends, it acts as a simple, pressure-balanced column of water that gives the operator a direct, continuous indication of water level while the boiler is steaming.

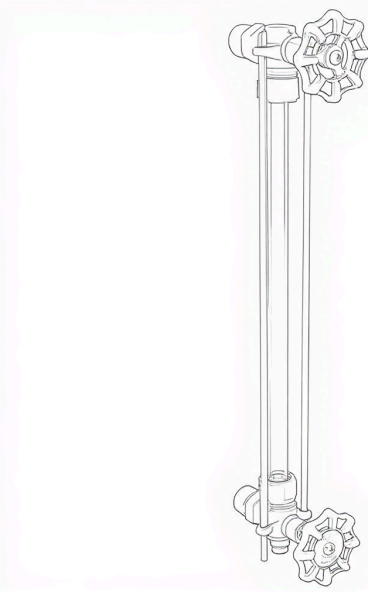

Fig. 5 Gauge Glass

3.5.1 Proving a gauge glass

A gauge glass is proved by momentarily opening each cock to confirm that steam can reach the top fitting, water can reach the bottom fitting, and the drain passage is clear.
If any passage is blocked, the glass cannot be trusted.

1. Ensure the steam cock, water cock, and drain cock move freely before applying pressure.
    - Stand to the side of the gauge glass
    - Confirm handles operate smoothly
    - Ensure the drain pipe is directed to a safe discharge point
2. Blow down the gauge using the drain cock
    - This confirms the drain passage is clear and resets the water level.
    - With both steam and water cocks open, open the drain cock fully
    - Observe a strong discharge of water followed by steam
    - Close the drain cock; the glass should refill to the true level
3. Prove the steam connection. Ensures the top fitting is not blocked by scale or sludge.
    - Close the water cock
    - Open the drain cock briefly -The glass should blow clean steam from the top connection -Close the drain cock

4. Prove the water connection. Ensures the bottom fitting is clear and supplying water.
    - Close the steam cock
    - Open the drain cock briefly
    - The glass should blow solid water from the bottom connection
    - Close the drain cock

3.5.2 Return the gauge to service

Confirm the water level stabilizes at a believable height

If both cocks are closed under pressure, open the **steam cock first** Opening the steam cock first prevents water from being forced violently up the glass.

- Crack the steam cock slightly
- Allow steam to warm and pressurize the glass
- Once stable, open the steam cock fully
- Then open the water cock slowly to admit water