BOILER SYSTEMS

DEFINITIONS

Low Pressure Boilers operate at 15 psi or lower.

High Pressure Boilers operate above 15 psi.

One Boiler Horsepower equals 34,500 Btuh.

Fire Tube Boilers have the combustion gasses inside the tubes and are available up to 250 psi and 750 boiler horsepower. Fire tube boilers hold large amounts of water and have the potential for the most violent explosions.

Water Tube Boilers have water in their tubes and the tubes are surrounded by combustion gasses. They have been manufactured to operate at up to 3206 psi and are available in much larger capacities than fire tube boilers. Fire tube boilers require more skilled operation.

The *ASME Code* governs boiler design and installation.

BOILER SAFETY

In 1990 the National Board of Boiler and Pressure Vessel Inspectors (NBBPVI) documented 2891 accidents, resulting in 113 injuries and 17 deaths. The problems were distributed as follows:

38%	Malfunctioning low-water cutoffs
14%	Corrosion or erosion
46%	Other
2%	Faulty design, fabrication, or installation

Float type low-water cutoffs must be cleared of mud. Probe type low-water cutoffs must not be allowed to become covered with scale.

Boilers are not designed to support the weight of the breeching or stack.

Chemical fumes, including CFC's (chlorine) and battery chargers (sulfuric acid), can cause boiler corrosion.

DRAFT SYSTEMS

The draft provides causes the pressure difference needed to move combustion gasses

through the boiler. Boilers can be *Natural Draft* or *Mechanical Draft.*

Natural draft systems rely on the natural bouyancy of hot air. Mechanical draft systems have fans. A fan that blows into the boiler is called a *forced draft* fan. A fan located between the boiler and the stack is called an *induced draft* fan. Some boilers have both and this is called a *combination draft* system.

FUELS

Coal is classified as *lignite, bituminous* and *anthracite*. Lignite has low heating value and high moisture content and is rarely used in boilers. Bituminous coal is soft and generally has high sulfur content and is extracted from eastern US coal mines. Anthracite coal is harder and generally has low sulfur content and is extracted from western strip-mines.

Fuel oil is manufactured by distilling crude oil. It is classified by grades as shown in the table below:

FUEL OIL CHARAC-TERISTICS	No. 1	No. 2	No. 4	No. 5	No. 6
TYPE	Distillate Kerosene	Distillate	Very Light Residual	Light Residual	Residual
COLOR	Light	Amber	Black	Black	Black
API GRAVITY	40	32	21	17	12
SPECIFIC GRAVITY	.8250	.8654	.9279	.9259	.9861
#/GALLON	6.87	7.206	7.727	7.935	8.212
Btu/GAL	137,000	141,000	146,000	148,000	150,000
Btu/#	19,850	19,500	19,100	18,950	18,750

BURNERS

The main types of burners are gas burners, fuel oil burners, stokers and pulverizers.

Gas burners can be high pressure or low pressure. High pressure burners are generally used in gas/oil combination burners.

BOILER WATER TREATMENT

Poor water treatment can cause caustic embrittlement, scale, corrosion, and carryover.

Caustic embrittlement is the collection of alkaline material leading to weakening of metal. Boiler alkalinity must be controlled to prevent this.

Scale is the collection of *hardness* on surfaces. Hardness consists of calcium, magnesium and other elements in the second column of the periodic chart. Scale buildup insulates heat transfer surfaces, decreases efficiency, and increases thermal stresses. Hardness and total dissolved solids are controlled to minimize scaling. *Softening* reduces hardness by replacing hardness ions with sodium ions which are more soluble in water. *Blowdown* and *deionization* are used to control hardness and total dissolved solids.

Corrosion is controlled by removing oxygen and carbon dioxide, and controlling the pH, sulfites and alkalinity of the boiler water. The prefered pH range is between 9 and 10.

Carryover is caused by alkalinity, dissolved solids, and sludge. It can cause water hammer. *Priming* is carryover of small water particles. *Foaming* is rapid fluctuation of the water level due to impurities on the water surface which increase surface tension.

Blowdown can be surface or bottom. Surface blowdown is used to reduce carryover, TDS, alkalinity and hardness. This is because the TDS concentration is highest at the water surface. Surface blowdosn is often continuous. Bottom blowdown is usually used to reduces sludge and is periodic. Blowdown is often combined with heat recovery.

Chemicals are available for oxygen scavenging (sodium sulfite), softening (phosphates, which convert calcium and magnesium carbonate to nonadhering sludge), alkalinity and pH (caustic soda or soda ash).

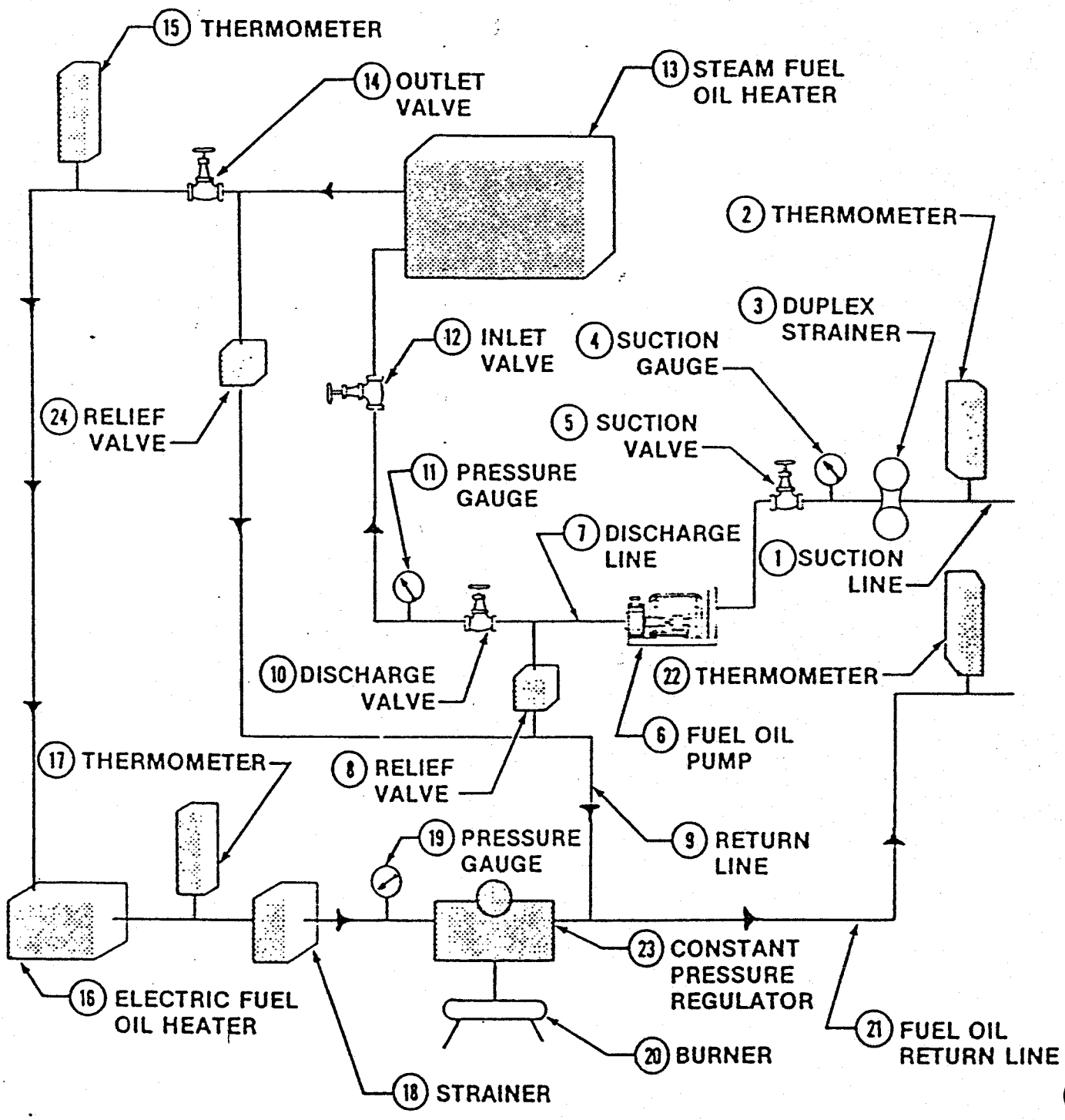

Figure 5-1. Fuel oil must be supplied to the burner at the correct temperature and pressure.

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BOILER SEMINAR KJWW ENGINEERING
BY JEFF BOLDT AND TOM KLEIN
AUGUST 7, 1992

ABBREVIATIONS AND BOILER FITTINGS

A. ASME Symbols and Abbreviations

1. See handout #1 attached. Symbols are certification that the item in question has been built according to ASME code and has been inspected after construction by an assigned ASME testing person.

2. Abbreviations used in the ASME Code include:

   a. NOWL - Normal Operating Water Level. This is the water level that is maintained in a steam boiler, and seen about halfway up in the gauge glass.

   b. MAWP - Maximum Allowable Working Pressure. This is the limiting pressure that the boiler may operate at. It is determined by the design and construction of the boiler to meet ASME code. It is found on the boiler nameplate. See detail #1a attached.

B. Boiler Fittings

1. See detail #2 attached for general schematic overview of fitting locations.

2. Safety Valve (steam)
   Safety Relief Valve (water):
   (see details #3, #4, #5 and #6)

- Relieves over-pressure from boiler
- Considered as the most important fitting on the boiler
- Mounted at the highest point on the boiler shell
- No other valves between it and the boiler
- If more than 500 sq. ft. of heating surface in the boiler, at least 2 are required, piped to outside
- Works by popping action, both opening and closing
- sized by lbs/hr for steam, btu/hr relieving capacity
- must relieve full capacity of the boiler while not allowing the pressure inside to exceed the MAWP by 6%
- pressure should drop 2-4 psi before closing after popping off
- should be tested by opening handle once per month
- should be tested once per year with evaporation test, boiler inspector must be present

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3. Water Column:
(see details #7 and #8)

- reduces movement of water for accurate boiler water level reading
- incorporates gauge glass shutoff valves and mounting fittings for visual means of determining water level in boiler. See detail for proper level in glass in relation to top heating surfaces.
- many times has tri-cocks, or three small valves located above, directly at, and below NOWL. Tri-cocks are used as a secondary means of checking the water level in the boiler
- column and gauge glass have blowdown valves for flushing sediment out. Also note cross tee's used at elbow connections allowing wire brush cleaning of column lines

4. Pressure Controllers
(see details #9 and #10)

- regulates the pressure in steam boilers by controlling the burner firing rate
- mounted at the highest point on the boiler
- pigtail or u-tube siphon is required to protect bellows or diaphragm on bottom of controllers from live steam
- must be mounted in true vertical position to avoid incorrect mercury switch action in ON/OFF type pressure controllers for single-fire burners

4. Boiler Vent:

- mounted at the highest point of the boiler
- a single 1/2" or 3/4" valve
- used to vent air during filling boiler with water
- used to blow off air from steam chamber in boiler before "cutting boiler in on line" on system
- used to allow air into boiler to prevent vacuum inside while cooling down after taking "off line" from system for draining, cleaning, and inspection
- must meet same pressure rating as boiler

5. Pressure Gauge
(see detail #11)

- incorporates Bourdon tube that flexes with pressure form boiler, moving needle against face
- pressure range should be 1-1/2 to 2 times MAWP of boiler
- u-tube or pigtail siphon is required to protect gauge from live steam

6. Fusible Plug
(see detail #12)

- only required on new coal fired boilers. Some older fuel oil and gas boilers may still have them
- it is the last warning of low water before damage is done to the heating surfaces
- made of a brass or bronze plug with a tin center core.
- 100% tin core melts at about 450 deg. F
- allows steam to audibly whistle through the plug when core melts after water has uncovered the fusible plug
- two types: fire-side type screws from fire-side into water-side; water-side type screws from water-side into fire-side. The two are not interchangeable

7. Bottom and Surface (or Skimming) Blowdown Valves:
(see detail #13)

- bottom blowdown valve piped to bottom of boiler shell
- surface blowdown valve piped to NOWL on side of boiler;
- surface blowdown removes impurities on top of water, decreasing water tension for better steaming
- four reasons to blowdown a boiler
    a. control high water within the boiler
    b. remove sludge and sediment: heavies with bottom blowdown, floaters with surface blowdown
    c. control chemical concentrations in the boiler
    d. drain a boiler for cleaning/inspection (bottom)
- for bottom blowdown, quick opening valve should be opened 1st and closed last; allows more control during blowdown, and also replacement of seats in slow opening valve

8. Main Steam Shut-Off and Automatic Non-Return Valves
(see details #14 and #15)

- should be OS&Y gate type valve, with rising stem
- mount directly on boiler steam flange to isolate boiler as close to boiler as possible and avoid certified welding between boiler and stop valve
- two in series are required on high pressure boilers in battery with one another
- if two, closest to boiler may be a non-return valve
- non-return valve acts as a combination shut-off and check valve, cutting the boiler in on line automatically when the boiler has reached main pressure

9. Questions

	ASME CODE SYMBOL STAMP	SAFETY RELIEF VALVE
	ASME CODE SYMBOL STAMP	HEATING BOILER
	ASME CODE SYMBOL STAMP	POWER BOILER
	ASME CODE SYMBOL STAMP	WATER HEATER
	ASME CODE SYMBOL STAMP	LOCOMOTIVE BOILER
	ASME CODE SYMBOL STAMP	SAFETY VALVE
	ASME CODE SYMBOL STAMP	BOILER ASSEMBLY
	ASME CODE SYMBOL STAMP	MINIATURE BOILER
	ASME CODE SYMBOL STAMP	PRESSURE PIPING

DETAIL # 1

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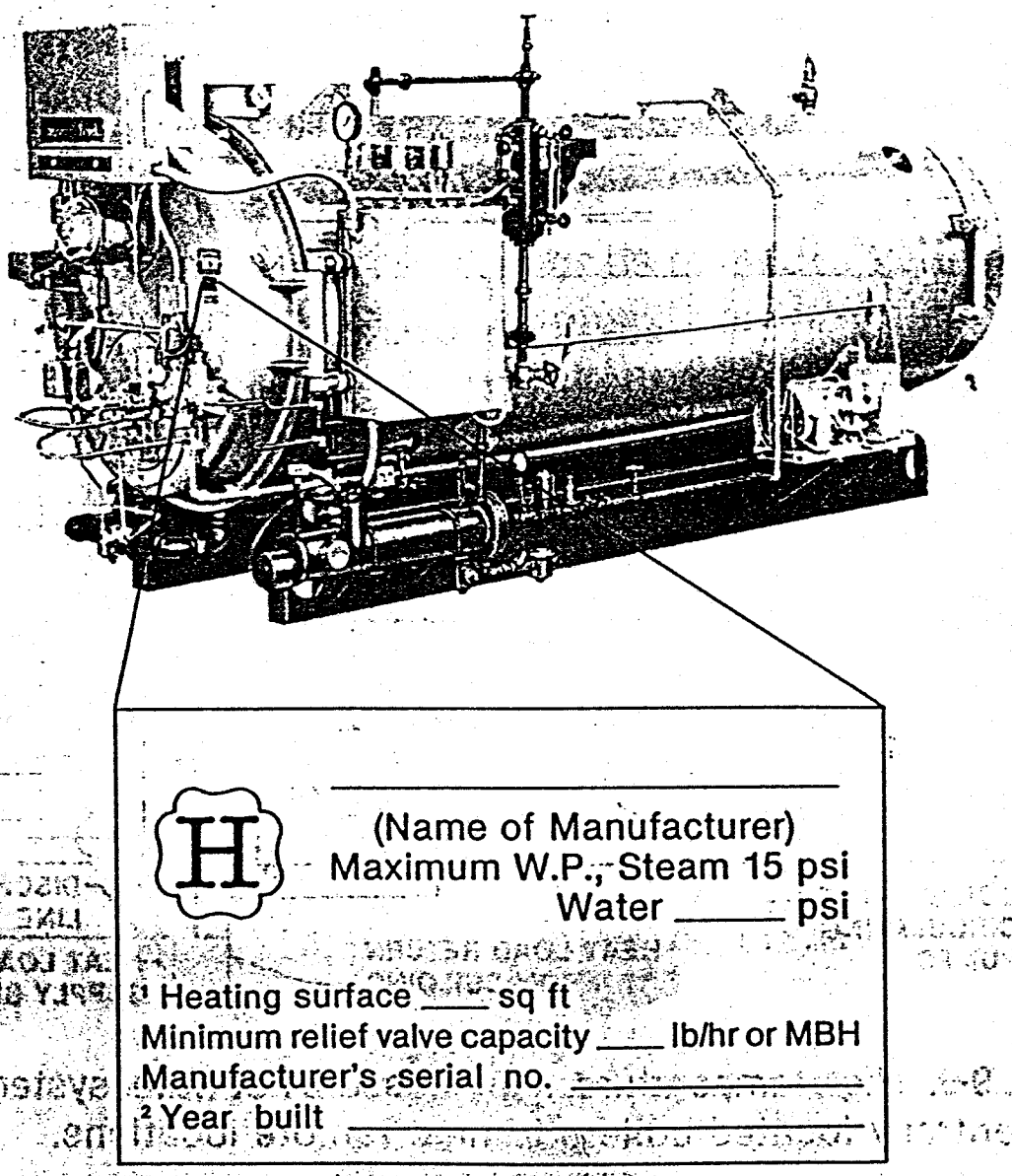

Figure 9-8. All boilers must have specifications for operation stamped or on a nameplate mounted on the boiler. (*Cleaver-Brooks*)

DETAIL *1A

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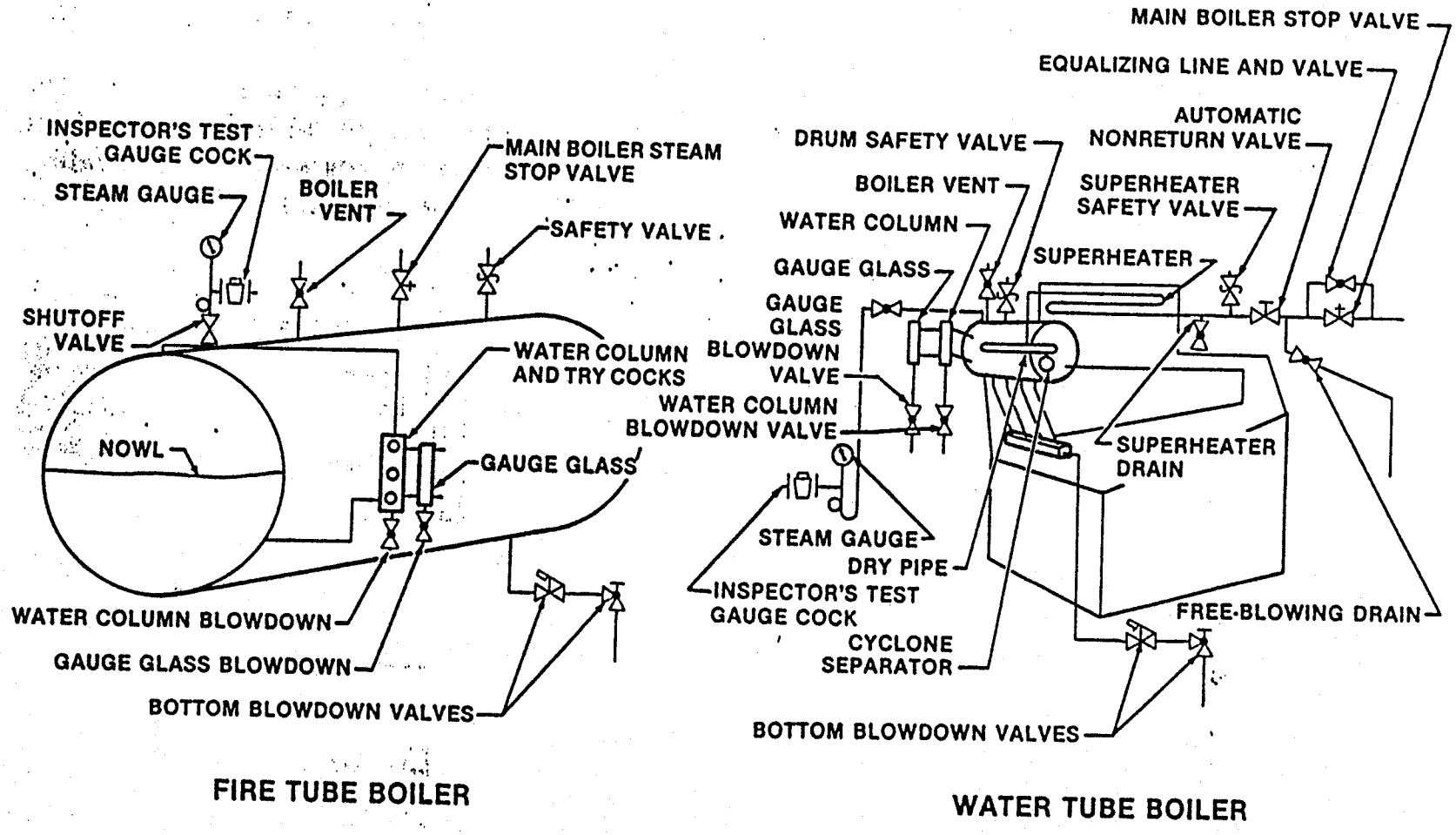

Figure 2-1. Fittings on boilers are located for visibility and accessibility.

DETAIL # 2

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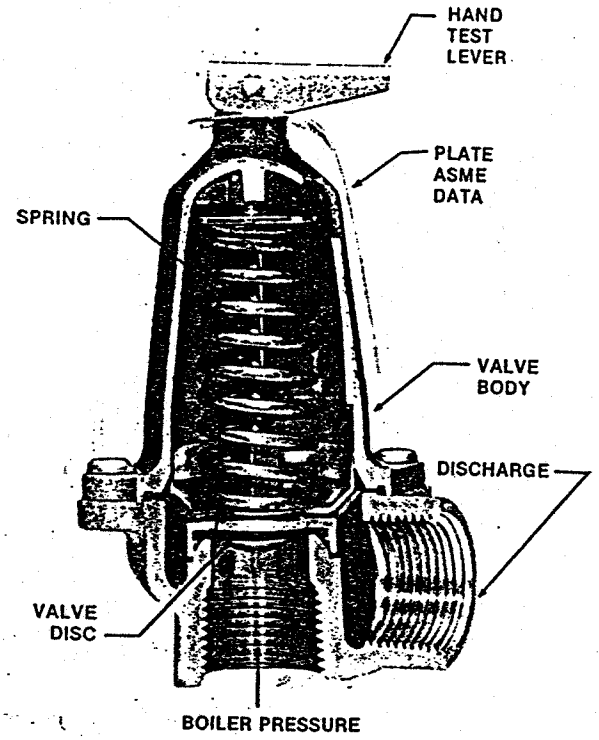

Figure 9-10. The safety relief valve prevents the boiler from exceeding its MAWP. (*Bell & Gossett Co.*)

DETAIL # 3

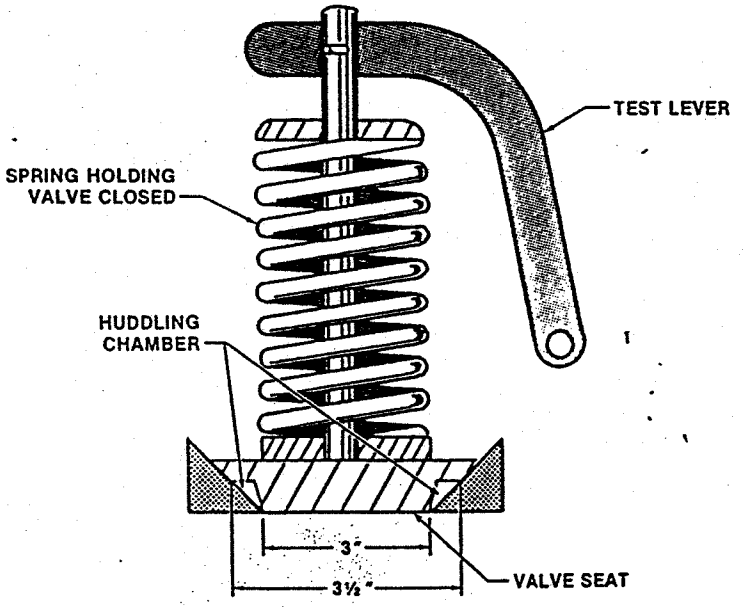

Figure 2-2. The huddling chamber allows the safety valve to open quickly, preventing damage to the valve seat.

DETAIL # 4

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DETAIL #5

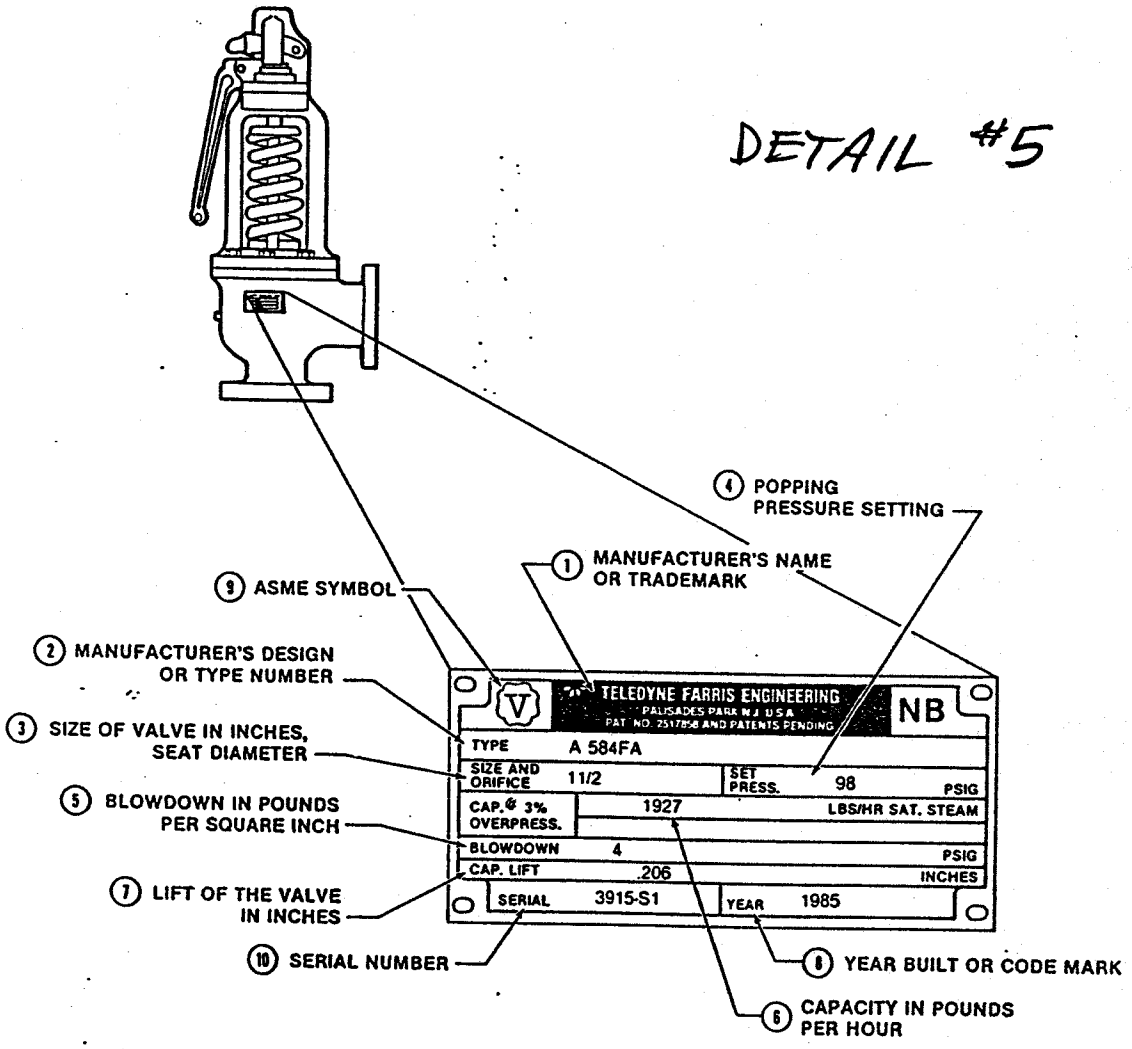

Figure 2-5. The ASME code requires certain data on all safety valve data plates. (*Teledyne Farris Engineering*)

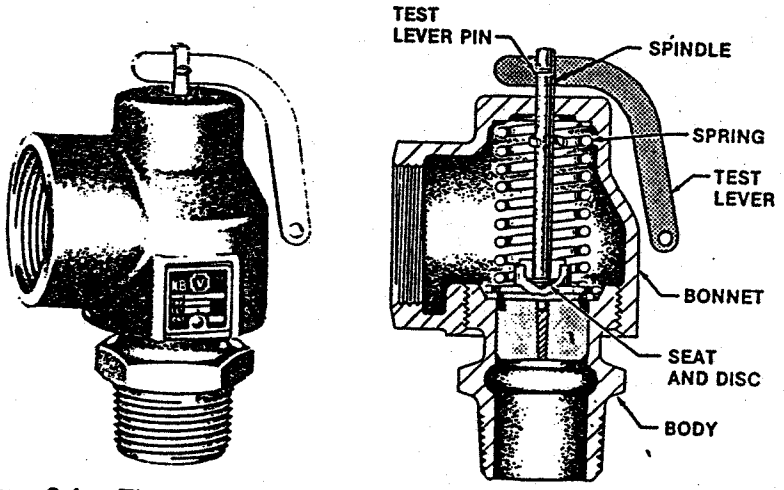

Figure 2-1. The spring-loaded pop safety valve pops open when steam pressure exceeds 15 pounds per square inch in the low pressure boiler. (*Manning, Maxwell, and Moore, Inc.*)

DETAIL #6

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DETAIL #7

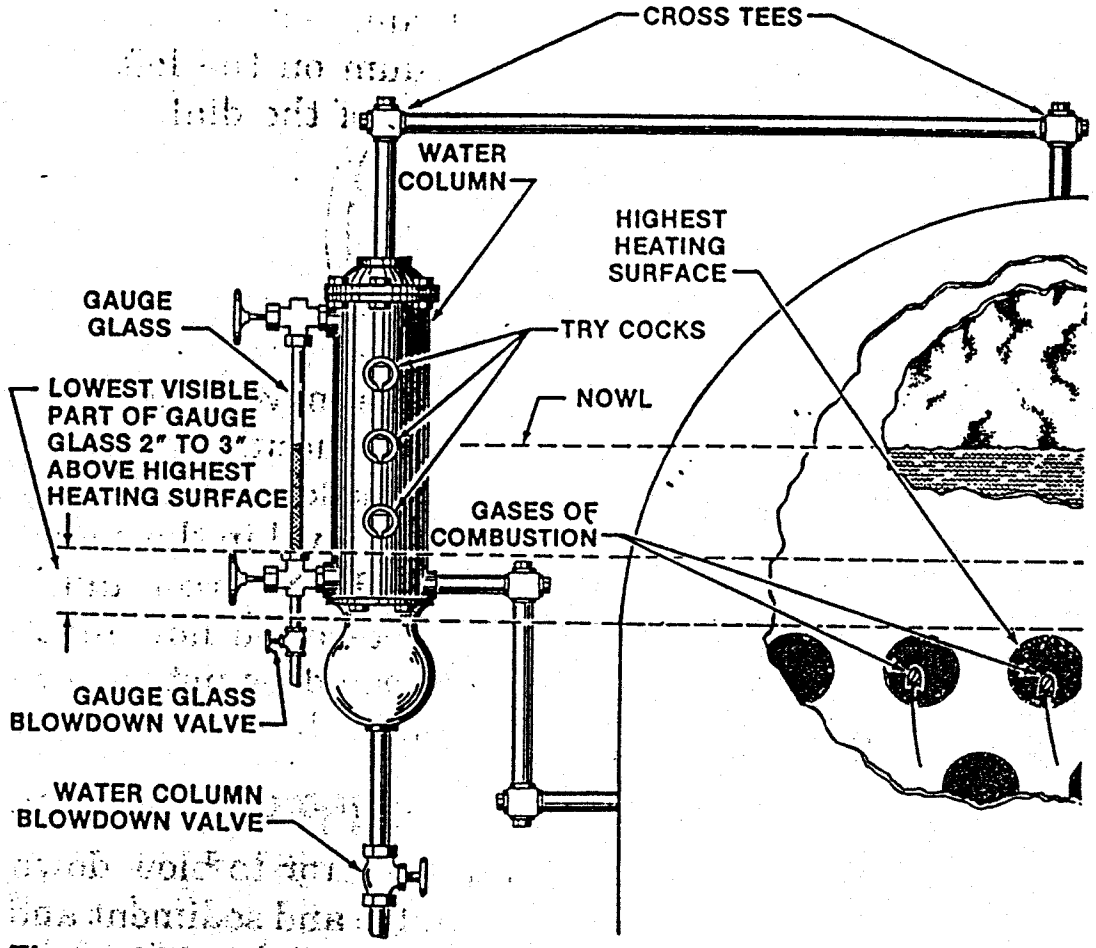

Figure 2-7. The gauge glass indicates the level of water in the boiler. Try cocks on the water column provide a second method of determining water level in the boiler.

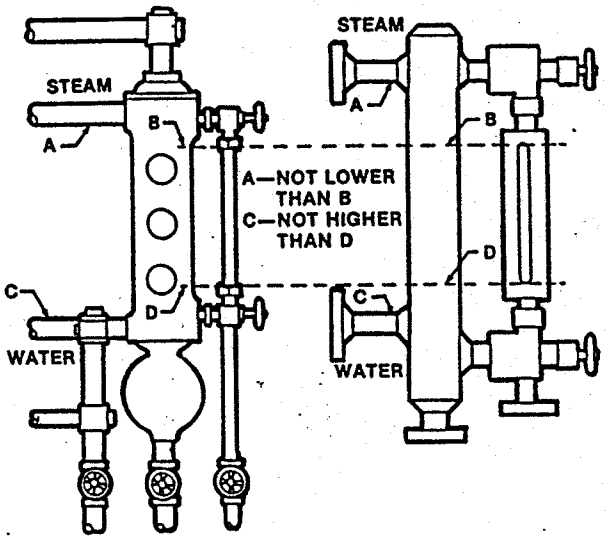

Figure 2-7. The arrangement of steam and water connections for a water column is specified in the ASME code.

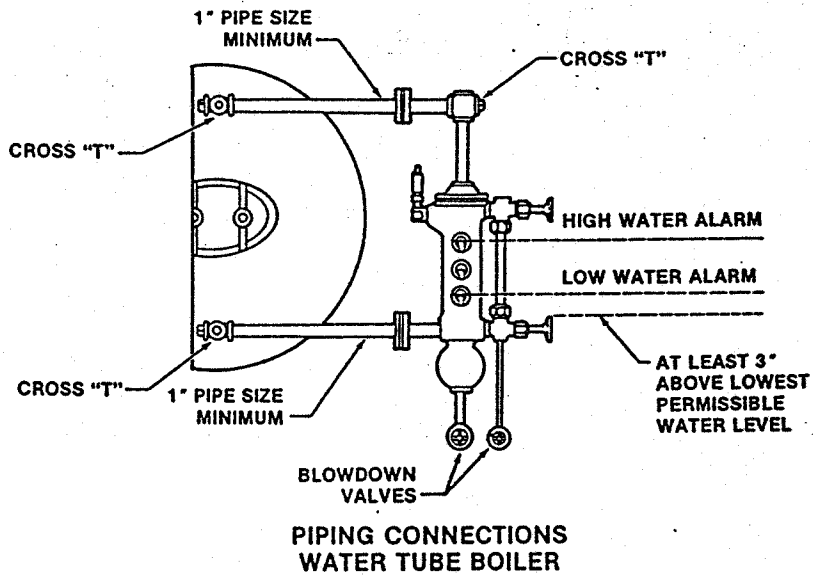

Figure 2-6. The location of the water column varies on different types of boilers.

DETAIL # 8

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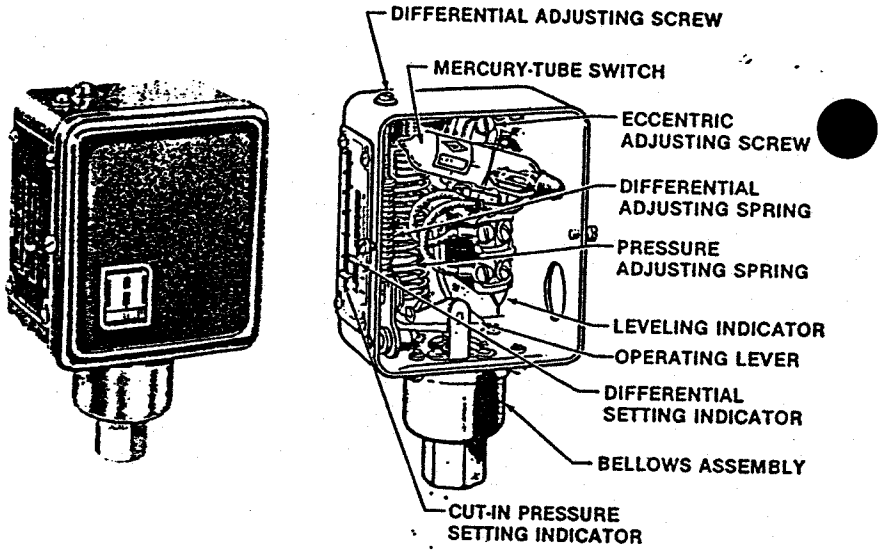
DETAIL #9



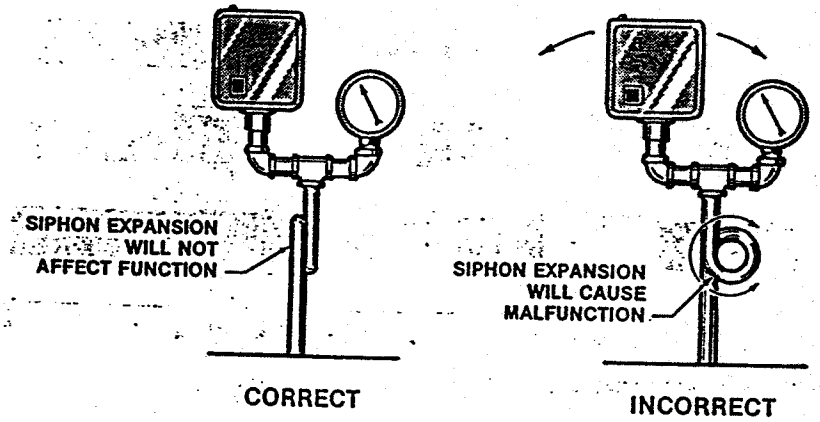
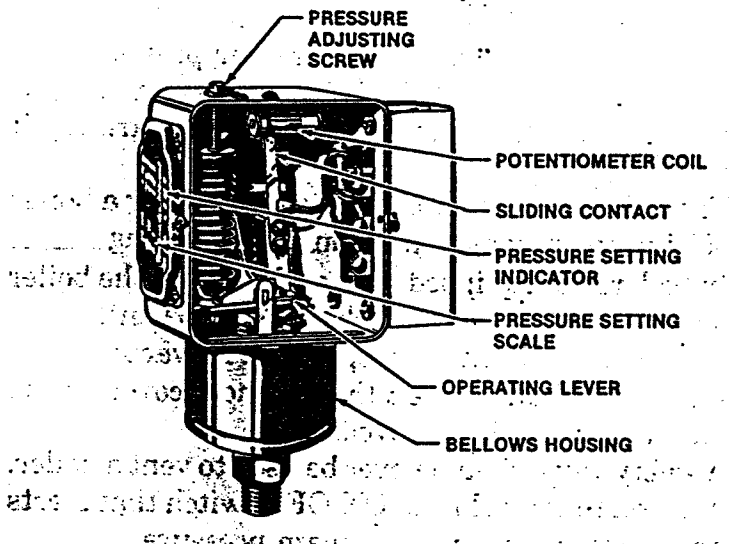


Figure 2-12. The pressure control turns the burner on and off. It must be installed correctly to function properly. (*Honeywell, Inc.*)



DETAIL #10

Figure 2-14. The modulating pressure control regulates high and low fire in the burner based on steam demand.

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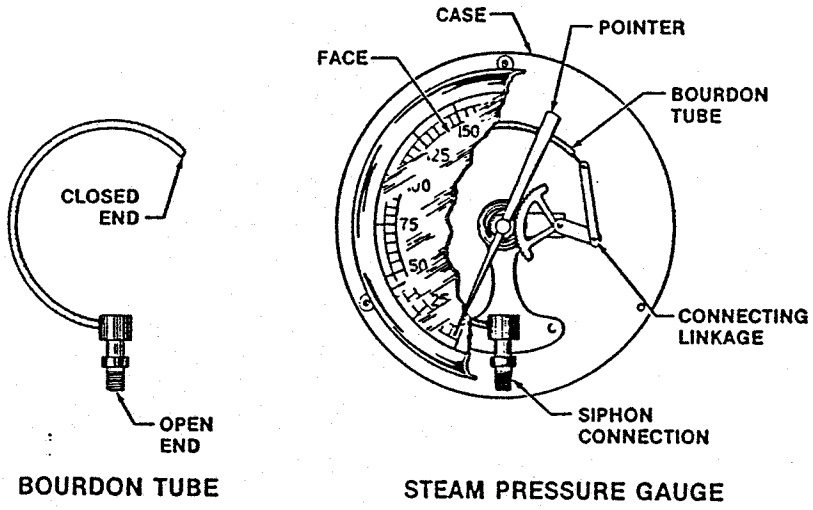


Figure 2-4. Pressure from the boiler causes the Bourdon tube to straighten in the pressure gauge. Connecting linkage converts movement of the Bourdon tube to the pointer.

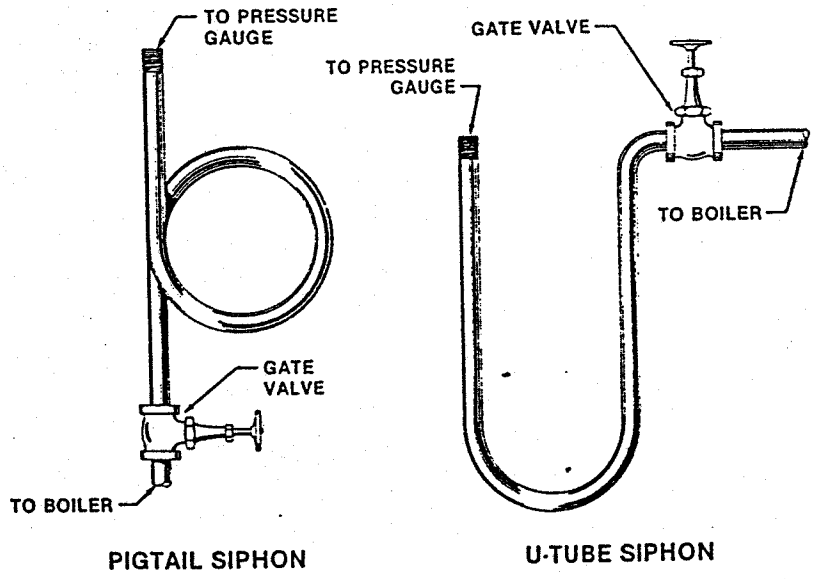
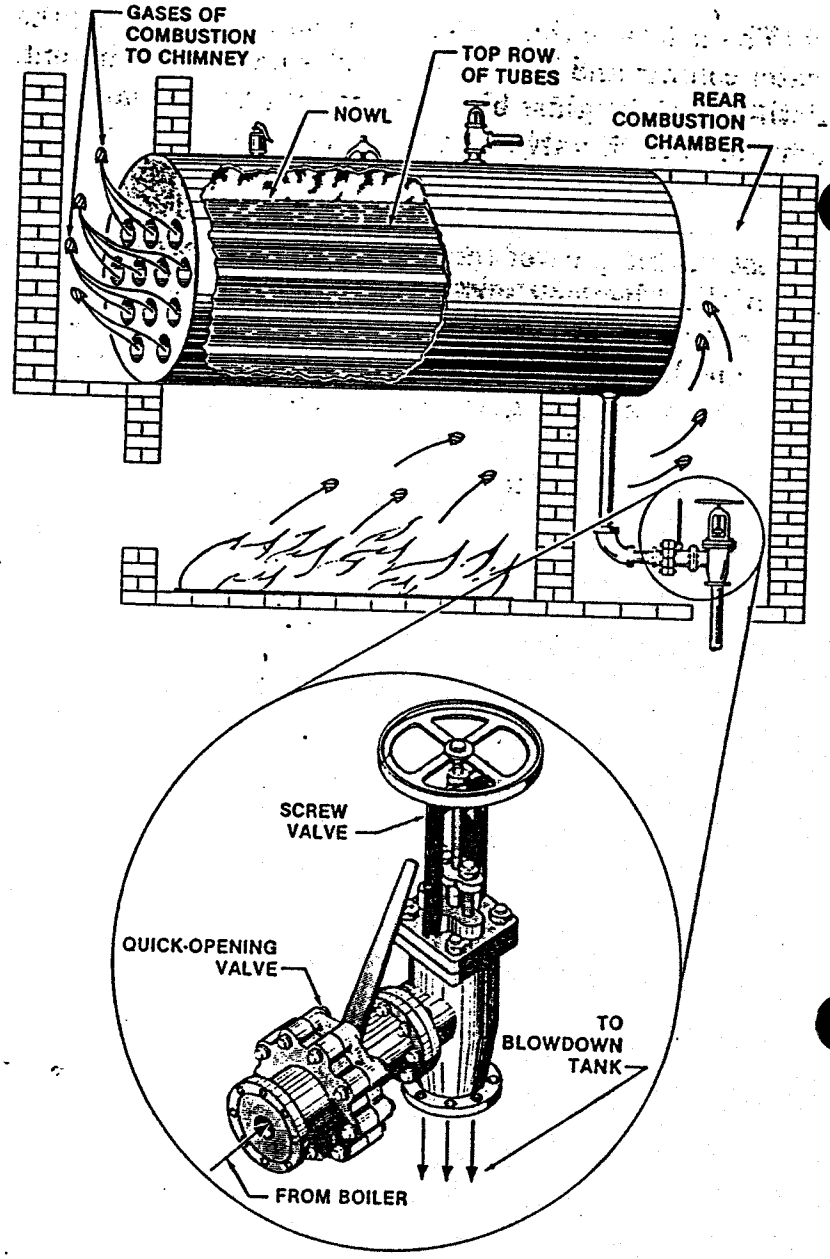


Figure 2-5. Siphons are used to prevent damage to the Bourdon tube of the steam pressure gauge caused by steam.

DETAIL # 11

DETAIL #13



BOTTOM BLOWDOWN VALVES

Figure 2-8. When two blowdown valves are used, the quick-opening valve should always be opened first and closed last.

DETAIL #12

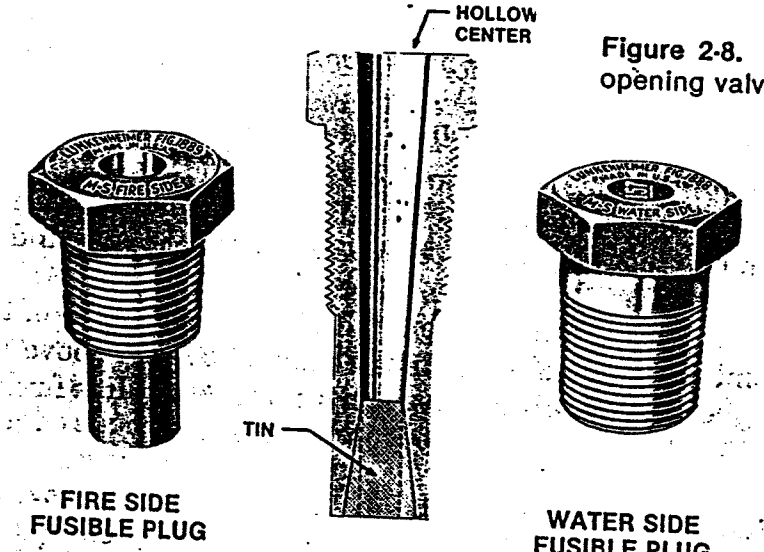


Figure 2-11. The tin in fusible plugs melts at 450°F, warning the operator of a low water level condition. (*Lunkenheimer Co.*)

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DETAIL #14

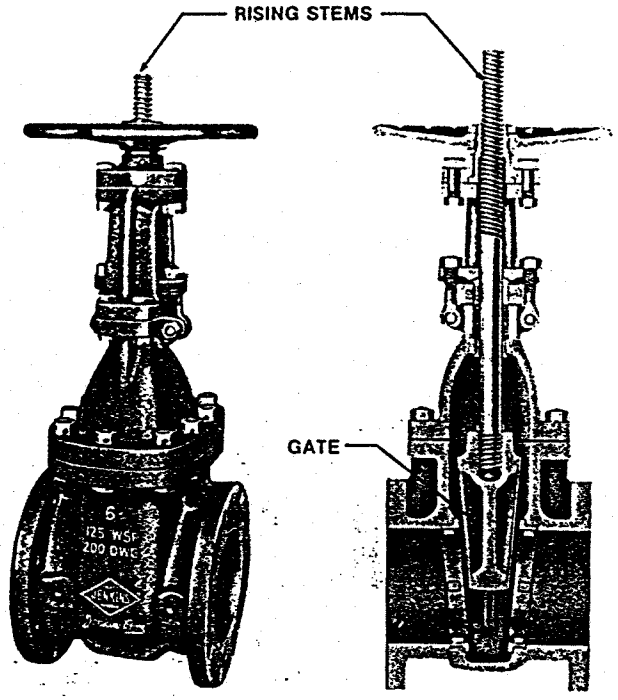

Figure 2-19. The os&y valve is used as the steam boiler stop valve. It will not restrict the flow of steam. *(Jenkins Bros.)*

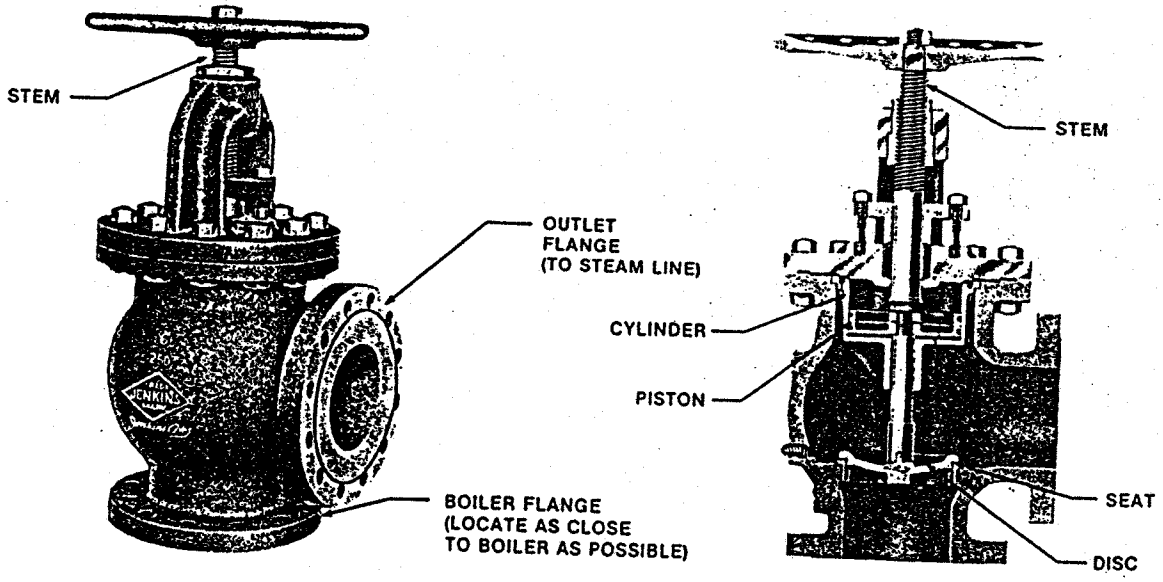

Figure 2-20. The automatic nonreturn valve is located as close to the boiler shell as is practical. It cuts the boiler in on the line and off the line automatically. *(Jenkins Bros.)*

DETAIL #15

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