STATE OF OREGON
DEPARTMENT OF CONSUMER AND BUSINESS SERVICES

BUILDING AND CODES DIVISION

BOILER CLASS 5, 5A/5B LICENSE EXAMINATION STUDY GUIDE

General Information for all Licensees

The following study guide is to be used to assist you in preparing for the questions on the State of Oregon Boiler Licensing Exams. This is not an extensive listing of knowledge expected from a "Qualified Certified Person." Where there are general discussions of ASME, NBIC, and NFPA Code requirements or of Oregon Administrative Rules or statutes, the study guide is not controlling: the applicable code, rule or statute is the final authority.

The exam questions are randomly selected from a set of over 400 questions that cover administrative rules, ASME, NBIC and NFPA Codes, materials, math, drawing, repairs, physical science, safety, trade knowledge and welding for Class 4 and Class 5 candidates. The exam questions are based upon the knowledge and experience that is expected of candidates for the Class certification being attempted.

The rules for licensing of persons installing, altering or repairing boilers or pressure vessels are listed in ORS 480.630 through ORS 480.645. Requirements for each "Qualified Certified Person" who can be licensed to install, alter or repair boilers, pressure vessels and pressure piping in the State of Oregon are listed in OAR 918-225-0691. These consist of Class 2, Class 3, Class 4, Class 5, Class 5-A and Class 5-B. The Class 1 Trainee/Helper and Class 6 Welder are not required to take and pass the Oregon Boiler License Exam to be certified. The exam covers the Oregon Revised Statutes and the Oregon Administrative Rules for boilers and pressure vessels but this study guide does not cover those administrative rules. These administrative rules may be printed off the web site for review and are available on line at:
http://www.cbs.state.or.us/external/bcd/programs/boiler.html

- Boiler Statutes: Oregon Revised Statutes (ORS) 480.510 to 480.670
- Boiler Administrative Rules: Oregon Administrative Rules(OAR) 918-225-0220 through 918-225-0800

The **2015 Oregon Boiler and Pressure Vessel Specialty Code** containing the minimum safety standards for boilers, pressure vessels, pressure piping, nuclear components, parts, items, and repair and alteration procedures follow:

(1) ORS 480.510 to 480.670 and OAR chapter 918, division 225;

(2) The **Boiler and Pressure Vessel Code of The American Society of Mechanical Engineers (ASME)**, **2013 Edition** as published, including Section I; Section II, Parts A, B,C and D; Section IV; Section V; Section VIII, Division 1, 2 and 3; Section IX; and Section X.

(3) The **2012 Edition of the ANSI/ASME B31.1 Power Piping Code**.

(4) The **2012 Edition of the ANSI/ASME B31.3 Process Piping Code**.

(5) The **2013 Edition of the ANSI/ASME B31.5 Refrigeration Piping Code**.

(6)The **2011 Edition of the ANSI/ASME B31.9 Building Service Piping Code**.

(7) The **2013 Edition of the National Board Inspection Code (NBIC) ANSI/NB 23**;

(8) The **2011 Edition of NFPA 85**, **Boiler and Combustion Systems Hazards Code**; and

(9) The **2012 Edition of ASME CSD-1**, **Controls and Safety Devices for Automatically Fired Boilers**.

The ASME Codes listed above are "codes of construction" and list the allowable design, materials, construction and installation of Code items. The NBIC lists the installation requirements and the permissible repairs to Code items.

This study guide will summarize sections of the above codes and discuss trade practices to assist in passing the Boiler license exam. For a more complete understanding of the above Codes, refer to the individual Code sections.

Class 5

Class 5 Pressure Piping Mechanic. A person holding this license may fabricate, install, alter and repair pressure piping; install boilers and pressure vessels by attachment of piping connections; and install, assemble and repair cast iron sectional boilers. Applicants shall:

1. Have a minimum of 2,000 hours of experience performing pipe-welding or brazing on B31 pressure piping and 2,000 hours of experience performing work on pressure piping. Experience must be verified as established in OAR division 30; and

2. Pass an examination testing the applicant's knowledge of:

    A. American Society of Mechanical Engineers Boiler and Pressure Vessel Code, **Sections I, II, IV, V, VI, VII, VIII, IX, CSD-1 and B 31 Pressure Piping;**

    B. Structural and mechanical blueprints with the ability to interpret specifications;

    C. Pressure piping systems and controls;

    D. Boiler and Pressure Vessel Laws, ORS 480.510 to 480.665 and OAR chapter 918, division 225; and

    E. Welding, brazing, chemical bonding procedures, heat treatment, metallurgy and other procedures applicable to pressure piping systems.

Class 5-A

Class 5-A Process Piping Mechanic License. A person holding this license may fabricate, install, alter or repair B31.3 process piping. Applicants shall:

1. Have a minimum of 2,000 hours of experience performing pipe-welding or brazing on B31.3 process piping and 2,000 hours of experience performing work on pressure piping. Experience must be verified as established in OAR division 30; and

2. Pass an examination testing the applicant's knowledge of:

    A. American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section B31.3;

    B. Structural and mechanical blueprints with the ability to interpret specifications;

    C. Pressure piping controls;

    D. Boiler and Pressure Vessel Laws, ORS 480.510 to 480.665 and OAR chapter 918, division 225; and

    E. Welding, brazing, chemical bonding procedures, heat treatment, metallurgy and other procedures applicable to pressure piping systems.

ASME B31.3 Category "M" piping is designated as lethal service piping. Category "M" piping is designated by the system owner and must be inspected by a Certified Process Piping Inspector that is employed by the piping system's owner.

All piping systems should be designed with consideration of vibration, thermal and seismic loadings.

Class 5-B

Class 5-B Refrigeration Piping Mechanic License. A person holding this license may fabricate, install, alter or repair B31.5 refrigeration piping. Applicants shall:

1. Have a minimum of 2,000 hours of experience performing pipe-welding or brazing on B31.5 refrigeration piping and 2,000 hours of experience performing work on pressure piping. Experience must be verified as established in OAR division 30; and

2. Pass an examination testing the applicant's knowledge of:

    A. American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section B31.5;

    B. Structural and mechanical blueprints with the ability to interpret specifications;

    C. Pressure piping controls;

D. Boiler and Pressure Vessel Laws, ORS 480.510 to 480.665 and OAR chapter 918, division 225; and

E. Welding, brazing, heat treatment, metallurgy and other procedures applicable to pressure piping systems.

Piping systems for refrigeration piping may utilize materials that meet the ASME B31.5 Code. These materials may be reclaimed provided the piping is properly identified. Bending and cold springing to align pipe is allowed providing the finished piping surface is free of cracks and buckles. Bell and Spigot type fittings may not be used. Toxic service fluids cannot use cast or malleable iron fittings. Piping designs for exposed piping systems must include the effects of wind loading. All pressure piping systems shall be designed for seismic loadings.

ASME Section IX covers brazing requirements.

A3 and B3 refrigerant piping butt and miter groove welds require both visual and 5% radiographic inspection.

Pressure testing of refrigeration piping systems shall be at least 110% but not more than 130% of the system design pressure.

Pressure Vessel Installations

Piping Attachments

Flanged Attachments- The bolts in a flanged connection must exhibit full thread engagement. This means that bolts shall engage so that the threading goes completely through the nut. Follow manufacturers' recommendations when tightening flange bolts.

Threaded fittings- Completed thread fittings must leave at least two threads exposed. In addition, different sized fittings have a minimum number of threads that must be engaged in the fitting. Minimum thread engagement in threaded fittings are as follows:

- Under 1-1/2" NPS 4 threads
- 1-1/2" & 2" NPS 5 threads
- 2-1/2" to 4" NPS 7 threads
- 5" & 6" NPS 8 threads
- 8" NPS 10 threads
- 10" NPS 12 threads
- 12" NPS 13 threads

EXAMPLE: A 2" NPS fitting must have at least 5 threads engaged and must leave at least 2 threads exposed.

Piping Materials-

- Piping materials for ASME applications must be listed in ASME Section II.
- ASME-listed piping materials must have identifying marks recording the piping type, manufacturer and heat numbers of the batch for traceability.

- When ASME piping materials are cut, the identifying numbers must be transferred to the cut pieces. Since coatings would make the identifying markers unreadable, painting prior to installation or galvanizing is not allowed.
- Some non-metallic piping, including plastic piping, is listed in ASME Section II and is allowed in ASME B31.9, Building Service Piping, but the use of PVC plastic pipe is not allowed.
- PVC piping may not be used because it may fracture under pressure and will become brittle when cold. In air compressors, PVC could be affected by compressor oils in the air stream.
- ASME B31.9, Building Service Piping covers piping systems operated at pressures up to 150 psi.

Used piping-
Used piping and piping fittings may only be used after thorough cleaning and inspection by an authorized inspector. If identifying marks are not clearly visible, the inspector may require mechanical and/or chemical testing to verify the composition of the material.

Pressure testing of vessels and piping systems-
Leak testing of pressure vessels and piping systems may be required by an inspector. The To safely pressurize a system for a leak test:

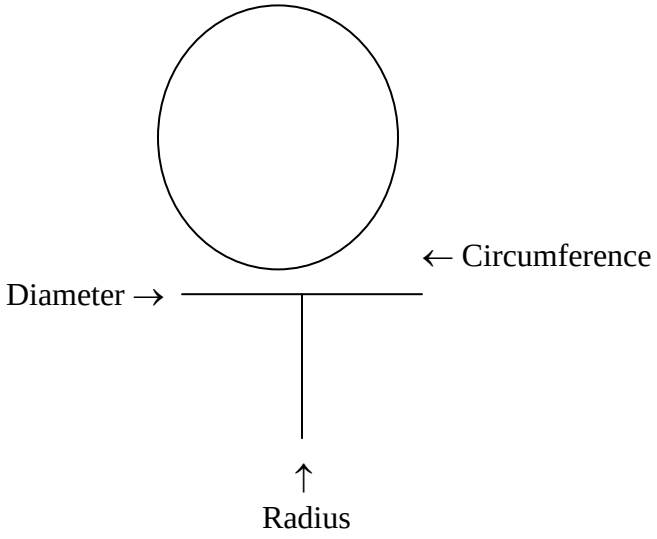
- the system's pressure must be gradually increased to a required test pressure (provided by the inspector)
- the test pressure must be maintained for a designated period of time, generally between 10 to 20 minutes.
- If water is used to perform the leak test, the metal temperature must be at least 60^{o}F to assure the vessel is not thermally stressed. For personnel safety, the temperature should not exceed 120^{o}F.
- If air or nitrogen is used to perform the leak test, the test will be performed at lower pressures and must first be approved by an inspector. Air and nitrogen under pressure have high kinetic energy and could create an explosion if there is a rupture.

Piping weight and hydrotests-
When installing piping, the additional weight that will be applied during a hydrotest must be taken into consideration. Even air piping must be installed so that it can bear the weight that will be applied during a hydrotest. Thus, an installer must know the weight of the entire piping system in order to properly design and select pipe supports and hangers.
To know the weight of a section of pipe that is filled with water, you must know:

- The weight of the pipe per foot of run
- The volume inside the pipe
- The weight of the water required to fill that volume

Figuring out this information sometimes requires the use of basic math and the memorization of some basic facts about the weight of water and the volume of water within an area.

Mathematical terms related to circles:



For the purposes of using math in the field, π (pi) is rounded off to be 3.14

You should also know how to convert fractions into decimals:

To convert ¾ into a decimal, divide 3 by 4, which would give you .75
You can use a calculator to do this, or you could do it long hand by adding a decimal point and zero to the top half of the fraction (dividing 3.0 by 4) and putting your answer to the right of the decimal point your answer.

½ = .50 [1.0÷2 = .50]
1/3 = .333 [1.0 ÷ 3 = .333]
4/5 =.80 [4.0 ÷5 = .80]
7/8 = .875 [7.0 ÷ 8 = .875]

Area of a circle
The formula for calculating the area of a circle is**:**

Radius x Radius x 3.14 = Area
(πr^2= Area)

Example- For a **6 inch** diameter pipe, the radius equals one half of the diameter, 3 inches

3 inches x 3 inches x 3.14= 28.3 square inches

Circumference of a circle
The formula for calculating the circumference of a circle is:

Diameter x 3.14= Circumference

2

(πd=Circumference)

Example- For a 6 inch diameter pipe,

6 inches x 3.14= 18.84 inches in circumference

Also, with pipes there are two circumferences:

- the inner circumference (the circle that is on the inside of the pipe)
- the outer circumference (the circle that is on the outside of the pipe)

As pipes get larger there can be a substantial difference between the inner circumference and the outer circumference.

To calculate the inner circumference you would use the diameter of the inside of the pipe.
To calculate the outer circumference, your diameter would be the diameter from the inside of the pipe plus the thickness of the pipe.

Example- The outer circumference of a ½" thick pipe with a 6 inch inner diameter would be:
7 inches (6" inner diameter plus ½" thickness on both sides) x 3.14= 21.98 inches

Volume of a cylinder (or pipe)

The formula for calculating the volume of a cylinder is:

Area x Length = Volume

Example- For a **6 inch** pipe with a **24 inch** run (length):

28.3 inches x 24 inches = 679.2 cubic inches of volume

Calculating gallons of water per cubic inch

The formula for knowing how much water is in a volume of pipe is:

One gallon of water = 231 cubic inches of piping

We know from the previous calculations that a 6 inch pipe that runs 24 inches pipe holds **679.2** cubic inches of water volume.

679.2 (volume in cubic inches) ÷ 231 (# of cubic inches in a gallon) = 2.94 gallons

Weight of water

The formula for the weight per gallon of water is:

One gallon of water weighs 8.34 pounds

Since our 6 inch pipe that runs 24 inches holds 2.94 gallons of water we can determine the weight of the water as follows:

2.94 gallons x 8.34 pounds = 24.5 pounds of water

Pressure of water

The formula to determine the pressure of water at the bottom of a column of water (for example, the bottom of a pipe or tank) is:

Height of the column in feet x .434 = pressure per square inch (PSI)

Example- The pressure for a 40 foot high column of water is:

40 x .434 = 17.36psi

Boiling point of water and other substances -

- The boiling point of a liquid is the temperature at which the vapor pressure of the liquid equals the environmental pressure surrounding the liquid.
- A liquid in a vacuum environment has a lower boiling point than when the liquid is at atmospheric pressure.
- A liquid in a high pressure environment has a higher boiling point than when the liquid is at atmospheric pressure.
- In other words, the boiling point of liquids varies with and depends upon the surrounding environmental pressure.
- The normal boiling point of a liquid is the special case in which the vapor pressure of the liquid equals the defined atmospheric pressure at sea level.

Example- The normal boiling point of water is 100°C/212°F

Heat Capacity

Specific heat capacity is the measure of the heat energy required to increase the temperature of a unit of a substance by a certain temperature. More heat energy is required to increase the temperature of a substance with high specific heat capacity than one with low specific heat capacity.

The term "BTU" is used to describe the heat value (energy content) of fuels, and also to describe the power of boilers, as well as heating and cooling systems. When used as a unit of power, BTU 'per hour' is understood, though this is often confusingly abbreviated to just "BTU".

- 1 watt is approximately 3.413 BTU/h
- 1000 BTU/h is approximately 293 W
- 1 horsepower is approximately 2,544 BTU/h

A BTU is also the energy required to raise one pound of water by one degree Fahrenheit.

Design Pressure

All pressure containing *components* must be rated at a design pressure at least as high as the vessel design pressure. Piping components such as flanges and valves are typically marked with the design pressure.

Valves

- ASME approved safety relief valves are required for every vessel

- Shut off valves are not permitted on either the inlet or discharge of safety relief valves
- The piping on the discharge side of a safety relief valve may not be reduced down nor routed such that the flow could be restricted by pocketing that traps liquid.
- The discharge from the safety relief valve must be directed to a safe location.
- Safety relief valves must be handled carefully so as to not disturb their setting
- If the safety relief valve's assembly seal is not intact, the valve must be retested and re-certified or the unit must be replaced.
- Safety relief valves can only be disassembled and set by a NBIC authorized Service Center.
- Valves should be positive shut off. Positive shut off valves include gate valves, ball valves, tapered cock valves and globe valves. Globe valves are directional and should be installed with the flow direction below the disc.
- Valves should be clearly marked as suitable for the service. For example, a water, oil gas service valve should be marked: "W-O-G" for water, oil and gas.

Workplace Safety

Pipe fitters and boilermakers are commonly exposed to potential safety hazards.

General Safety Precautions

- When working on oxygen piping or oxygen generators, care should be taken to eliminate organic materials as these can combust when exposed to the oxygen. A simple oily rag exposed to oxygen can ignite.
- Oxygen storage tanks must be installed on a non oxidizing surface.

Confined areas, like service pits or the inside of a boiler or pressure vessel, can lack sufficient oxygen for safe breathing. Before entering such a space:

- Make sure an OSHA approved confined space entry procedure is being followed. (Oxygen levels must be tested, there must be adequate ventilation, and the temperature must not be too high).
- Where welding is taking place there must be a trained person watching for fire and able to perform rescues and emergency medical treatment.

Fires and explosions are one big risk in the work site. In order to deal with this risk safety precautions should always be followed and individuals need to know how to properly use fire extinguishers.

Fire extinguishers are marked with the class of fire they are designed to be used upon:

Class A	Wood, sawdust, paper, rags
Class B	Flammable liquids, oils, tars and gasses
Class C	Electrical equipment
Class D	Combustible, self-oxidizing metals

Water hoses should *only* be used on Class A fires. Water can cause explosions or a worsening of the fire if it is used on a Class B, C, or D fire.

Foam, CO_2 and dry powder extinguishers eliminate the oxygen from different types of fires, the following types of extinguishers are suited to the following type of fire:

- **Class A fires,** water or CO_2 extinguishers
- **Class B fires,** CO_2 or foam extinguishers
- **Class C fires,** CO_2 extinguishers or dry chemical extinguishers must be used if there is live current
- **Class D fires,** different metals require different extinguishing materials, thus the work site should have dry powder extinguishers that are appropriate for the potential fire dangers

Blueprints

Blueprints are generally drawn through isometric projection. Isometric projection is a mathematical method of constructing a 3 dimensional object without using perspective. Isometric projection was an attempt to make drawings more realistic.
The mathematics involved mean that all lengths when drawn at 30 degrees can be drawn using their true length (in other words lines aren't shortened as with oblique drawings).
An isometric drawing shows two sides of the object and the top *or* bottom of the object. All vertical lines are drawn vertically, but all horizontal lines are drawn at 30 degrees to the horizontal. Isometric is an easy method of constructing a reasonable '3 dimensional' images.

The term *isometric* comes from the Greek for "equal measure", reflecting that the scale along each axis of the projection is the same (this is not true of some other forms of graphical projection).

Boiler Installation Requirements

ASME stamps
All boilers and pressure vessels shall be installed to comply with the Oregon State Boiler and Pressure Vessel Law and must be ASME Code Stamped (unless installed to an approved International standard):

- **Section I power boilers** shall be stamped with a **A**, **M**, **E**, or "**S**" code stamp.
- **Section IV hot water heating boilers and hot water supply boilers** shall be stamped with an "**H**" or "**HLW**" code stamp.
- **Unfired pressure vessels** shall be stamped with a "**U**" or "**UM**" code stamp.
- **Welded boiler external piping over NSP 2"**, if installed by other than the boiler manufacturer, must be stamped with a "**S**" or "**PP**" code stamp.

Notifying Authorized Inspector before Work Begins

All installation/repair permits issued by the State of Oregon Building Codes Division require that the authorized inspector be notified prior to commencement of work. It is imperative that the inspector is contacted as some installations and most repairs require inspections before much progress is made on a project. Work done prior to the approval of the inspector may have to be removed and re-done.

Controls and Safety Devices for Automatically Fired Boilers (CSD-1)

ASME CSD-1, Controls and Safety Devices for Automatically Fired Boilers applies to all boilers under 12,500,000 BTU.

National Fire Protection Association (NFPA) requirements apply to boilers 12,500,000 Btu and over.

Control devices are required to be **tested and certified by the Underwriters Laboratory** (UL). Rebuilt and repaired devices are not allowed as their certification is no longer valid.

All **electrical components** shall be mounted in the appropriate National Electrical Manufacturers Association (NEMA) enclosures.

All **wiring** for boilers shall be rated for the maximum temperature to which they may be exposed.

Boiler Clearances
Installation of boilers in newly constructed boiler rooms shall have:

- A minimum **side clearance of 36 in.** on each side and adequate room to all for removal and installation of boiler tubes.
- The **top clearance must be at least 36 in.**, unless there is a top manway where a top clearance of 84 in. is required.
- Boilers with bottom openings shall have at least **12 in. bottom clearance**.
- Boilers **in battery** (connected to each other) shall have a **minimum of 48" clearance** between the boilers.

Boiler Room Exits
Boiler rooms shall provide two means of exit when the boiler room exceeds 500 sq. ft. and the boilers have a capacity of 1,000,000 Btu/hr or greater.

Multiple Boiler Installations
For multiple boiler installations:

- Steam boilers shall all be installed such that all boilers have the same low water operation level.
- High pressure steam outlet stop valves used where the boilers have man-ways and a common header require two outside screw and yoke rising stem block valves.
- A stop valve shall be installed in each supply and return connection for each boiler.

- For high pressure steam boilers with man-ways connected to a common header, the boiler external piping ends at the second block valve.
- Diligence must be exercised to assure that the boiler you are working is locked out and tagged out.
- Each boiler shall have temperature, pressure and level limit controllers and not rely on safety controllers that are located on a common header.
- Steam boilers operated in battery shall not be installed closer than 48 inches from each other.

CSD-1

The operation of control systems and safety devices installed as required by CSD-1 shall be tested by the installing contractor prior to release to the owner/user. Installing contractors shall provide a written report for each installation that shall list:

1) each control and safety device installed in accordance with CSD-1
2) name of the manufacturer and model number of each device
3) operational tests performed

The above items shall be verified by signature of an authorized representative of the installing contractor on this report. This report shall be made available to the authorized inspector prior to final inspection. The installing contractor shall provide to the owner/user pertinent operating, testing, servicing and cleaning instructions for the controls and safety devices together with complete wiring and piping diagrams and a written precaution that operating, testing and servicing may only be performed by qualified individuals.

Valves in General

- All valves or cocks shall have adjustable stem packing glands and provide tight closure.

- Valves shall indicate when open by either a lever in cock valves or a rising stem for gate valves.

- No shut off or other valves are to be placed between the boiler and the pressure controllers, nor should valves be placed on the discharge side of a pressure relieving valve.

- Discharge piping must be directed to a safe location and the weight of that discharge piping cannot be supported on a valve, as this could cause distortion of the valve mechanism and affect the performance of the valve.

- The purpose of stop check valves on the main boiler steam discharge line to a steam header for multiple boilers is to prevent steam from entering a cold boiler. Cold water should never be introduced into a hot boiler. Feedwater piping should be located such that the addition of water is not onto a hot boiler surface.

- "Water hammer" is a pressure surge or wave resulting when a fluid in motion is forced to stop or suddenly change direction. **Water hammer commonly occurs when a valve is closed suddenly at an end of a piping system, and a pressure wave develops in the pipe**. Water hammer in piping or a vessel can cause a rupture. The hammering sound heard is the result of liquid water traveling ahead of expanding steam. The pressure wave can exceed the safe allowable pressure in the pipe or vessel.

Pressure Relieving Valves

Pressure relieving valves are generally spring controlled valves that pop open at a preset pressure to assure that the vessel cannot over-pressurize.

- **Any pressure relieving device** used on an ASME boiler or pressure vessel must be marked with an ASME "V", "HV" or "UV" code stamping.

- **Section I power boilers** that exceed 500 sq. ft. of heating surface must have 2 or more safety valves. The valves shall be sized such that the relieving capacity will not allow the pressure of the boiler to exceed 106% of the maximum allowable working pressure (MAWP).
  Example: A 750 square foot boiler with a MAWP of 150 pounds per square inch would require 2 safety valves. The two valves, in combination, could not allow the boiler to exceed 159 psi (106% of the MAWP)

- **An electric boiler** with a power input of more than 1100 kW must have 2 or more safety valves. The valves shall be sized such that the relieving capacity will not allow the pressure of the boiler to exceed 106% of the maximum allowable working pressure (MAWP)
  Example: A 750 square foot boiler with a MAWP of 150 pounds per square inch would require 2 safety valves. The two valves, in combination, could not allow the boiler to exceed 159 psi (106% of the MAWP)

- **Section IV steam boilers** cannot have individual safety valves that are larger than 4" NPS (4" nominal pipe size)

- **Steam boilers** must use a safety valve that is designed for steam only

- **Section IV heating boilers** cannot have individual safety valves that are larger than 4" NPS.

- **Section IV boiler** valves shall be made of ASME Code Section II approved materials or an ASME Code accepted standard, such as ANSI. The minimum pressure/temperature rating shall at least equal the pressure limits stamped on the boiler and equal to the boiler design temperature but not less than 250^{o}F.

- **Hot water boilers** must have a relief valve designed for water use. The safety relief valve shall be set to relieve at or below the MAWP of the boiler

- **Section VIII pressure vessels** use a valve with an enclosed spring that is designed for either liquid or gas applications. Air is a gas.

- All spring controlled pressure relieving valves must be mounted with the valve stem in a vertical position, close to the vessel (for boilers the device must be mounted directly to the boiler)

- **Steam boilers** must have the safety valves located at the top of the boiler and above the normal high water operation level

- **Steam boilers** shall have at least one steam pressure control device that will shut off the fuel supply when the steam pressure reaches a preset operating pressure. An additional pressure controller is required that will prevent generation of steam pressure that exceeds the MAWP of the boiler. This high limit pressure controller shall have a safety shutdown and lockout with a manual reset. Steam boilers also require a siphon tube or other means that maintains a water seal between the boiler and the pressure controllers. Residential installations do not require the lockout feature on the high limit pressure controller. Steam supply connections to a pressure control shall not be less than the following:

    - Non-ferrous materials
      NPS ¼" up to 5 ft. length
      NPS ½" over 5 ft. length

    - Ferrous materials
      NPS ½" up to 5 ft. length

    - NPS 1" over 5 ft. length

Temperature and Pressure Safety Valves

Hot water service vessels with a temperature limit of 210^{o}F, such as HLW hot water storage tanks, some coil type boilers and hot water heaters shall utilize a temperature and pressure safety valve (T&P).

- T & Ps have a bi-metallic probe that opens the valve prior to the boiling point of water.
- T & Ps may be mounted in a horizontal position but must be located such that the probe is always immersed in water at the normal operating liquid level and the outlet pointed down. The horizontal mounting cannot be lower than 4" from the top of the vessel and cannot have more than 4" of interconnecting piping. The discharge must be self draining.

Gages

All boilers shall have a shut off cock between the boiler and a gage with a lever handle that is parallel with the supply line to the gage when the cock is open

Section I steam boilers shall:

- Have a pressure gage that reads approximately double the relief setting of the safety relief valve and never less than 1 ½ times the relief safety setting.
- Have a siphon tube that maintains a water seal between the boiler and the gage. The minimum size for the siphon if used shall be ¼" inside diameter.
- Have connections to the boiler, except the siphon, that are not less than ¼" NPS, but where steel or wrought iron pipe or tube is used, they shall not be less than ½" inside diameter.

Section IV hot water heating and hot water supply boilers require a temperature gage or thermometer located in the liquid portion of the boiler near or at the outlet of the boiler.

Section I and Section IV steam boilers require water level indicators.

- Section I boilers must have a visible gage that is mounted with the lowest visible water level at least 2" above the lowest permissible water level.
- Section IV steam boilers must have a visible gage that is mounted with the lowest visible water level at least 1" above the lowest permissible water level.
- Multiple gage glasses must have a 1" overlap in visible water level.
- Connections to and from the water column must be a minimum NPS 1 with the boiler connections having the upper connection in the steam section of the boiler and the lower in the water section.
- The drain on the water column must be at least NPS ¾.
- Gage glass connections must be at least NPS ½.
- A cross or tee pipe fitting shall be used at 90^{o} turns to facilitate cleaning.

Water Level Controls

Water level controls vary with the type of boiler.

- Commercial installations of **steam boilers** require two low water fuel cutoffs.
    - One cutoff is mounted to actuate before the other cutoff
    - The lower cutoff unit must actuate prior to loss of visible water in the sight glass
    - The lower cutoff must shut down the energy to the burner *AND* lock out as well. There is to be a manual reset on the locking out unit.
    - The units on steam boilers must be located on separate water columns with no intervening valves and separate attachments to the boilers water section. There may be a common steam section attachment.
    - Cross or tee pipe fittings shall be used at 90^{o} turns to facilitate cleaning.
    - Controls should be cleaned annually.

- **Coil type hot water heating boilers** that require forced circulation shall have a flow sensing switch that will prevent operation of the burner when there is an inadequate flow rate. The flow switch shall have a testing circuit that will automatically restore to service after testing is complete.
- **Hot water heating boilers** shall have a temperature actuating control to shut off the fuel supply when the water reached a preset operating temperature. A second temperature control is required to limit the water temperature to the maximum allowable temperature; the upper set point adjustment must be fixed at the maximum allowable temperature. This

control shall cause a shut down and lockout of the boiler. The lockout feature on the high limit device is not required on residential installations.

Pressure testing boilers depends upon the type of boiler. Most types of boilers are to be hydro tested by filling the boiler with water that is at least 60^{o}F and gradually increasing the pressure to 1-1/2 times the MAWP of the boiler. The boiler temperature should not exceed 120^{o}F. The pressure shall be measured by a certified gage that has a measuring range of about double the test pressure but in no case less than 1 ½ times the test pressure.

Drains and Bottom Blow Down Pipes

Section IV low pressure boiler drains for steam or hot water boilers shall:

- Be a minimum of ¾" NPS
- Have a valve that is pressure rated at least equal to the MAWP of the boiler, but in no case less than 30 PSI.
- The valve must have a minimum temperature rating of no less than 250°F
- Drain piping must be located at the lowest point of the boiler shell.

Cast iron boilers are required to have a wash out opening that is NPS 1-1/2 for boilers with a volume more than 5 ft^3 or NPS 1 for boilers not more than 5 ft^3. Damaged cast iron boiler sections are not allowed to be brazed, welded or epoxy repaired. Code welding cannot be done on metals that have over 0.35% carbon. Cracked or eroded sections can only be replaced with a new section.

Cast aluminum boilers are required to have a wash out opening that is NPS 1-1/2 for boilers with a volume more than 5 ft^3, NPS 1 for boilers from 2 ft^3 to not more than 5 ft^3 or NPS ¾ for boilers less than 2 ft^3.

Section I steam boiler bottom blow down pipe fitting within the boiler external boundary shall:

- Be made of steel
- The pipe thickness shall not be less than that of a schedule 80 pipe for boilers with a maximum working pressure exceeding 100 PSI
- Galvanized steel pipe and fittings shall not be used for blow down pipe.
- Section I steam boilers with a working pressure of more than 100 PSI shall have two slow opening valves or one quick opening valve at the boiler nozzle followed by a show-opening valve.

Minimum size of bottom blow-off piping and valves are:

1. Square feet of heating area for Section I "S" Stamped boilers
    - up to 20 Minimum NPS ½"
    - over 20 to100 Minimum NPS ¾"
    - above 100 Minimum NPS 1"
    - Maximum size of blow down pipe is 2 ½"

2. Steam capacity in lbs per hr for Section IV "H" Stamped boilers
    - up to 500 NPS ¾"
    - 501 to 1250 NPS 1"
    - 1251 to 2500 NPS 1-1/4"
    - 2501 to 6000 NPS 1 ½"
    - Above 6000 NPS 2"

Disconnects

- CSD-1, CE-100 requires an electrical switch to disconnect all power to the burner controls.
    - This disconnect must be capable of being locked in the open position and be located on or adjacent to the boiler.
    - The disconnect shall remove all electrical sources of potential.

- Boiler installations also require a manually operated remote shut down switch outside each entry door to the boiler room.
    - If a boiler room door opens to the outside of the building, the switch shall be just inside the door.
    - Manually operated remote shut down switches shall be marked for easy identification.

Vents

Combustion air shall be adequate for the design of the boiler. Should vents be equipped with louvers or fans to supply combustion air, the louvers or fans must be interlocked with the burner so that flow is proven during burner operation.

Boilers firing LP gas that do not comply with ANSI Z21.13 which are installed indoors, shall be equipped with safety shutoff devices or the complete shutoff type that will shut off the flow of gas to both the main burner(s) and pilot(s) in the event of a flame, pilot or ignition failure.

Boilers having an input rating of 400,000 but/hr or less, with field installed gas burner assemblies and boiler units that do not comply with ANSI Z21.13/CSA 4.9 shall comply with the provisions for purging, safety control timing, action on flame failure, loss of combustion air, combustion air proving and fuel supervision given in ASME CSD-1 Table CF-1 or Table CF-2, as applicable.

Gas fired boilers in excess or 400,000 btu/hr input shall meet all of the requirements of CSD-1 (Combustion Side Control) part of CF:

- Required lines must be vented to atmosphere shall not be connected to a common manifold and must run full size to a point of safe discharge. The terminal point shall be provided with means to prevent stoppage by foreign material, moisture or insects.

- Supply line manually operated shut off valves for NPS 2" and larger, the valves shall be lubricated plug type with stops and the handle shall indicate clearly the "on" and "off" positions.
- Pilot piping shall have a similar shut off valve.
- For purge, post-purge, flame failure, proving and start times see ASME CSD-1, Table, CF-1, Table CF-2, Table CF-3, and Table CF-4.

Oil fired boiler burners that have an input rating greater than 3 gph require:

- A UL 296 or a UL 726 label
- Supply line filters and strainers located upstream of the safety shutoff valve
- A pressure relief valve connected to a fuel supply line in which pressure greater than the design pressure can build up by closing any valve. The relief discharge shall be routed to the oil tank or the pump suction.
- For burners (except rotary cup), unless the oil pump is integral with the burners motor shaft and operates over 20 gpm, the main burner shall have a low pressure interlock switch that will cause a safety shutdown if the oil pressure falls below the manufacturers design pressure
- Burners with a low pressure interlock switch that will cause a safety shutdown if the atomizing air of steam falls below the manufacturer's design pressure
- For preheated oil system, burners shall have a high oil temperature interlock switch that will cause a safety shutdown and lockout when the oil temperature exceeds preset limits.
- An interlock switch to cause safety shutdown for low temperature oils that allows circulation to reestablish preset oil temperature
- Two approved safety shut off valves or one safety shutoff valve and a nozzle cutoff valve integral to the fuel unit shall be provided. The safety shutoff valves shall conform to the Standard for Electrically Operated Valves, UL 429. A nozzle cutoff valve shall conform to the Standard for Pumps for Oil Burning appliances, UL 343.
- Safety shutdowns and lockouts established upon loss of combustion air for boilers rated greater than 20 gpm. For boilers rated less than or equal to 20 gpm, where the forced or induced draft fans are not integral with the motor shaft, loss of combustion air shall shut off the burner.
- That each main burner assembly shall provide a primary safety control that will de-energize fuel supply upon flame loss. The primary safety control shall require manual resetting even in the event of a power loss.
- For purge, post-purge, flame failure, proving and start times see ASME CSD-1 and Table CF-5

Electrically heated boilers for steam or hot water service greater than 115 kW shall comply with Standard for Electric Boilers UL 834, NEC and NFPA 70.

Boiler units having inputs greater than 2,500,000 Btu/hr (gas fired) or 20 gph (oil fired) shall be equipped with an interlocked damper to provide for low fire starts.

Expansion Tanks

Hot water heating boilers shall have an expansion tank consistent with the capacity of the system. For systems designed for a working pressure of 30 psi, the expansion tank shall be designed for a minimum hydrostatic test of 75 psi. Expansion tanks for systems designed to operate above 30 psi, the tank shall be designed in accordance with ASME Section VIII, Division 1. Provisions shall be made for draining the tank without emptying the system, except for pre-pressurized tanks.

"H" Stamped Boiler Expansion Tank Capacities

System Volume	Tank Capacities (Gallons)	
Gallons	Pressurized Diaphragm Type	Non-pressurized Type
• 100	9	15
• 200	17	30
• 300	25	45
• 400	33	60
• 500	42	75
• 1000	83	150
• 2000	165	300

System vol. includes boiler, radiation and piping, not expansion tank.

Above expansion tank capacities based upon 195^{o}F, fill pressure 12 psi and 30 psi operating pressure.

"HLW" Stamped Boiler Expansion Tank Capacities

System Volume	Tank Capacities (Gallons)	
Gallons	Pressurized Diaphragm Type	Non-pressurized Type
• 50	1	3
• 100	2	6
• 200	3	12
• 300	4	18
• 400	5	24
• 500	6	30
• 1000	12	60
• 2000	24	120

System volume includes boiler, radiation and piping, not expansion tank.

Above expansion tank capacities based upon 180^{o}F, fill press 60 psi and 125 psi operating pressure.

(06)

Table CF-1 400,000 Btu/hr (117 228 W) and Smaller (Gas — Natural Draft)

Safety Control	Pilot Ignition Gas			
	Continuous Pilot	Intermittent Pilot	Interrupted Pilot	Direct Ignition System
Purge requirements [Note (1)]	None	None	None	None
Pilot flame establishing period	None	15 sec max.	15 sec max.	Not applicable
Main burner flame establishing period	None	None	15 sec max.	15 sec max.
Flame failure response time [Note (2)]				
Pilot	180 sec max.	4 sec max.	4 sec max.	Not applicable
Main burner	Not applicable	Not applicable	4 sec max.	4 sec max.
Valve closing time	Not applicable	5 sec max. after de-energization	5 sec max. after de-energization	5 sec max. after de-energization
Action on pilot flame failure [Note (1)]	Safety shutdown	Safety shutdown [Note (2)]	Safety shutdown [Note (2)]	Not applicable
Action on main burner flame failure [Note (1)]	Not applicable	Not applicable	Safety shutdown [Note (2)]	Safety shutdown [Note (2)]

NOTES:
(1) After safety shutdown, wait a minimum 5 min time delay before resetting ignition system. (Instructional requirement.)
(2) If the ignition system includes a relight feature, one relight attempt shall be initiated within 0.8 sec upon loss of flame.

Table CF-2 400,000 Btu/hr (117 228 W) and Smaller (Power Gas Burners and Mechanical Draft Atmospheric Gas Burners), 3 gph (11.4 L/h) and Smaller (Oil) (06)

Safety Control	Pilot Ignition Gas			Direct Ignition System	
	Continuous Pilot	Intermittent Pilot	Interrupted Pilot	Gas	Oil
Purge requirements [Note (1)]	None	None	None	None	None
Pilot flame establishing period	None	15 sec max.	15 sec max.	Not applicable	Not applicable
Main burner establishing period	None	None	15 sec max.	15 sec max.	30 sec max.
Flame failure response time					
Pilot	180 sec max.	4 sec max.	4 sec max.	Not applicable	Not applicable
Main burner	Not applicable	Not applicable	4 sec max.	4 sec max.	30 sec max.
Valve closing time	None	5 sec max. after de-energization	5 sec max. after de-energization	5 sec max. after de-energization	Not applicable
Action on pilot flame failure	Safety shutdown	Safety shutdown [Note (1)]	Safety shutdown [Note (2)]	Not applicable	Not applicable
Action on main burner flame failure	None	None	Safety shutdown [Note (2)]	Safety shutdown [Note (2)]	Safety shutdown [Note (2)]
Combustion air proving action on loss of combustion air	Mechanical draft — close main gas valve and recycle	Mechanical draft — close main gas valve and recycle	Mechanical draft — close main gas valve and recycle	Mechanical draft — close main gas valve and recycle	Safety shutdown required if fan not integral with burner motor shaft
Fuel pressure supervision	None	None	None	None	None

NOTES:
(1) After safety shutdown, wait a minimum 5 min time delay before resetting ignition system. (Instructional requirement.)
(2) If ignition system includes a relight feature, one relight attempt shall be initiated within 0.8 sec upon loss of flame.

(06)

Table CF-3 Safety Controls for Automatically Fired Units: Power Gas Burners and Mechanical Draft Atmospheric Gas Burners

Safety Control	Greater Than 400,000 Btu/hr (117 228 W) and Less Than or Equal to 2,500,000 Btu/hr (732 678 W)	Greater Than 2,500,000 Btu/hr (732 678 W) and Less Than or Equal to 5,000,000 Btu/hr (1 465 356 W)	Greater Than 5,000,000 Btu/hr (1 465 356 W) and Less Than 12,500,000 Btu/hr (3 663 389 W)
Purge requirements	Four air changes in 90 sec, or at 60% damper opening, with both damper opening and air flow proven [Note (1)] Air changes to include fire box and boiler passes Instructional requirement: minimum 5 minute shutoff before lighting constant pilot	Four air changes at 60% damper opening with both damper opening and air flow proven [Note (1)]	Four air changes at 60% damper opening with both damper opening and air flow proven
Pilot flame type and establishing period			
Continuous	15 sec (initial start only)	Not permitted	Not permitted
Interrupted	15 sec	10 sec	10 sec
Intermittent	15 sec	Not permitted	Not permitted
Main burner ignition type and establishing period	Pilot only: 15 sec max. if interrupted pilot used Direct ignition system: 4 sec max.	Interrupted pilot only, 10 sec max. Direct ignition system: 4 sec max. [Note (2)]	Interrupted pilot only, 10 sec max.
Flame failure response time	4 sec max.	4 sec max.	4 sec max.
Valve closing time	5 sec max. after de-energization	1 sec max.	1 sec max.
Action on flame failure	Safety shutdown and lockout or recycle once	Safety shutdown and lockout	Safety shutdown and lockout
Action on power or control input interruption after safety shutdown and lockout	Manual reset required in accordance with CG-610	Manual reset required in accordance with CG-610	Manual reset required in accordance with CG-610
Proven low fire start	Not required	See CF-610	See CF-610
Combustion air proving — action on loss of combustion air	Required: safety shutdown and lockout or recycle	Required: safety shutdown and lockout	Required: safety shutdown and lockout
Fuel pressure supervision	Not required for ignition systems with pilots. Required for direct ignition systems: high and low gas pressure arranged to cause safety shutdown and lockout.	Required: high and low gas pressure arranged to cause safety shutdown and lockout	Required: high and low gas pressure arranged to cause safety shutdown and lockout

GENERAL NOTE: Timings shown above shall be within the tolerances established by the nationally recognized testing agency where the primary safety controls are labeled and/or listed [see CF-310(c) and CF-510(c)].

NOTES:
(1) For dampers with a fixed mechanical stop, see CF-210(a)(1) and CF-210(a)(2).
(2) Maximum input at light off shall be less than or equal to 2,500,000 Btu/hr (732 678 W).

(06)

Table CF-4 Safety Controls for Automatically Fired Units: Atmospheric Gas Burners — Natural Draft

Safety Control	Greater Than 400,000 Btu/hr (117 228 W) and Less Than or Equal to 2,500,000 Btu/hr (732 678 W)	Greater Than 2,500,000 Btu/hr (732 678 W) and Less Than or Equal to 5,000,000 Btu/hr (1 465 356 W)	Greater Than 5,000,000 Btu/hr (1 465 356 W) and Less Than 12,500,000 Btu/hr (3 663 389 W)
Purge Requirements	None, if unrestricted air passages; if automatic burner dampers are used, prove open 90 sec Instructional requirement: minimum 5 min complete fuel shutoff period before lighting constant pilot		
Pilot flame type and establishing period			
Continuous	15 sec (initial start only)	10 sec (initial start only)	10 sec (initial start only)
Interrupted	15 sec	10 sec	10 sec
Intermittent	15 sec	10 sec	10 sec
Main burner ignition type and establishing period	Pilot only; 15 sec max. if interrupted pilot used, 25 to 30 sec if safety shutoff valve has full opening	Pilot only; 10 sec max. for modulating or high-low firing	Pilot only; 10 sec max.
Flame failure response time	4 sec max.	4 sec max.	4 sec max.
Valve closing time	5 sec max.	1 sec max.	1 sec max.
Action on flame failure	Safety shutdown and lockout or recycle once after a minimum 5 min time delay	Safety shutdown and lockout or recycle once after a minimum 5 min time delay	Safety shutdown and lockout or recycle once after a minimum 5 min time delay
Proven low fire start	Not required	See CF-610	See CF-610
Combustion air proving — action on loss of combustion air	Not applicable	Not applicable	Not applicable
Fuel pressure supervision	Not required	Required: high and low gas pressure arranged to cause safety shutdown and lockout	Required: high and low gas pressure arranged to cause safety shutdown and lockout

GENERAL NOTE: Timings shown above shall be within the tolerances established by the nationally recognized testing agency where the primary safety controls are labeled and/or listed [see CF-310(c) and CF-510(c)].

Table CF-5 Safety Controls for Automatically Fired Units: Oil-Fired Burners (06)

Safety Control	Greater Than 3 gph (11.4 L/h) [approx. 400,000 Btu/hr (117 228 W)] and Less Than or Equal to 20 gph (75.7 L/h) [approx. 2,800,000 Btu/hr (820 599 W)]	Greater Than 20 gph (75.7 L/h) [approx. 2,800,000 Btu/hr (820 599 W)]
Purge requirements	When oil pump operates independently of the burner, four air changes in 90 sec or at 60% damper opening, with damper opening and air flow proven if total input is in excess of 7 gph (26.5 L/h) [approx. 1,000,000 Btu/hr (293 071 W)] [Note (1)]	Four air changes at 60% damper opening with both damper opening and air flow proven [Note (1)]
Postpurge	Not required	15 sec min.
Pilot type and establishing period		
Continuous	Not permitted	Not permitted
Intermittent	Not permitted	Not permitted
Interrupted	10 sec max. if pilot is used	Required: 10 sec max. Exception: see Note (2)
Main burner ignition type and establishing period	Interrupted pilot, 15 sec max. Intermittent direct ignition system, 15 sec max. Interrupted direct ignition system, 15 sec max.	Interrupted pilot only Exception: see Note (2) Nos. 2 and 4 oil — 10 sec max. Nos. 5 and 6 oil — 15 sec max.
Flame failure response time	Intermittent direct ignition system, greater than 3 and less than or equal to 7 gph (11.4 L/h to 26.5 L/h), 15 sec max. Intermittent direct ignition system, greater than 7 and less than or equal to 20 gph (26.5 L/h to 75.7 L/h), 4 sec max. Interrupted pilot or direct ignition system, greater than 3 and less than or equal to 20 gph (11.4 L/h to 75.7 L/h), 4 sec max.	4 sec max.
Valve closing time	5 sec max. after de-energization	1 sec max.
Action of flame failure	Safety shutdown and lockout or recycle once [Note (3)]	Safety shutdown and lockout
Proven low fire start	Not required	See CF-610
Combustion air proving — action on loss of combustion air	Required if fans not integral with burner motor shaft; safety shutdown and lockout or recycle	Required: safety shutdown and lockout
Fuel pressure supervision	Not required	Required if oil pump not integral with burner motor shaft. See CF-45C.
Low atomizing media supervision	Required unless atomization by air pump integral with burner motor shaft. See CF-450(b).	Required. See CF-450(b).
Oil temperature supervision	High and low temperature supervision required on preheated oil. Excess temperature shall cause safety shutdown and lockout.	High and low temperature supervision recuired on preheated oil. Excess temperature shall cause safety shutdown and lockout.

GENERAL NOTE: Timings shown above shall be within the tolerances established by the nationally recognized testing agency where the primary safety controls are labeled and/or listed [see CF-310(c) and CF-510(c)].

NOTES:

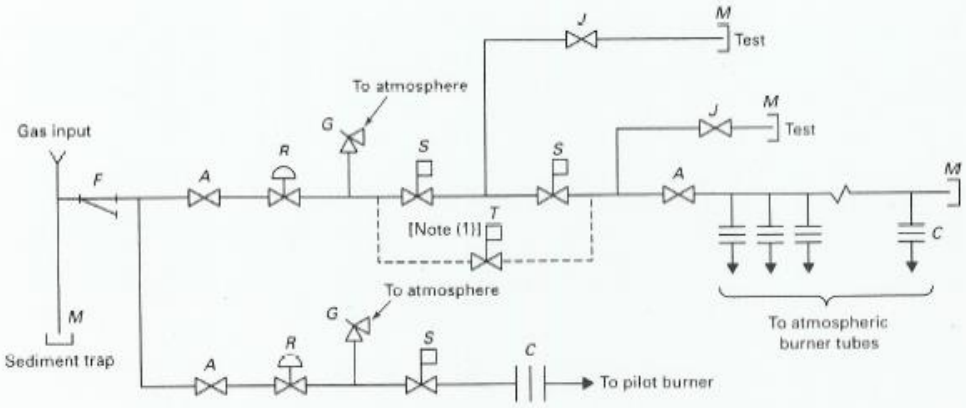
(1) For dampers with a fixed mechanical stop, see CF-470(a) and (b)(1).

(2) With proven low fire start at a low fire input rate of not more than 20 gph (75.7 L/h), interrupted pilot or direct ignition system allowed. Main burner establishing period: 15 sec max.

(3) Recycle permitted when a maximum 4 sec flame failure response time is used.

NONMANDATORY APPENDIX B
TYPICAL FUEL TRAINS

(06) **Fig. B-1 Typical Atmospheric Gas Fuel Train [Greater Than 400,000 Btu/hr (117 228 W) and Less Than or Equal to 2,500,000 Btu/hr (732 678 W)]**

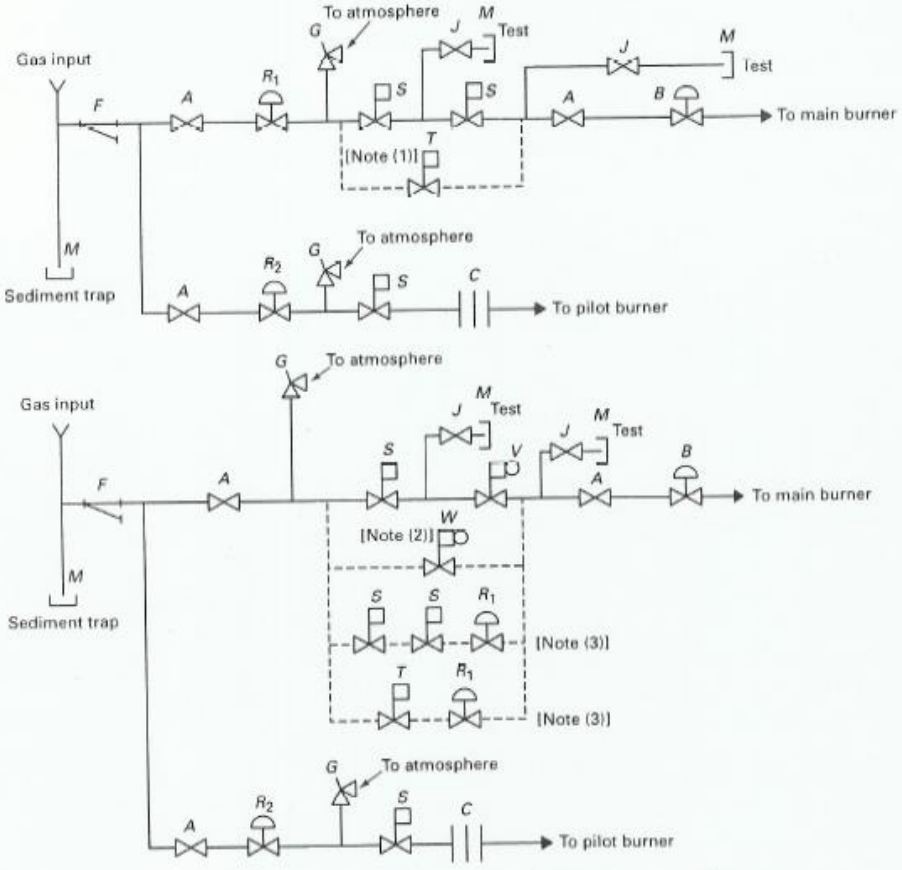


A = manual valve
C = orifice
F = gas filter or strainer (if required)
G = relief valve (if required)
J = leakage test valve
M = pipe cap
R = pressure regulator
S = safety shutoff valve
T = safety shutoff valve with proof of closure

GENERAL NOTE: Since boiler design may vary, ANSI Z21.13/CSA 4.9, Gas-Fired Low Pressure Steam and Hot Water Boilers, does not contain a typical fuel train; however, through laboratory testing procedures, ANSI Z21.13/CSA 4.9 does determine that safe lighting of the boiler will be accomplished; this Standard illustrates a typical fuel train for boilers. The specific fuel train diagram for boilers complying with ANSI Z21.13/CSA 4.9 is supplied in the boiler manufacturer's instructions.

NOTE:
(1) Alternate arrangement — *T* may be used in place of two *S*-type valves.

Fig. B-2 Typical Gas Fuel Train [Greater Than 400,000 Btu/hr (117 228 W) and Less Than or Equal to 2,500,000 Btu/hr (732 678 W)] (06)



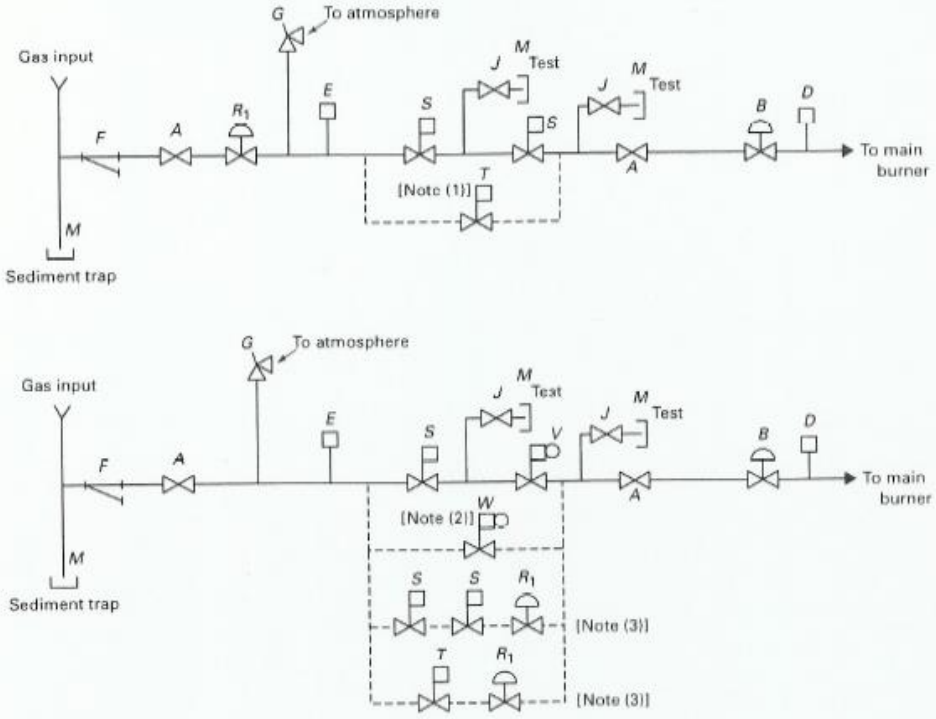
A = manual valve
B = firing rate valve
C = orifice
F = gas filter or strainer (if required)
G = relief valve (if required)
J = leakage test valve
M = pipe cap
R_1 = main gas pressure regulator
R_2 = pilot gas pressure regulator
S = safety shutoff valve
T = safety shutoff valve with proof of closure
V = main gas pressure regulator/safety shutoff combination valve
W = main gas pressure regulator/safety shutoff combination valve with proof of closure

GENERAL NOTE: Since boiler design may vary, ANSI Z21.13/CSA 4.9, Gas-Fired Low Pressure Steam and Hot Water Boilers, does not contain a typical fuel train; however, through laboratory testing procedures, ANSI Z21.13/CSA 4.9 does determine that safe lighting of the boiler will be accomplished; this Standard illustrates a typical fuel train for boilers. The specific fuel train diagram for boilers complying with ANSI Z21.13/CSA 4.9 is supplied in the boiler manufacturer's instructions.

NOTES:
(1) Alternate arrangement — *T* may be used in place of two *S*-type valves.
(2) Alternate arrangement — *W* may be used in place of an *S*-type and a *V*-type valve.
(3) Alternate arrangement — R_1 may be downstream of two *S*-type valves or a *T*-type valve.

(06)

Fig. B-3 Typical Gas Fuel Train [Greater Than 400,000 Btu/hr (117 228 W) and Less Than or Equal to 2,500,000 Btu/hr (732 678 W)] Direct Ignition System

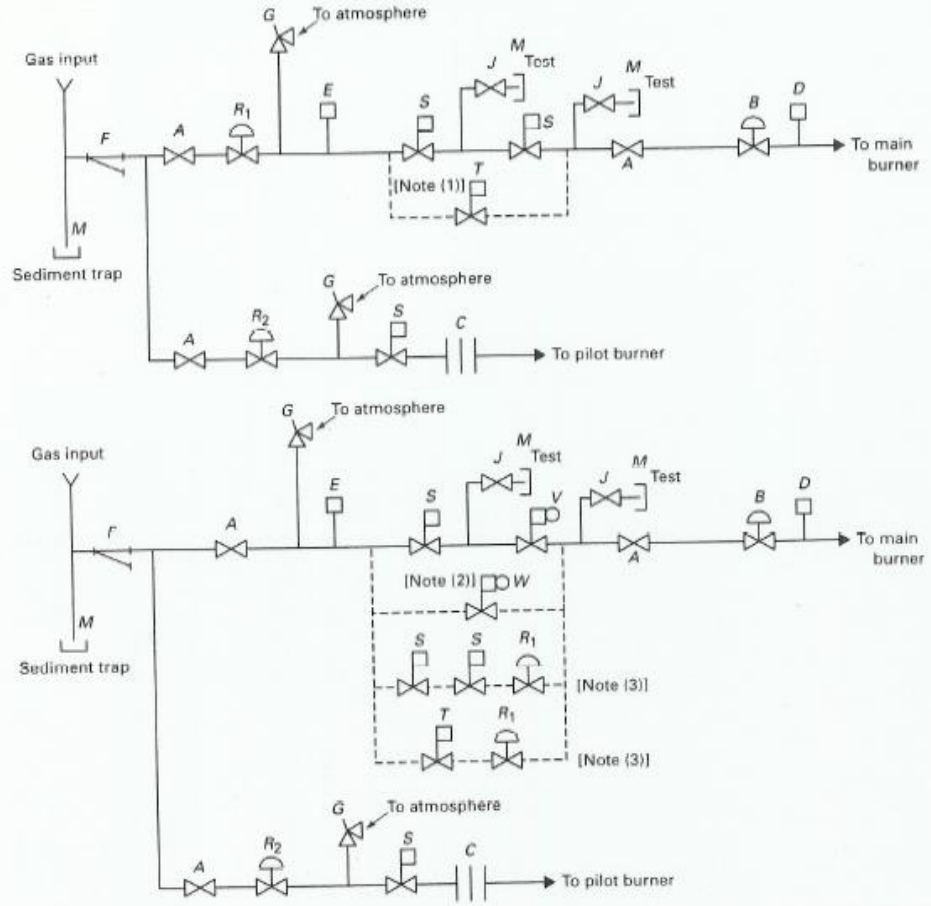


A = manual valve
B = firing rate valve
C = orifice
D = high gas pressure switch
E = low gas pressure switch
F = gas filter or strainer (if required)
G = relief valve (if required)
J = leakage test valve
M = pipe cap
R_1 = main gas pressure regulator
R_2 = pilot gas pressure regulator
S = safety shutoff valve
T = safety shutoff valve with proof of closure
V = main gas pressure regulator/safety shutoff combination valve
W = main gas pressure regulator/safety shutoff combination valve with proof of closure

GENERAL NOTE: Since boiler design may vary, ANSI Z21.13/CSA 4.9, Gas-Fired Low Pressure Steam and Hot Water Boilers, does not contain a typical fuel train; however, through laboratory testing procedures, ANSI Z21.13/CSA 4.9 does determine that safe lighting of the boiler will be accomplished; this Standard illustrates a typical fuel train for boilers. The specific fuel train diagram for boilers complying with ANSI Z21.13/CSA 4.9 is supplied in the boiler manufacturer's instructions.

NOTES:
(1) Alternate arrangement — T may be used in place of two S-type valves.
(2) Alternate arrangement — W may be used in place of an S-type and a V-type valve.
(3) Alternate arrangement — R_1 may be downstream of two S-type valves or a T-type valve.

Fig. B-4 Typical Gas Fuel Train [Greater Than 2,500,000 Btu/hr (732 678 W) and Less Than or Equal to 5,000,000 Btu/hr (1 465 356 W)] (06)



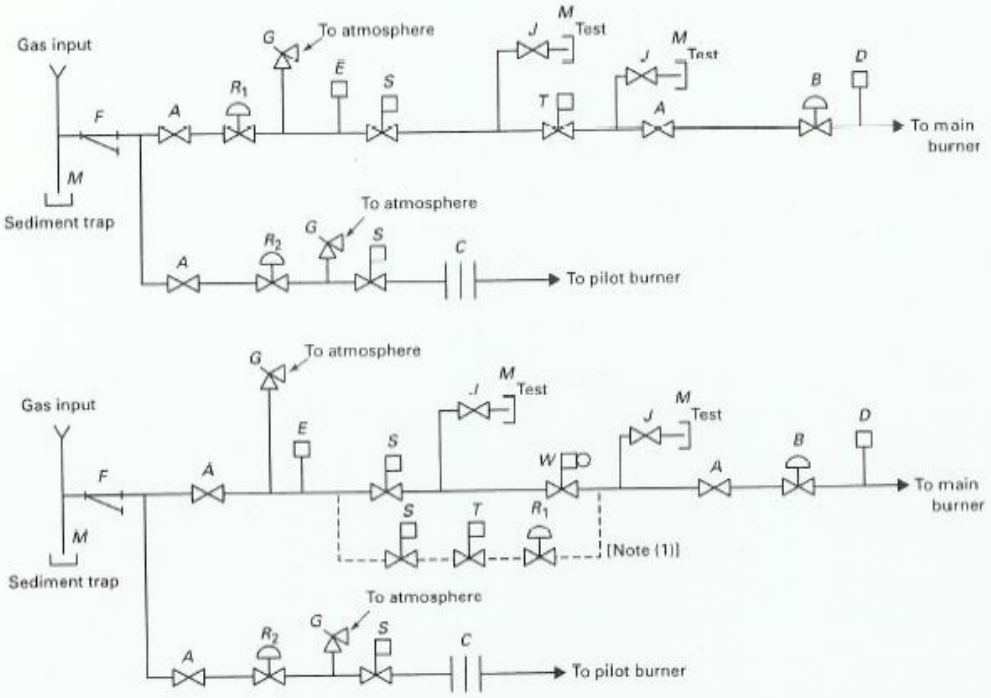
A = manual valve
B = firing rate valve
C = orifice
D = high gas pressure switch
E = low gas pressure switch
F = gas filter or strainer (if required)
G = relief valve (if required)
J = leakage test valve
M = pipe cap
R_1 = main gas pressure regulator
R_2 = pilot gas pressure regulator
S = safety shutoff valve
T = safety shutoff valve with proof of closure
V = main gas pressure regulator/safety shutoff combination valve
W = main gas pressure regulator/safety shutoff combination valve with proof of closure

GENERAL NOTE: Since boiler design may vary, ANSI Z21.13/CSA 4.9, Gas-Fired Low Pressure Steam and Hot Water Boilers, does not contain a typical fuel train; however, through laboratory testing procedures, ANSI Z21.13/CSA 4.9 does determine that safe lighting of the boiler will be accomplished; this Standard illustrates a typical fuel train for boilers. The specific fuel train diagram for boilers complying with ANSI Z21.13/CSA 4.9 is supplied in the boiler manufacturer's instructions.

NOTES:
(1) Alternate arrangement — *T* may be used in place of two *S*-type valves.
(2) Alternate arrangement — *W* may be used in place of an *S*-type and a *V*-type valve.
(3) Alternate arrangement — R_1 may be downstream of two *S*-type valves or a *T*-type valve.

(06)

Fig. B-5 Typical Gas Fuel Train [Greater Than 5,000,000 Btu/hr (1 465 356 W) and Less Than 12,500,000 Btu/hr (3 663 389 W)]

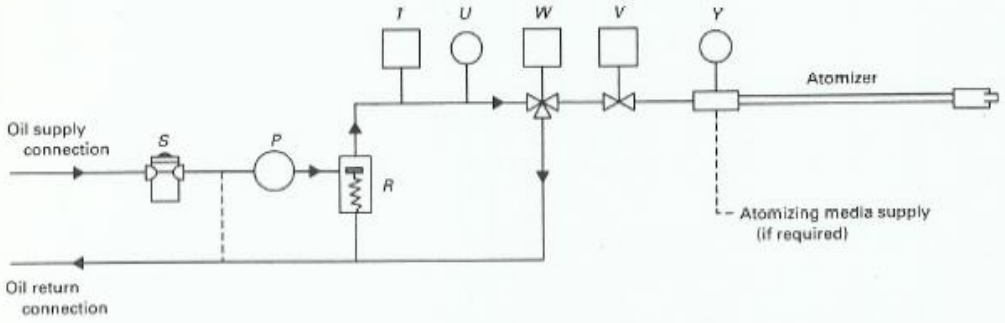


A = manual valve
B = firing rate valve
C = orifice
D = high gas pressure switch
E = low gas pressure switch
F = gas filter or strainer (if required)
G = relief valve (if required)
J = leakage test valve
M = pipe cap
R_1 = main gas pressure regulator
R_2 = pilot gas pressure regulator
S = safety shutoff valve
T = safety shutoff valve with proof of closure
W = main gas pressure regulator/safety shutoff combination valve with proof of closure

GENERAL NOTE: Since boiler design may vary, ANSI Z21.13/CSA 4.9, Gas-Fired Low Pressure Steam and Hot Water Boilers, does not contain a typical fuel train; however, through laboratory testing procedures, ANSI Z21.13/CSA 4.9 does determine that safe lighting of the boiler will be accomplished; this Standard illustrates a typical fuel train for boilers. The specific fuel train diagram for boilers complying with ANSI Z21.13/CSA 4.9 is supplied in the boiler manufacturer's instructions.

NOTE:
(1) Alternate arrangement — R_1 may be downstream of an *S* type and a *T* type valve.

Fig. B-6 Typical Oil Fuel Train



P = fuel pump
R = shutoff valve and/or pressure relief valve
S = fuel strainer
T = oil temperature interlock switch (if required)
U = oil pressure interlock switch (if required)
V = safety shutoff valve
W = safety shutoff valve (may be 3-way for recirculation)
Y = atomizing media supply pressure interlock switch (if required)

A Class 4 boilermaker may do welding repairs on ASME Code boilers and pressure vessels only if employed by a firm that holds a current NBIC “”R” Stamp Certificate and if the boilermakers welding meets the firm’s welding certification program.

All Code repairs shall be such that the material and repair conform to the vessel’s original ASME construction code.

Repairs to pressure retaining items shall not be initiated without the authorization of the inspector, who shall determine the repair methods that are acceptable.

Routine Repairs-
The NBIC defines four repairs as “routine”. Routine repairs may be accomplished with prior inspector approval. The four are:

1) Welded repairs or replacement of tubes or pipes NPS 5 and smaller, or sections thereof, where neither post weld heat treatment nor NDE other than visual inspection is required by the original code of construction.

2) The addition or repair of non-load bearing attachments to the pressure retaining items where post weld heat treatment is not required.

3) Weld buildup of wasted areas in shells and heads not exceeding 100 sq. in. or 25% of nominal wall thickness or 1/2 inch, which ever is less.

4) Corrosion resistance weld overlay not exceeding 100 sq. in.

All weld repairs to pressure containing components require a pressure test to verify leak tightness integrity of the repair.

Repairs-
A repair is the work necessary to restore pressure retaining item to a safe and satisfactory operating condition. Some examples of repairs are:

- Weld repair or replacement or pressure retaining parts that have failed in a weld or base metal
- Weld buildup of wasted areas
- Addition of studs, hex steel or expanded metal for refractory lining
- Replacement of boiler and heat exchanger tubes where welding is involved
- The addition of a nozzle provided the nozzle is identical to a nozzle in the original design and is no closer than three times its diameter from another nozzle
- Installation of a flush patch
- Replacement of a slip on nozzle with a weld neck nozzle or vice-versa

Steam locomotive and historic steam boiler repairs are controlled by the National Board Inspection Code (NBIC).

The NBIC allows flush patches, wasted area buildup and ground out defects repairs to be done with an alternative to post weld heat treatment. Specific preheating, maintenance of temperature throughout the repair and controlled cool down may be approved by the authorized inspector.

Alterations-
An alteration is any change to the vessel that would change the pressure containing capacity as listed on the original Manufacturer's Report. Some examples of an alteration are:

- Increasing the MAWP
- Decrease in the minimum temperature
- Addition of new nozzles other than those classified as a repair
- Change in dimensions or contour of pressure retaining surface
- Increasing steaming capacity requiring an increased relieving capacity
- Replacement of pressure retaining part with a material of different allowable stress or nominal composition from that used in the original design

General Information that applies to alterations and repairs-

Boilers may have shell sections replaced with only flush patches.

ASME Section I requires that all circumferential welds to be stress relieved.

Certified "R" Stamp weld repairs or alterations of ASME Code stamped vessels require the Certificate holder to attach a permanent repair nameplate to the vessel listing the Certificate holders name, National Board "R" Stamp number and date of the repair.

Welding

Welding on new installations is controlled by ASME Section IX and the employer's qualified weld procedure specification (WPS).

Welded repairs to ASME Code boilers and pressure vessels are controlled by ASME Section IX, the employer's qualified weld procedure specification, the NBIC and original code of construction.

An approved quality control program defining controls for welding, NDE, material handling, heat treatment, weld procedure specification, welder's log and documentation is required for Code welding. This QC program can be part of an ASME "S" or "U" Stamp certification for fabricating new boilers or pressure vessels, a NBIC "R" Stamp Certification for vessel repair or a State of Oregon "O" Stamp Pressure Piping Certification.

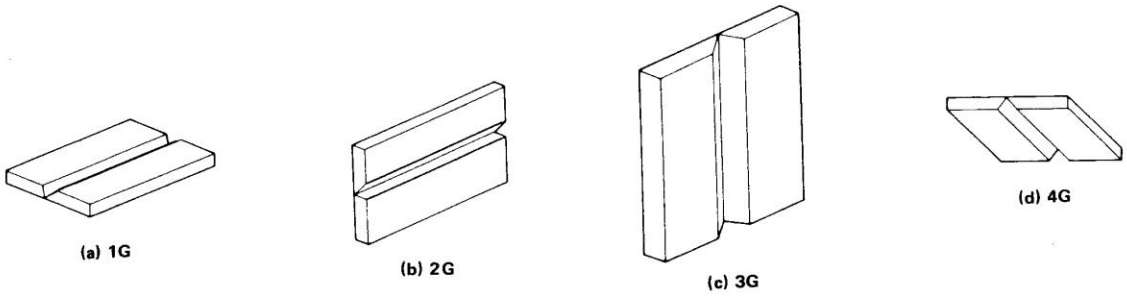
The inspector shall be contacted prior to weld construction or repair. The employer's quality control program includes a "traveler" to document project progress and inspector acceptance of critical events that may include material confirmation, fit up, hold points, NDE and pressure tests.

The WPS is a written qualified welding procedure prepared to provide directions to the welder to assure compliance with Code requirements. A WPS used for Code welding shall be available to the inspector. The WPS shall describe all of the essential, nonessential and supplementary essential variables for each welding process used in the WPS. The minimum temperature for welding shall always be specified in the WPS. The WPS shall detail the following:

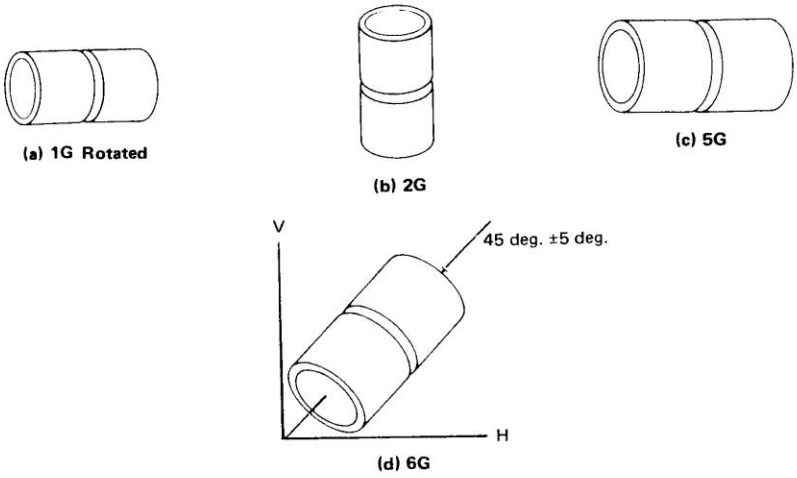
- Weld joint
- Base Metals
- Filler Metals
- Weld Positions
- Preheat
- Post Weld Heat Treatment
- Gas and/or Electrical
- Welding Technique

ASME Section IX Tables QW-252 through QW-265 list the specific requirements for the different variables for fourteen types of welding. The description of each variable is listed in ASME Section IX Article IV.

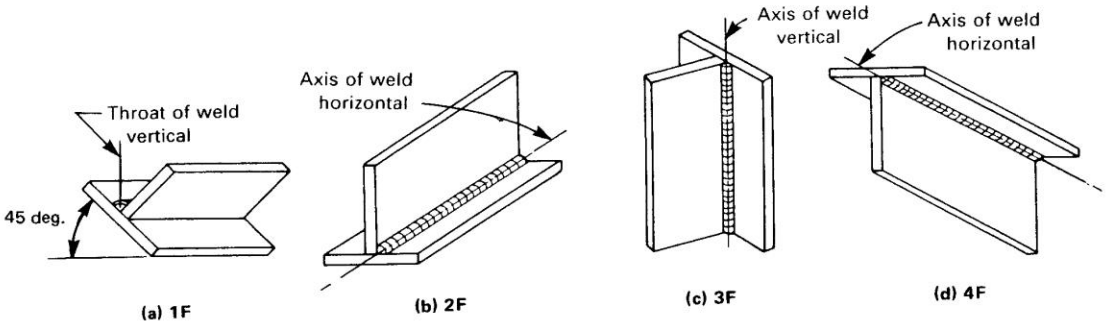
Weld positions are specifically described in the WPS. Qualifying on certain weld positions may allow variations in the position used. The following are a general description of welding positions:



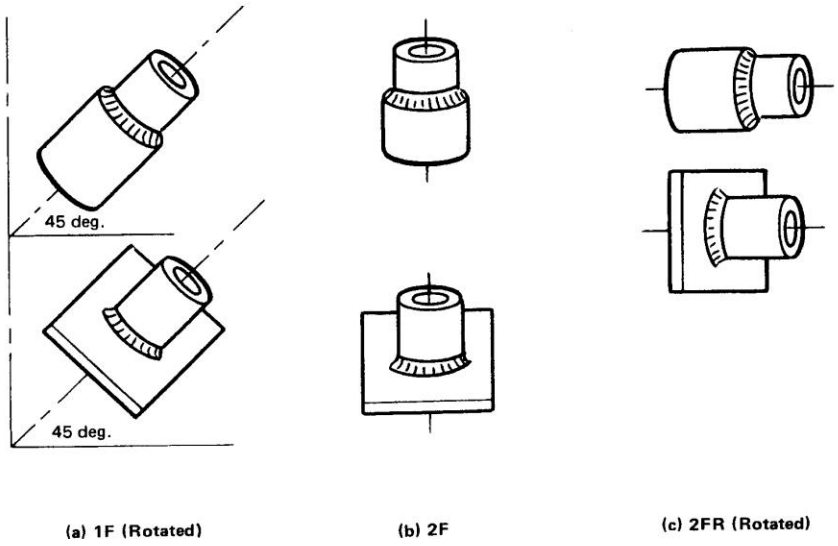
QW-461.3 GROOVE WELDS IN PLATE — TEST POSITIONS



QW-461.4 GROOVE WELDS IN PIPE — TEST POSITIONS



QW-461.5 FILLET WELDS IN PLATE — TEST POSITIONS



(a) 1F (Rotated) (b) 2F (c) 2FR (Rotated)

(d) 4F (e) 5F

QW-461.6 FILLET WELDS IN PIPE — TEST POSITIONS

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QW-461.9
PERFORMANCE QUALIFICATION — POSITION AND DIAMETER LIMITATIONS
(Within the Other Limitations of QW-303)

Qualification Test		Position and Type Weld Qualified [Note (1)]		
		Groove		
Weld	Position	Plate and Pipe Over 24 in. (610 mm) O.D.	Pipe ≤ 24 in. (610 mm) O.D.	Fillet Plate and Pipe
Plate — Groove	1G	F	F [Note (2)]	F
	2G	F,H	F,H [Note (2)]	F,H
	3G	F,V	F [Note (2)]	F,H,V
	4G	F,O	F [Note (2)]	F,H,O
	3G and 4G	F,V,O	F [Note (2)]	All
	2G, 3G, and 4G	All	F,H [Note (2)]	All
	Special Positions (SP)	SP,F	SP,F	SP,F
Plate — Fillet	1F	. . .	. . .	F [Note (2)]
	2F	. . .	. . .	F,H [Note (2)]
	3F	. . .	. . .	F,H,V [Note (2)]
	4F	. . .	. . .	F,H,O [Note (2)]
	3F and 4F	. . .	. . .	All [Note (2)]
	Special Positions (SP)	. . .	. . .	SP,F [Note (2)]
Pipe — Groove [Note (3)]	1G	F	F	F
	2G	F,H	F,H	F,H
	5G	F,V,O	F,V,O	All
	6G	All	All	All
	2G and 5G	All	All	All
	Special Positions (SP)	SP,F	SP,F	SP,F
Pipe — Fillet [Note (3)]	1F	. . .	. . .	F
	2F	. . .	. . .	F,H
	2FR	. . .	. . .	F,H
	4F	. . .	. . .	F,H,O
	5F	. . .	. . .	All
	Special Positions (SP)	. . .	. . .	SP,F

NOTES:
(1) Positions of welding as shown in QW-461.1 and QW-461.2.
F = Flat
H = Horizontal
V = Vertical
O = Overhead
(2) Pipe $2\frac{7}{8}$ in. (73 mm) O.D. and over.
(3) See diameter restrictions in QW-452.3, QW-452.4, and QW-452.6.

Seal welding is used to prevent leakage in boiler tubes to tube sheet connections and in threaded pipe connections provided the entire exposed threaded section is covered with weld.

- Seal welds are for tightness only and do not impart additional strength.
- Boiler fire tubes must extend at least 1/8 in. from the tube sheet to be seal welded.
- Seal welding water tube boiler tubes may be done on either side of the tube sheet.

Leaking, eroded, corroded or damaged boiler tubes may be repaired by:

- Plugging
- Replacing a section of the tube
- Welding a window patch
- Total tube replacement.
- Sectional replacement should remove a minimum of 3-1/2 times the tube diameter.
- The NBIC allows re-ending or piecing pipes or tubes provided the thickness is not less than 90% of that required by the original code of construction.
- All boiler tube welds must be full penetration welds. Care must be taken to prevent foreign matter from falling into the open tube while replacing a section.

Welded joint stress cracking is usually caused by a high differential of hardness in the heat affected zone (HAZ) between the parent metal and the weld filler metal.

- When the heat produced in welding dissipates too rapidly, the HAZ is “quenched” and the hardness of the metal increases.
- The thinner the parent metal, the more the hardness differential increases.
- Preheating an area approximately 3 in. on each side of the weld and maintenance of heating during the weld reduces the rate of heat dissipation.
- Wrapping the finished weld while still hot with insulation controls the cool down to assure a moderate rate of cooling. This practice will minimize stress cracking at welds.

ASME B31.1 Pressure Piping and ASME Section I boilers have stringent stress relieving requirements that may require post weld heat treatment (PWHT). The tables in B31.1 are similar to the Section I requirements but the Section I “Notes” section of the PWHT tables found in PW-39 of that Code are much more extensive. Refer to the specific PWHT requirements for Section I boiler welding. The “Table 132 Postweld Heat Treatment” from ASME B31.1 is reprinted at the end of this section.

Welding quality is assured by following a proper welding procedure.

- The root gap allows full penetration of the weld.
- Tack welds position the two pieces that are to be welded and maintain alignment while the root pass is laid in.
- The stringer beads are deposited along straight lines without oscillation in parallel lines to fill the groove.
- These stringer beads may be a different filler metal, depending upon the WPS.
- The number of beads or passes needed to complete the weld depends upon the electrode diameter, level and root opening.
- Each pass is ground or wire brushed to remove slag and spatter.

- Inclusions where the length is less than 3 times its width and less than 1/8” for thickness (t) up to 3/8” or 1/3t for t over 3/8” or ¾” for t over 2-1/4” when viewed in a radiograph are acceptable.
- The top pass is the weld reinforcement.
- The finished weld surface shall be sufficiently free from coarse ripples, grooves, overlaps, abrupt edges and valleys.
- The surface is to be flush with the outside surface of the material to be welded but may have weld reinforcement limited to the values in ASME Section B31.1 Table 127.4.2.
- Undercuts shall not exceed 1/32 in.

TABLE 127.4.2
REINFORCEMENT OF GIRTH AND LONGITUDINAL BUTT WELDS

Thickness of Base Metal, in. (mm)	Maximum Thickness of Reinforcement for Design Temperature					
	> 750°F (400°C)		350°F–750°F (175°C–400°C)		< 350°F (175°C)	
	in.	mm	in.	mm	in.	mm
Up to 1/8 (3.0), incl.	1/16	2.0	3/32	2.5	3/16	5.0
Over 1/8 to 3/16 (3.0 to 5.0), incl.	1/16	2.0	1/8	3.0	3/16	5.0
Over 3/16 to 1/2 (5.0 to 13.0), incl.	1/16	2.0	5/32	4.0	3/16	5.0
Over 1/2 to 1 (13.0 to 25.0), incl.	3/32	2.5	3/16	5.0	3/16	5.0
Over 1 to 2 (25.0 to 50.0), incl.	1/8	3.0	1/4	6.0	1/4	6.0
Over 2 (50.0)	5/32	4.0	The greater of 1/4 in. (6 mm) or 1/8 times the width of the weld in inches (millimeters).			

GENERAL NOTES:

(a) For double welded butt joints, this limitation on reinforcement given above shall apply separately to both inside and outside surfaces of the joint.

(b) For single welded butt joints, the reinforcement limits given above shall apply to the outside surface of the joint only.

(c) The thickness of weld reinforcement shall be based on the thickness of the thinner of the materials being joined.

(d) The weld reinforcement thicknesses shall be determined from the higher of the abutting surfaces involved.

(e) Weld reinforcement may be removed if so desired.

Non-Destructive Examination (NDE) may consist of any of the following:

- **Visual inspection**
- **Magnetic Particle Examination** – The following relevant indications are unacceptable:

    1. Any crack or linear indication
    2. Rounded indications with a dimension greater than 3/16 in.
    3. Four or more rounded indications in a line separated by 1/16 in or less to edge
    4. Ten or more rounded indications 6 sq in of surface with the major dimension of this area not to exceed 6 in.

- **Liquid Penetrant Examination** - The following relevant indications are unacceptable:

    1. Any crack or linear indication
    2. Rounded indications with a dimension greater than 3/16 in.
    3. Four or more rounded indications in a line separated by 1/16 in or less to edge

4. Ten or more rounded indications 6 sq in of surface with the major dimension of this area not to exceed 6 in.

- **Radiography** – Welds that are shown by radiography to have any of the following types of discontinuities are unacceptable:

    1) Any type of crack or zone of incomplete fusion or penetration
    2) Any other elongated indication which has a length greater than: ¼ in. for t up to ¾ in, 1/3t for t from ¾ in. to 2-1/4 in or ¾ in for t over 2-1/4 in where t is the thickness of the thinner portion of the weld
    3) Any group of indications in line that have an aggregate length greater than t in a length of 12t, except where the distance between the successive indications exceeds 6L where L is the longest indication in the group
    4) Porosity in excess of that shown in Appendix A-250 of Section I of the ASME Boiler and Pressure Vessel Code
    5) Root concavity

- **Ultrasonic Examination** – Unacceptable discontinuities are:

    1. Discontinuities evaluated as being cracks, lack of fusion or incomplete penetration
    2. Any other indication which has a length greater than: ¼ in. for t up to ¾ in, 1/3t for t from ¾ in. to 2-1/4 in or ¾ in for t over 2-1/4 in where t is the thickness of the thinner portion of the weld

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TABLE 132
POSTWELD HEAT TREATMENT

P-Number from Appendix A	Holding Temperature Range, °F (°C)	Holding Time Based on Nominal Thickness	
		Up to 2 in. (50 mm)	Over 2 in. (50 mm)
P-No. 1 Gr. Nos. 1, 2, 3	1100 (600) to 1200 (650)	1 hr/in. (25 mm) 15 min minimum	2 hr plus 15 min for each additional inch over 2 in. (50 mm)

GENERAL NOTES:

(A) PWHT of P-No. 1 materials is not mandatory, provided that all of the following conditions are met:
- (1) the nominal thickness, as defined in para. 132.4.1, is $\frac{3}{4}$ in. (19.0 mm) or less;
- (2) a minimum preheat of 200°F (95°C) is applied when the nominal material thickness of either of the base metals exceeds 1 in. (25.0 mm).

(B) When it is impractical to PWHT at the temperature range specified in Table 132, it is permissible to perform the PWHT of this material at lower temperatures for longer periods of time in accordance with Table 132.1.

P-Number from Appendix A	Holding Temperature Range, °F (°C)	Holding Time Based on Nominal Thickness	
		Up to 2 in. (50 mm)	Over 2 in. (50 mm)
P-No. 3 Gr. Nos. 1, 2	1100 (600) to 1200 (650)	1 hr/in. (25 mm) 15 min minimum	2 hr plus 15 min for each additional inch over 2 in. (50 mm)

GENERAL NOTES:

(A) PWHT of P-No. 3 materials is not mandatory, provided all of the following conditions are met:
- (1) the nominal thickness, as defined in para. 132.4.1, is $\frac{5}{8}$ in. (16.0 mm) or less;
- (2) a minimum preheat of 200°F (95°C) is applied when the nominal material thickness of either of the base metals exceeds $\frac{5}{8}$ in. (16.0 mm);
- (3) the specified carbon content of the P-No. 3 base material is 0.25% or less.

(B) When it is impractical to PWHT at the temperature range specified in Table 132, it is permissible to perform the PWHT of this material at lower temperatures for longer periods of time in accordance with Table 132.1.

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TABLE 132
POSTWELD HEAT TREATMENT (CONT'D)

P-Number from Appendix A	Holding Temperature Range, °F (°C)	Holding Time Based on Nominal Thickness	
		Up to 2 in. (50 mm)	Over 2 in. (50 mm)
P-No. 4 Gr. Nos. 1, 2	1300 (700) to 1375 (750)	1 hr/in. (25 mm) 15 min minimum	2 hr plus 15 min for each additional inch over 2 in. (50 mm)

GENERAL NOTE:
(A) PWHT is not mandatory for P-No. 4 material under the following conditions:
- (1) welds in pipe or attachment welds to pipe complying with all of the following conditions:
  - (A) a nominal material thickness of $\frac{1}{2}$ in. (13.0 mm) or less;
  - (B) a specified carbon content of the material to be welded of 0.15% or less;
  - (C) application of 250°F (120°C) minimum preheat during welding.
- (2) for seal welding of threaded or other mechanical joints provided:
  - (A) the seal weld has a throat thickness of $\frac{3}{8}$ in. (9.0 mm) or less;
  - (B) a minimum preheat of 250°F (120°C) is maintained during welding.
- (3) attachment welds for non-load-carrying attachments provided in addition to (1)(B) and (1)(C) above:
  - (A) stud welds or fillet welds made by the SMAW or GTAW process shall be used;
  - (B) the hardened portion of the heat affected zone (HAZ) shall not encroach on the minimum wall thickness of the pipe, as determined by welding procedure qualification using the maximum welding heat input. The depth of the HAZ shall be taken as the point where the HAZ hardness does not exceed the average unaffected base metal hardness by more than 10%.
  - (C) if SMAW is used, the electrode shall be the low hydrogen type;
  - (D) the thickness of the test plate used in making the welding procedure qualification of Section IX shall not be less than that of the material to be welded;
  - (E) the attachment weld has a throat thickness of $\frac{3}{16}$ in. or less.

P-Number from Appendix A	Holding Temperature Range, °F (°C)	Holding Time Based on Nominal Thickness	
		Up to 2 in. (50 mm)	Over 2 in. (50 mm)
P-No. 5A Gr. No. 1	1300 (700) to 1400 (760)	1 hr/in. (25 mm) 15 min minimum	2 hr plus 15 min for each additional inch over 2 in. (50 mm)

GENERAL NOTE:
(A) PWHT is not mandatory for P-No. 5A material under the following conditions:
- (1) welds in pipe or attachment welds to pipe complying with all of the following conditions:
  - (A) a nominal material thickness of $\frac{1}{2}$ in. (13.0 mm) or less;
  - (B) a specified carbon content of the material to be welded of 0.15% or less;
  - (C) a minimum preheat of 300°F (150°C) is maintained during welding.
- (2) attachment welds for non-load-carrying attachments provided in addition to (1)(B) and (1)(C) above:
  - (A) stud welds or fillet welds made by the SMAW or GTAW process shall be used;
  - (B) the hardened portion of the heat affected zone (HAZ) shall not encroach on the minimum wall thickness of the pipe, as determined by welding procedure qualification using the maximum welding heat input. The depth of the HAZ shall be taken as the point where the HAZ hardness does not exceed the average unaffected base metal hardness by more than 10%.
  - (C) if SMAW is used, the electrode shall be the low hydrogen type;
  - (D) the thickness of the test plate used in making the welding procedure qualification of Section IX shall not be less than that of the material to be welded;
  - (E) the attachment weld has a throat thickness of $\frac{3}{16}$ in. or less.

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TABLE 132
POSTWELD HEAT TREATMENT (CONT'D)

P-Number from Appendix A	Holding Temperature Range, °F (°C)	Holding Time Based on Nominal Thickness	
		Up to 2 in. (50 mm)	Over 2 in. (50 mm)
P-No. 5B Gr. Nos. 1, 2	1300 (700) to 1400 (760)	1 hr/in. (25 mm) 15 min minimum	2 hr plus 15 min for each additional inch over 2 in. (50 mm)

P-Number from Appendix A	Holding Temperature Range, °F (°C)	Holding Time Based on Nominal Thickness	
		Up to 2 in. (50 mm)	Over 2 in. (50 mm)
P-No. 6 Gr. Nos. 1, 2, 3	1400 (760) to 1475 (800)	1 hr/in. (25 mm) 15 min minimum	2 hr plus 15 min for each additional inch over 2 in. (50 mm)

GENERAL NOTE:
(A) PWHT is not mandatory for P-No. 6 Type 410 material provided all of the following conditions are met:
(1) the specified carbon content is not more than 0.08%;
(2) the nominal material thickness is $\frac{3}{8}$ in. (10 mm) or less;
(3) the weld is made with A-No. 8, A-No. 9, or F-No. 43 filler metal.

P-Number from Appendix A	Holding Temperature Range, °F (°C)	Holding Time Based on Nominal Thickness	
		Up to 2 in. (50 mm)	Over 2 in. (50 mm)
P-No. 7 Gr. Nos. 1, 2	1350 (730) to 1425 (775)	1 hr/in. (25 mm) 15 min minimum	2 hr plus 15 min for each additional inch over 2 in. (50 mm)

GENERAL NOTES:
(A) In lieu of the cooling rate described in para. 132.5, P-No. 7 material cooling rate shall be not greater than 100°F (55°C) per hr in the range above 1200°F (650°C) after which the cooling rate shall be sufficiently rapid to prevent embrittlement.
(B) PWHT is not mandatory for P-No. 7 Type 405 material provided all of the following conditions are met:
(1) the specified carbon content is not more than 0.08%;
(2) the nominal material thickness is $\frac{3}{8}$ in. (10 mm) or less;
(3) the weld is made with A-No. 8, A-No. 9, or F-No. 43 filler metal.

P-Number from Appendix A	Holding Temperature Range, °F (°C)	Holding Time Based on Nominal Thickness	
		Up to 2 in. (50 mm)	Over 2 in. (50 mm)
P-No. 8 Gr. Nos. 1, 2, 3, 4	None	None	None

GENERAL NOTE:
(A) PWHT is neither required nor prohibited for joints between P-No. 8 austenitic stainless steels.

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TABLE 132
POSTWELD HEAT TREATMENT (CONT'D)

P-Number from Appendix A	Holding Temperature Range, °F (°C)	Holding Time Based on Nominal Thickness	
		Up to 2 in. (50 mm)	Over 2 in. (50 mm)
P-No. 9A Gr. No. 1	1100 (600) to 1200 (650)	1 hr/in. (25 mm) 15 min minimum	2 hr plus 15 min for each additional inch over 2 in. (50 mm)

GENERAL NOTES:
(A) PWHT is not mandatory for P-No. 9A material when welds on pipe or attachment welds to pipe comply with all of the following conditions:
(1) a nominal material thickness of $\frac{1}{2}$ in. (13.0 mm) or less;
(2) a specified carbon content of the material to be welded of 0.15% or less;
(3) a minimum preheat of 250°F (120°C) is maintained during welding.
(B) When it is impractical to PWHT at the temperature range specified in Table 132, it is permissible to perform the PWHT of this material at lower temperatures for longer periods of time in accordance with Table 132.1 but the minimum PWHT shall not be less than 1000°F (550°C).

P-Number from Appendix A	Holding Temperature Range, °F (°C)	Holding Time Based on Nominal Thickness	
		Up to 2 in. (50 mm)	Over 2 in. (50 mm)
P-No. 9B Gr. No. 1	1100 (600) to 1175 (630)	1 hr/in. (25 mm) 15 min minimum	2 hr plus 15 min for each additional inch over 2 in. (50 mm)

GENERAL NOTES:
(A) PWHT of P-No. 9B material is not mandatory for a nominal material thickness of $\frac{5}{8}$ in. (16.0 mm) or less provided the Welding Procedure Qualification has been made using material of thickness equal to or greater than the production weld.
(B) When it is impractical to PWHT at the temperature range specified in Table 132, it is permissible to perform the PWHT of this material at lower temperatures for longer periods of time in accordance with Table 132.1, but the minimum PWHT temperature shall not be less than 1000°F (550°C).

P-Number from Appendix A	Holding Temperature Range, °F (°C)	Holding Time Based on Nominal Thickness	
		Up to 2 in. (50 mm)	Over 2 in. (50 mm)
P-No. 10H Gr. No. 1	...	...	...

GENERAL NOTE:
(A) Postweld heat treatment is neither required nor prohibited. If any heat treatment is performed after forming or welding, it shall be performed within the temperature range listed below for the particular alloy, followed by a rapid cool:

Alloy S31803	1870°F–2010°F
Alloy S32550	1900°F–2050°F
Alloy S32750	1880°F–2060°F
All others	1800°F–1900°F

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TABLE 132
POSTWELD HEAT TREATMENT (CONT'D)

P-Number from Appendix A	Holding Temperature Range, °F (°C)	Holding Time Based on Nominal Thickness	
		Up to 2 in. (50 mm)	Over 2 in. (50 mm)
P-No. 10I Gr. No. 1	1350 (730) to 1500 (815)	1 hr/in. (25 mm) 15 min minimum	1 hr/in. (25 mm)

GENERAL NOTES:

(A) In lieu of the cooling rate described in para. 132.5, the P-No. 10 I material cooling rate shall be not greater than 100°F/hr in the range above 1200°F (650°C), after which the cooling rate shall be sufficiently rapid to prevent embrittlement.

(B) Postweld heat treatment is neither required nor prohibited for a nominal thickness of $\frac{1}{2}$ in. or less.