STATE OF OREGON
DEPARTMENT OF CONSUMER AND BUSINESS SERVICES

BUILDING AND CODES DIVISION

BOILER CLASS 2 LICENSE EXAMINATION STUDY GUIDE

General Information for All License Types

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)**, **2007 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**;

(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.

<u>Class 2</u>

Class 2 Pressure Vessel Installer License. A person holding this license may install or repair unfired pressure vessels by any **non-welded** method of attachment.

Class 2 licensees are required to take 8 hours of continuing education during each 3-year licensing cycle.

1. There are no minimum qualifications required to obtain this license. Applicants shall pass an examination testing the applicant's knowledge of the **Boiler and Pressure Vessel Law**, Oregon Revised Statutes, 480.510 to 480.670; Oregon Administrative Rules, chapter 918, division 225; and **American Society of Mechanical Engineers, Boiler** and **Pressure Vessel Code**, **Section VIII, Division 1**, **General Requirements**.

2. Persons who install refrigeration process equipment assembled and sold as a modular unit by the manufacturer and who do not attach piping to a pressure vessel during the installation are exempt from this rule. To qualify for this exemption, the attachment shall be made by any method other than fusion welding.

<u>Piping Attachments</u>

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.

<u>Piping Materials-</u>

- 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.

<u>Used piping</u>-
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.

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

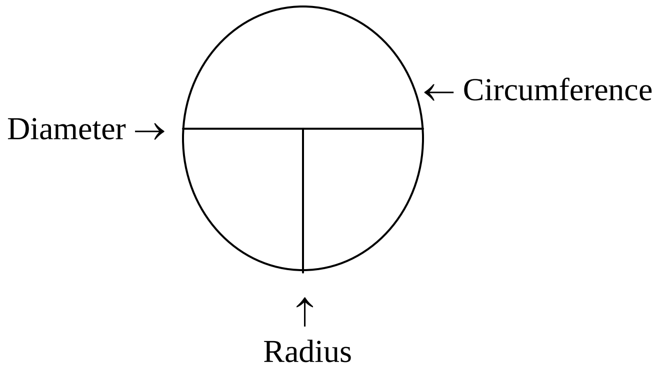
- the system's pressure must be gradually increased to a required test pressure (provided by the inspector)
- the test pressure must be maintained for a designated period of time, generally between 10 to 20 minutes.
- If water is used to perform the leak test, the metal temperature must be at least 60^{o}F 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
(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)

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- 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

<u>Blueprints</u>

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).