

Body of Knowledge For
State of Ohio
High Pressure Engineers License Exam

Licensed High Pressure Boiler Operators must have knowledge on a variety of subjects relating to power plant systems including; steam boilers, environmental controls, water treatments, economic devices, and safe operation to prevent injury or damage. This includes high pressure and low pressure boilers.

The State of Ohio High Pressure Engineers License Examination is designed to determine if individuals have such knowledge. The body of knowledge is a study guide that provides a list of specific topics in which the Boiler Operator should be knowledgeable.

Only information covered in the categories outlined in this Body of Knowledge will be utilized for the examination questions. Each specific examination may not cover every topic of the Body of Knowledge.

Steam Plant Operation, 8th Edition by Woodruff and Lammers (Excluding Chapters 9 & 10) is the primary reference document. *Low Pressure Boilers second edition* by Frederick M. Steingress (Excluding Chapters 9 & 10) is the reference used for low pressure boilers

Books or other reference materials are not to be brought to the examination site, however non-programmable calculators may be used.

Body of Knowledge For
State of Ohio
High Pressure Boiler Operators License Exam

- Part 1 Boilers - steam cycle, fuel / energy source, utility boilers , industrial boilers, cogeneration.
- Part 2 Boiler Design / Application, heat transfer, steam properties, control devices, furnace design, economic devices, firing equipment, and draft.
- Part 3 Boilers - Construction; materials, support, types of stress, openings and fittings, heating surface and capacity.
- Part 4 Combustion – fuels, control of the rate of combustion.
- Part 5 Combustion Equipment - specific types of equipment for each type of fuel including safety devices, monitoring and adjusting fuel burning equipment, and mechanical and draft.
- Part 6 Boiler Indicators and Devices - to provide for operation, prevent over-pressure, determine water level, valves, piping, blow down systems, and measuring devices.
- Part 7 Boiler Operation - abnormal operations, start up, shut down, efficiency, water supplies, idle boilers, maintenance, repairing, and evaluation of a boilers' condition
- Part 8 Pumps – type, applications, facts used in selecting, conditions for operating, and maintenance.
- Part 9 Boiler Auxiliary Support Equipment – types and operation of feed water heaters, water system make up, condensate, polished systems, blow down systems, steam traps, separators, lubricator types and devices with their auxiliaries.
- Part 10 Environment Control – types, technology, particulate control, equipment for specific controls, mechanical, bag filter, and precipitator.
- Part 11 Math formulas
- Part 12 Ohio Laws and Rules

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1 - Boilers

Knowledge in the operation, maintenance, repair, economics of basic systems including the use of steam, the energy source to produce the steam, the distinction between industrial and utility boilers, and a good concept of how steam is generated from a heat source other than combustion within a boiler.

1.1 Steam Cycle

The Boiler Operator should know the Rankine Cycle, the effects of reheat cycles and regenerative feed water heating

1.2 Fuel / Energy Source

The Boiler Operator should know the types of fossil fuels used in a boiler, coal, oil, gas as well as the heat derived from nuclear fuel such as uranium.

1.3 Utility Boilers

The Boiler Operator should know that utility boilers are those plants that generally supply electricity to most of the United States. These boilers are most often fired with coal but are also fired with fuel oil and gas. Utility boilers have reheat cycles, and require very elaborate water treatment systems.

1.4 Industrial Boilers

The Boiler Operator should know industrial boilers are most often used for process steam, such as heating, driving operating turbines, for fans or pumps, and other process work.

1.5 Cogeneration.

The Boiler Operator should know that cogeneration is a system in which fuel is used to produce energy and the heat from the fuel is then directed to be used by a boiler to conserve energy and achieve the maximum efficiency from the heat generated.

2. Boiler Design/Application

The boiler operator should know: how the application affects the design, size, and type of boiler to be used. Also, the types of heat transfer, how they differ, and where each takes place within the furnace. The boiler operator must have an understanding of the relationship between steam pressure and temperature and how to control their parameters. The boiler operator must have knowledge of the

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rules for construction of boilers, including material properties, accessories supplied, and heat source. Knowledge is needed for plants that span the last fifty years or more.

2.1 Boiler Design / Application

The boiler operator should know fire tube, vertical (submerged and non-submerged), horizontal, water tube, and cast iron type boiler construction. The boiler operator should be able to describe the differences between package and site-erected boilers. The boiler operator must know the difference between a longitudinal weld joint and a circumferential weld joint. The operator should be able to describe the flow of gases through each type of boiler.

2.2 Heat Transfer

The boiler operator must understand conduction, convection, and radiation heat transfer. The boiler operator should be able to describe the various types of fluid flow and how they affect heat transfer. The density of steam versus boiler pressure, and the meaning of saturation temperature must be understood.

2.3 Steam, properties and Control Devices

The boiler operator should know location and purpose of a dry pipe, cyclone steam separators, steam scrubber, or baffles. The boiler operator should know the function, types, location, operation, start up, and efficiency of superheaters. Have an understanding of the affects of carryover and how it is prevented, steam quality, and desuperheaters or attemperators.

2.4 Furnace Design

The boiler operator should understand the reason(s) for having ash re-injection, furnace baffles, and water walls (water cooled furnace). The boiler operator should have knowledge of soot blower operation, types and location. Refractory walls, slag, erosion and spalling, purpose of a water screen, flame impingement, clinkers, clinker crinders are topics with which the boiler operator should be familiar.

2.5 Economic Devices

The boiler operator should know the construction location, types, and purpose of an economizer, air-preheaters, and thermocouples.

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- 2.6 Firing Equipment
The boiler operator should understand and be able to operate pulverized firing, chain grate firing, spreader stoker firing, and underfeed stoker firing.
- 2.7 Draft
The boiler operator should understand balanced draft units, pressurized draft unit, primary air, secondary air, tertiary air.
- 3. Boilers Construction
The boiler operator must be aware of the materials, design, and limits of those materials used in the equipment in their charge. Stress the access for cleaning, inspection, and repairs, as well as the appliances attached to the boiler to ensure it does not exceed the limits of its design. Also the operator must know the abilities and limits of the unit being operated to prevent failures of equipment that may result in injury or death.
 - 3.1 Materials
The boiler operator must have knowledge and understand limitations of materials used in boiler construction. The boiler operator should have knowledge of proper operating procedure which will help to prevent creep or graphitization. Being able to specify the nondestructive examination method to be used to inspect the boiler is also part of the knowledge needed by the boiler operator.
 - 3.2 Openings and Fittings
The boiler operator should know the requirement for the minimum size of a manhole or hand hole opening. In addition, he must be able to list the purpose of other openings in the drum, and be able to identify the process of rolling tubes into a boiler.
 - 3.3 Heating Surface and Capacity
The boiler operator should know the definition of heating surface, and how twelve square feet of heating surface is related to Ohio law concerning licensed operators and engineers. The operator must also be able to convert evaporation rate to horsepower.

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4. Combustion

The boiler operator must be proficient in the techniques used to control fuel and air to a furnace, thus regulating the release of heat to the boiler.

4.1 Fuels and their equipment

The boiler operator should know the combustion process, temperature required for combustion, atomization, and absolute pressure.

4.2 Control of the rate of Combustion

The boiler operator should know how to control the supply air (oxygen) part of combustion, the condition or degree under which combustion takes place, flue gas analysis methods, the amount of air required to burn a pound of fuel, and tempering of fuel.

5. Combustion Equipment

The boiler operator must be familiar with the devices used to supply fuel to the furnace. This includes using solid, gaseous, or liquid fuels; the protective devices, types of controls used, and understand the type or types of draft required for each fuel including units that operate on multiple fuels.

5.1 Combustion Equipment

The boiler operator should know operation and maintenance of coal stokers, such as chain grate, spreader underfeed, and pulverize. Must know oil fired burners, mechanical or pressure type, and the advantages and disadvantages of each. Also, operation and maintenance of gas fired burners whether the supply is natural or man made. The operator must be able to describe the method of disposing of ash and products of combustion, and know the physical requirements of the fuel system.

5.2 Safety Devices

The boiler operator must be able to explain how to properly fire a boiler. The boiler operator must be able to explain the importance of purging the furnace and of heating or pressurizing the fuel. The operator must know what devices are to be installed in the fuel system to protect it.

5.3 Monitoring the furnace

The boiler operator must be able to explain what can happen if the burner flame is not controlled properly.

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- 5.4 Draft

The boiler operator shall see to it that induced, over fire, and forced draft fans are operational, and must determine if a balanced draft on positive pressure furnace is distributing heat and gases as required to prevent failure in the furnace.

- 6. Boiler Indicators and Devices

The boiler operator must have knowledge of operation and maintenance relating to the devices that are provided to assist in determining and maintaining water level, steam pressure, isolating the boiler, and preventing over pressure of the boiler. The devices shall be in the proper location, using recommended code installation practices.

 - 6.1 Safety Devices

The boiler operator shall know the operation, maintenance, location, purpose, and proper installation of a boiler water column, safety valve, blow down valve, heater/non return valve, steam gauge, fusible plug, and feed water regulator.
 - 6.2 Safety Valve

The boiler operator shall be able to properly test the safety valve of the boiler and know the minimum number of valves required for installation. The boiler operator must know the requirements for; discharge piping, minimum blowback values, and the minimum capacity for safety valves.
 - 6.3 Boiler Water Level Devices

The boiler operator will know the proper procedure to determine the water level of the boiler, the location of the water column and the minimum size, strength, and type of pipe and fittings used.
 - 6.4 Valves and Their Applications

For each appliance, the boiler operator will know the type of valve used in which order it is used on feed water, blow down, steam header, water column, and all other connections to the boiler.
 - 6.5 Instrumentation

The boiler operator shall know how to use all measuring devices, insure that they are attached properly, and be able to perform test to prove their accuracy. These items may include; steam gauges, draft gauges, water gauges, fuel, and temperature gauges.

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7 Operation and Maintenance

The boiler operator must show evidence that indicates the comprehension of the theory of the production of steam from boilers, during all phases of operation, maintenance, repairs, and inspection.

7.1 Start Up and On-line Operation of Boilers

The boiler operator should understand the sequence of operation that leads up to on-line operation. This includes any special considerations for new, or newly repaired boilers.

7.2 Combustion

The boiler operator should be able to monitor, analyze, and regulate the combustion process to operate in the most efficient and safe manner.

7.3 Operational Problems

The boiler operator needs to be able to recognize problem areas immediately and control potentially un-safe operation. Abnormal operation, priming and carry over, tube failure, fires, inconsistent draft, and gauge glass breakage are some of the situations that an operator must, at all times, be ready to handle.

7.4 Idle Boilers

The boiler operator should be able to care for idle boilers, know how to take a boiler out of service, and know how to place a boiler in wet or dry lay up.

7.5 Boiler Maintenance

The boiler operator should be able to; perform routine maintenance, schedule maintenance, prepare boilers for internal inspections, and external inspections, or repairs. To obtain maximum efficiency in operation the boiler needs to be maintained on a regular schedule.

8. Pumps

The boiler operator shall demonstrate knowledge indicating comprehension of the operation, maintenance, start-up and shut down of all types of pumps used throughout a powerhouse.

8.1 Pumps

The boiler operator must be able to identify the types of pumps and the varied uses of pumps. The operator must understand their capabilities and

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what can be expected of injectors, duplex pumps, power pumps, vacuum pumps, rotary pumps, and centrifugal pumps.

8.2 Pump Operation

The boiler operator needs to be able to properly line up and bring pumps on line, regulate pump discharge and understand the performance characteristics of the pump.

8.3 Pump Maintenance

The boiler operator needs to know when and how to care for each type of pump, must identify the required routine maintenance, and schedule maintenance, to maintain peak performance of all types of pumps.

9. Boiler Auxiliary Support Equipment

The boiler operator shall demonstrate knowledge that indicates comprehension of the operation, maintenance, start-up and shut down of boiler auxiliary equipment used through out a powerhouse. These items include pre-heating, water treatment, distribution of steam, return of condensate, and lubrication operations.

9.1 Feedwater Heating Equipment

The boiler operator needs to know feed water heaters, closed and open, and deaerators. The boiler operator must have a thorough understanding of pre-heating of feedwater, and which components provide these benefits.

9.2 Boiler Water Treatment

The boiler operator needs to know water treatment. To maintain peak performance and limit down time, water quality is of great importance to safe operation. The boiler operator must be able to analyze and chemically treat water for each condition. The boiler operator must understand the affects of blowing down a boiler.

9.3 Piping Systems for Steam and Condensate

The boiler operator needs to know piping systems design, material selection, flanges and fittings are topics with which the operator must be familiar.

9.4 Steam Traps

The boiler operator needs to know the various designs and types of steam traps, separators, and strainers. To gain the most efficiency from the steam, it is dried for use using separators.

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- 9.5 Lubrication
The boiler operator must understand classification and uses of lubricants and lubricating devices. The applicant must know what provides the best protection and reduces friction, and the different methods of application.

- 10. Environmental Control
The boiler operator shall demonstrate knowledge that indicates comprehension of the operation, maintenance, start-up and shut down of environmental equipment and to comply with environmental responsibilities of the plants operation.
 - 10.1 Pollution Controls and Standards
The boiler operator needs to know the types of emissions, how they are monitored, and the operator must be able to differentiate one condition from another, and control the situation accordingly.

 - 10.2 Pollution Control Devices
The boiler operator needs to know how particulates are controlled, mechanical collectors, electrostatic precipitators, bag filter houses, how to control pollution by-products or stack gas emissions are topics with which the operator must be familiar.. The applicant needs to identify the different methods available and the principles of operation.

 - 10.3 Flue Gas Scrubbers
The boiler operators needs to know how to operate sulfur dioxide scrubber, wet scrubber, and dry scrubber. In addition to particulate control, the chemical balance as a result of combustion needs to be reduced to acceptable atmospheric standards.

- 11. Math Formulas
Math from the text the Boiler Operator must know the formulas as there will be no books, notes, and no programmable calculators allowed.
 - 11.1 The internal design pressure of an existing boiler.

 - 11.2 Absolute pressure.

 - 11.3 Rate at which tons of coal are being consumed in a chain grate stoker.

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- 11.4 Pressure due to head of water.
 - 11.5 Concentration of chlorides in boiler water.
 - 11.6 Tons of coal to develop pounds of steam per hour.
 - 11.7 Collection efficiency of an electrostatic precipitator.
 - 11.8 Pounds of water to condense one pound of steam
12. Ohio Laws and rules pertaining to the licensing of Stationary Boiler Operators, Boiler Operators, and Low Pressure Boiler Operators
- 12.1 Horsepower by heating surface
 - 12.2 Licenses renewals
 - 12.3 License revocation and expiration
 - 12.4 Experience and schooling
 - 12.5 Display of license
 - 12.6 Requirements of boilers over thirty (30) horsepower by heating surface