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Body of Knowledge For
State of Ohio
Stationary Steam Engineers License Exam

Licensed Stationary Steam Engineers must have knowledge on a variety of subjects relating to power plant systems including; steam boilers, steam turbines, steam engineering, 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 Stationary Steam 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 Steam Engineer should be knowledgeable.

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

Steam Plant Operation 8th Edition by Woodruff and Lammers 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 are not to be brought to the examination site, however non-programmable calculators may be used.

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Part 1	Boilers - steam cycle, fuel / energy source, utility boilers, industrial boilers, cogeneration.
Part 2	Boiler Design / Application, heat transfer, steam, properties and control devices, furnace design, economic devices, firing equipment, draft.
Part 3	Boilers - Construction; materials, support, types of stress, openings and fittings, heating surface and capacity.
Part 4	Combustion – fuels and 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 draft.
Part 6	Boiler - indicators and devices to provide for operation, prevent over-pressure, determine water level, valves, piping, blow down system, 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	Steam Turbines - design, construction, installation, types, sizes, applications, governors, lubrication controls, packing, condensers, cooling towers and ponds, valves, piping, safety devices, and design materials for construction.
Part 10	Steam Turbines Associated Equipment - maintenance, condenser operation and maintenance, steam air ejectors, traveling screens, and vacuum.
Part 11	Boiler Auxiliary Support Equipment - types and operation of feedwater heaters, water system, make up, condensate, polished systems, blow down systems, steam traps, separators, lubricator types and devices with their auxiliaries.
Part 12	Environmental Control - types, technology, particulate control, equipment for specific controls, mechanical, bag filter, and precipator.
Part 13	Math Formulas
Part 14	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 Steam Engineer should know the Rankine cycle, the effects of reheat cycles, and regenerative feedwater heating.

1.2 Fuel / Energy Source

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

1.3 Utility Boilers

The Steam Engineer 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 Steam Engineer 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 Steam Engineer should know that cogeneration is a system in which a 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 Steam Engineer 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 steam engineer must have an understanding of the relationship between steam pressure and temperature and how to control their parameters. The steam engineer must have knowledge of the 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 Steam Engineer should know fire tube, vertical (submerged and non-submerged), horizontal, water tube, and cast iron type boiler construction. The steam engineer should be able to describe the differences between package and site-erected boilers. The steam engineer must know the difference between a longitudinal weld joint and a circumferential weld joint. The engineer should be able to describe the flow of gases through each type of boiler.

2.2 Heat Transfer

The Steam Engineer must understand conduction, convection, and radiation heat transfer. The steam engineer 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 Steam Engineer should know location and purpose of a dry pipe, cyclone steam separators, steam scrubber, or baffles. The steam engineer 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 Steam Engineer should understand the reason(s) for having ash re-injection, furnace baffles, and water walls (water cooled furnace). The steam engineer 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 steam engineer should be familiar.

2.5 Economic Devices

The Steam Engineer should know the construction location, types, and purpose of an economizer, air-preheaters, and thermocouples

2.6 Firing Equipment

The Steam Engineer should understand and be able to operate pulverized firing, chain grate firing, spreader stoker firing, and underfeed stoker firing.

2.7 Draft

The Steam Engineer should understand balanced draft units, pressurized draft unit, primary air, secondary air, tertiary air.

3. Boilers Construction

The Steam engineer 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 limit of its design. Also the steam engineer must know the abilities and limits of the unit they are operating to prevent failures of equipment that may result in injury or death.

3.1 Materials

The Steam Engineer 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 Steam Engineer 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 Steam Engineer 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.

4. Combustion
The Steam Engineer 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 Steam Engineer should know the combustion process, temperature required for combustion, atomization, and absolute pressure.

4.2 Control of the rate of Combustion
The Steam Engineer 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 to burn a pound of fuel, and tempering of fuel.

5. Combustion Equipment
The Steam Engineer 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 Steam Engineer should know operations, maintenance of all 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 Steam Engineer 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 Steam Engineer must be able to explain how to properly fire a boiler. The steam engineer must be able to explain the importance of purging the furnace and of heating or pressurizing the fuel. The engineer must know what devices are to be installed in the fuel system to protect it.

5.3 Monitoring the furnace
The Steam Engineer must be able to explain what can happen if the burner flame is not controlled properly.

5.4 Draft
The Steam Engineer 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.

6.0 Boiler
The Steam Engineer 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 Steam Engineer shall know the operation, maintenance, location, purpose, and proper installation of a boiler water column, safety valve, blow down valve, header/non return valve, steam gauge, fusible plug, and feedwater regulator.

6.2 Safety valve
The Steam Engineer shall be able to test the safety valve of the boiler and know the minimum number of valves required for installation. The steam engineer must know the requirements for; discharge piping, minimum blow back values, and the minimum capacity for safety valves.

6.3 Boiler water level devices
The Steam Engineer 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 the pipe and fittings used.

6.4 Valves and their applications
For each appliance, the Steam Engineer will know the type of valve used, and in which order it is used on feedwater, blow down, steam header, water column, and all other connections to the boiler.

6.5 Instrumentation

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

7 Operation and Maintenance

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

7.4 Idle Boilers

The Steam Engineer 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 and dry lay up.

7.5 Boiler Maintenance

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

8. Pumps

The Steam Engineer shall demonstrate knowledge indicating comprehension of the operation, maintenance, start-up, and shut down of all types of pumps used through out a powerhouse.

8.1 Pumps

The Steam Engineer needs to be able to identify the types of pumps and the varied uses. The engineer must understand their capabilities and what can be expected of injectors, duplex pumps, power pumps, vacuum pumps, rotary pumps, and centrifugal pumps.

8.2 Pump operation

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

9. Steam Turbines

The Steam Engineer shall demonstrate knowledge that indicates comprehension of the operation, maintenance, construction, start-up and shut down of steam turbines used throughout a powerhouse.

9.1 Turbine design and theory

The Steam Engineer must be able to describe the types of turbines and demonstrate the theory behind the internal components of the turbine (staging, nozzles, compounding, etc.) and the process of converting heat energy to mechanical energy.

9.2 Turbine settings and adjustments

The Steam Engineer needs to understand clearances, thrust bearing functions, main bearings, packing, lubrication, how to obtain maximum performance. They must also know the importance of internal clearances being maintained and how to make adjustments accordingly.

9.3 Turbine control and regulation
The Steam Engineer needs to know how turbines are controlled using steam flow and governor operation in order to obtain maximum performance. Control of steam flow must be monitored, evaluated, and periodically adjusted.

9.4 Turbine start up and shut down
The Steam Engineer needs to know the sequence of operations for start up and shut down of small, medium, and large turbines. Turbine operating problems, ratings of turbine and applications of driven equipment, skills to obtain peak output and safe operations are topics in which a Steam Engineer must be knowledgeable.

10. Steam turbine and associated equipment
The Steam Engineer shall demonstrate knowledge that indicates comprehension of the operation, maintenance, start-up, shut down, of equipment such as condensers, air ejectors used through-out a powerhouse, and how they effect plant efficiency.

10.1 Condensers and cooling towers
The Steam Engineer needs to know condensers / cooling towers, circulating pumps, condensate pumps, and air ejectors. The engineer must understand that through the manipulation of basic scientific processes energy can be transferred and more power developed with use of specific components.

10.2 Turbine maintenance
The Steam Engineer needs to know turbine maintenance/condenser maintenance, preventative maintenance, inspection, tube leakage, water quality, scheduled down time for turbines, driven equipment, and associated support equipment, knowledgeable in what needs attention, how often and in what order, and able to analyze operating characteristics as a pre-planning strategy.

11. Boiler Auxiliary Support Equipment
The Steam Engineer 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 and return of condensate and lubrication operations.

11.1 Feedwater heating equipment
The steam engineer needs to know feedwater heaters, closed and open, and deaerators. The engineer must have a thorough understanding of pre-heating of feedwater, benefits of the same, and which components provide this benefit.

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

11.3 Piping systems for steam and condensate
The Steam Engineer needs to know piping systems. Design, material selection, flanges and fittings are topics with which the engineer must be familiar.

11.4 Steam traps
The Steam Engineer 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.

11.5 Lubrication
The Steam Engineer 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.

12 Environmental Control
The Steam Engineer 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.

12.1 Pollution controls and standards
The Steam Engineer needs to know the types of emissions, how they are monitored, and the engineer must be able to differentiate one condition from another, and control the situation accordingly.

12.2 Pollution control devices
The Steam Engineer needs to know how particulates are controlled. Mechanical collectors, electrostatic precipitators, bag filter houses, and how to control pollution by-products or stack gas emissions are topics with which the engineer must be familiar. The applicant needs to identify the different methods available and the principles of operation.

12.3 Flue gas scrubbers
The Steam Engineer 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.

13. Math Formulas
The Steam Engineer must know the formulas as there will be no books, notes, and no programmable calculators allowed.

13.1 The internal design pressure of an existing boiler

13.2 Absolute pressure

13.3 Rate at which tons of coal is being consumed in a chain grate stoker

13.4 Pressure due to head of water

13.5 Concentration of chlorides in boiler water

13.6 Pounds of water to condense one pound of steam

13.7 Collection efficiency of an electrostatic precipitator

13.8 Tons of coal to develop pounds of steam per hour.

13.9 Boiler horsepower

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14. Ohio Laws and Rules - Stationary Engineers should be familiar with Ohio laws which pertain to Stationary Engineers, High Pressure Boiler Operators, and Low Pressure Boiler Operators.

    14.1 Horsepower by heating surface

    14.2 License renewals

    14.3 License revocation and expiration

    14.4 Experience and schooling

    14.5 Display of license

    14.6 Requirements of boilers over thirty (30) horsepower by heating surface.