

Sample Powerhouse Operator Curriculum

This curriculum is designed to provide a power house operator with fundamental knowledge necessary to understanding equipment specific procedures and training. This core set of skills can be broken into five segments:

- Mathematics in the industrial environment
- Basic physics and chemistry for plant operations
- Process equipment and instrumentation fundamentals
- Steam system basics
- Boiler operation

The curriculum contains approximately 200 hours of training. It would be integrated into the training schedule for an established work force such that it could be completed in 20 months or less. For new hires, a large percentage of the first few weeks on the job could be used to complete the math and process fundamentals portion of the curriculum before any equipment specific training started. The training materials average \$3.78 per hour of instructional content for a total cost of \$745.75 per employee. This type of investment in training usually earns a handsome return from improved operating efficiency, and the early recognition of system abnormalities before a major breakdown or an environmental incident occurs.

Course #	Course Title	Hours	Unit Price
60	Plant Mathematics-Decimals & Percents	25.0	\$52.00
82	Plant Mathematics-Positive & Negative Numbers	4.0	\$15.50
78	Plant Mathematics-Reading & Preparing Simple Graphs	20.0	\$39.75
49	Plant Operator Series-Fundamentals of Physics	16.0	\$55.00
58	Plant Operator Series-Basic Chemistry	12.0	\$44.25
59	Plant Operator Series-Equipment	13.0	\$48.00
205	Fundamentals of Process Instrumentation	30.0	\$150.00
203	Reading A P&ID	6.0	\$47.00
53	Principles of Combustion	14.0	\$42.75
87	Steam & the Steam Generating Unit	4.5	\$18.50
131	Introduction to Steam Traps	2.0	\$12.75
91	Steam Trap Installation	3.0	\$14.75
88	Steam Trap Testing Practices	4.5	\$19.75
102	Steam Trap Troubleshooting	2.0	\$12.75
96	Monitoring Boiler Conditions	6.0	\$29.00
128	Boiler Start-Up Procedures	13.0	\$45.50
121	Boiler Shutdown Procedures	6.5	\$28.75
108	Boiler Efficiency	7.0	\$29.75
90	Water Chemistry	2.5	\$12.75
41	Boiler Feedwater	6.0	\$21.50
117	Water Testing	2.5	\$14.75
Totals:		199.5	\$754.75
Total Curriculum - Cost/Hour of Instruction:		\$3.78	

The following page provides a description of the content of each course.

The following abstracts describe each course in the powerhouse operations curriculum in the order in which the courses are recommended. This order has been selected to account for prerequisite requirements.

Mathematics - 49 hours

Course No. 60

25 hours

Plant Mathematics – Decimals and Percents

A refresher course on decimals and percents, their relationships to each other and to fractions, and the mathematical processes involving the three. Conversion from one form of notation (fraction, decimal, or percent) to another; adding, subtracting, multiplying, and dividing with decimals; rounding off and checking of decimal answers in problems; converting measurement units to decimals of other units in the same scale; working in decimals in solving multiplication and division problems involving percents; and practical sequential problems in the fields of production, laboratory control, and maintenance.

Elementary school mathematics.

Course No. 82

4 hours

Plant Mathematics – Positive and Negative Numbers

A refresher course on positive and negative numbers and their relationship to each other: using signs to determine positive or negative qualities; reading scale values above and below zero; adding negative numbers, positive and negative numbers; subtracting large positive numbers from smaller ones; and working problems that require the use of positive and negative numbers.

Elementary school mathematics.

Course No. 78

20 hours

Plant Mathematics – Reading and Preparing Simple Graphs

The reading and preparation of simple bar and line graphs.

Bar Graphs: recognition of the parts of a bar graph, identifying bars and reading their value; interpolation of values between scale divisions; selection of the proper bar graph based on content; preparation of simple bar graphs in both vertical and horizontal position, including selection and ordering of data, setup of scales, and drawing the bars; use of interrupted amount scale for clarity; and reading and preparing component bar graphs.

Line Graphs: identification of scales on line graphs; point coordinates and the proper way to write them; determining the value of a missing coordinate given one coordinate and curve; the concept of positive and negative coordinates; reading values from curve families and multi-scale graphs; plotting points with both positive and negative coordinates; recognition that two points do not determine curve shape; requirements for and setup of scales; preparation of smooth curves from raw data; and use of curve families and multi-scale graphs.

Basic Physics & Chemistry - 28 hours

Course No. 49

16 hours

Plant Operator Series – Fundamentals of Basic Physics

Basic principles of physics with which all new plant operators should be familiar: concepts of weight, form, volume, temperature, pressure, density, specific gravity, condensates, and vapors: conversion of “psi” to “feet of water” and “inches of mercury” and vice versa; absolute, gauge, and atmospheric pressure, and vacuum; effects of temperature and pressure on gas volumes (Ideal Gas Laws); compression and expansion; and the effects of temperature and pressure on liquids, vapors, and condensates.

Familiarity with multiplication and division of whole numbers and the use of fractions and decimals.

Course No. 58

12 hours

Plant Operator Series – Basic Chemistry

The basic chemistry that a plant operator needs to understand chemical reactions and acids and bases. Highlights include: atoms and molecules; elements and compounds; chemical reactions; catalysts; acidity and alkalinity; pH and the pH scale. Some of the chemical symbols introduced are: HCl, H₂SO₄, NaCl, NaOH, Hg, H₂, N₂, CO₂, and H₂O.

Arithmetic ability and basic knowledge of pressure and temperature.

Process Equipment & Instrumentation - 49 hours

Course No. 59

13 hours

Plant Operator Series – Equipment

Basic concepts of plant operating equipment and some of its hardware: an introduction to vessels such as tanks and columns or towers, including packing, distributors, and process flow; basic principles of positive displacement pumps, centrifugal pumps, reciprocating pumps, and compressors; fundamentals of heat exchange, including heat exchangers and steam trap principles; the main parts of a valve and an introduction to many types of valves.

In the last section of the course, the trainee follows a process flow using most of the equipment discussed in the course.
Knowledge of basic physics.

Course No. 205

30 hours

Fundamentals of Process Instrumentation

An over view of the physics associated with understanding instrumentation and process variables. Direct read instruments, how to read them and how they work. The concept of a simple control loop. The different types of temperature, pressure, level, flow and weight sensors and how they work. The role of a transmitter and how its output and input are related. Types of controllers and control modes. Types of recorders and how they are read. Control valves and other final control elements. Simple, cascade, feedforward and ratio control. The course is divided into three books, Part I - Introduction, Part II - Sensors and Part III - Control Loops and Their Elements. There is a Completion Exercise associated with each book to provide a means of evaluating how the trainee has learned the material.

Familiarity with multiplication and division of whole numbers and the use of fractions and decimals. Ability to read simple line graphs.

Course No. 203

6 hours

Reading A P&ID

Highlights include parts of a P&ID (body, title block, revisions etc.), using the Master Sheet, equipment symbols, instrument symbols, line designations and identifying process lines, tracing process flow and following instrument control loops

Understand the basic concepts of process equipment such as pumps, check valves, heat exchangers and control valves.

Steam System Basics - 30 hours

Course No. 53

14 hours

Principles of Combustion

The principles of combustion as they apply to the combustion of commercial fuels: the chemical symbols for elements and compounds encountered in combustion; ignition temperatures; chemical formation of CO₂, SO₂, H₂O; products of combustion; complete, incomplete, and perfect combustion; effect of time, temperature, and turbulence on quality of combustion; the BTU; heating value of fuel; effects of excess air; and combustion of solid, liquid, and gaseous fuels.
Ability to add, subtract, multiply and divide simple fractions and decimal numbers.

Course No. 87

4.5 hours

Steam and the Steam Generating Unit

Definitions of saturated, superheated, and wet steam; latent heat of steam; pressure/temperature relationship of saturated and wet steam; relative weights of steam and water; effect on water and steam as heat is added or taken away; condensing steam; the main parts of a steam generating unit; difference between fire-tube and water-tube boiler; boiler circulation and water walls circulation; and identification of some parts of a boiler and a water wall.
Ability to interpret simple sketches and a basic knowledge of the principles of combustion.

Course No. 131

2 hours

Steam Traps – Introduction

Information on the five types of steam traps in general use: thermostatic, float-thermostatic, impulse, thermodynamic (disc), and inverted bucket. The principle of operation and the critical operational part of each type of trap are discussed.
A general nontechnical understanding of steam.

Course No. 91

3 hours

Steam Traps – Installation

Location, sequence, and arrangement of components for a standard steam trap installation; where steam traps must be installed; and safety measures to avoid injuries.
Course 88 or equivalent knowledge of how to test a steam trap.

Course No. 88

4.5 hours

Steam Traps – Testing Practices

How steam and condensate are formed; the need for and importance of steam traps; testing of any type of trap by watching condensate discharge from the open end of a pipe; testing two types of traps in closed-end piping by watching condensate discharge from a test connection; test of all other trap types with closed-end piping by listening to trap operation; safety hazards to be avoided during testing.
Ability to read simple sketches.

Course No. 102

2 hours

Steam Traps – Troubleshooting

This course covers a procedure for correcting faulty steam trap system operation using a checklist. The major steps in the procedure are: (1) test the trap; (2) correct important defects; (3) test the trap again; (4) replace the trap; and (5) list the needed corrections. There is also an optional step of “repair in place” instead of “replace the trap”.
Courses 88 and 91 or equivalent knowledge of testing and installation procedures.

Boiler Operation - 43.5 hours

Course No. 96

6 hours

Boiler Operation – Monitoring Boiler Conditions

Identification of normal furnace and boiler conditions by observation of flame appearance and instruments; determination of normal and abnormal excess air by appearance of flame and by observation of O₂, CO₂ meters, or steam flow-air flow meter; and variations, if any, of boiler conditions with load changes such as: boiler exit gas temperature, feedwater flow, feedwater temperature, CO₂ and O₂, steam flow-air flow, furnace draft, boiler outlet drag and windbox or undergrate air pressure, boiler water level, etc.

Ability to interpret simple sketches; basic physics; a basic knowledge of combustion; and knowledge of the basic parts of a steam generating unit.

Course No. 128

13 hours

Boiler Operation – Start-up Procedure

General procedures involved in boiler load increases; putting a boiler on the line; allowable warm-up rate; boiler start-up; filling a boiler with water; establishing a minimum stable flame; and identification of parts, such as pilot burner, manholes and handholes, etc.

Ability to read simple sketches and graphs and a basic knowledge of combustion, properties of steam, steam generating units, and normal boiler operation.

Course No. 121

6.5 hours

Boiler Operation-Shutdown Procedures

General procedures involved in boiler load reduction; taking a boiler off the line; allowable cooling rate; boiler shutdown and draining of boiler, effect of cooling rate on boiler water level; and identification of boiler parts such as chemical feed valve, drum vent valve, etc.

Ability to read simple sketches and graphs and a basic knowledge of combustion, properties of steam, steam generating units, and normal boiler operation.

Course No. 108

7 hours

Boiler Operation-Boiler Efficiency

Boiler, water column, and gage glass blowdown, soot blowing and ash removal, feedwater control and operator control of boiler efficiency. Identification of parts, procedure and reasons for water column and gage glass blowdown, mud drum and water wall intermittent blowdown, soot blowing and ash removal; the one-, two-, and three-element control systems and the relative differences among them; the meaning of boiler efficiency from an operator's viewpoint; and recognition of optimum boiler efficiency by observation of furnace conditions and steam generator instruments.

Ability to interpret simple sketches and a basic knowledge of the principles of combustion, properties of steam, and the steam generating unit.

Course No. 90

2.5 hours

Water Treatment – Water Chemistry

The basic chemistry needed to understand the “how” and “why” of water treatment: source of water, water quality, dissolved and suspended impurities in water; ions; attraction between anions and cations; hardness; pH and the pH scale; alkalinity; and specific conductance.

Basic knowledge of chemical terms.

Course No. 41

6 hours

Water Treatment – Boiler Feedwater

The “why” and “how” of boiler feedwater treatment; the cause and effect of deposits, corrosion, and carryover; specific conductance; blowdown; internal chemical treatment including sulfite, phosphate, and chelates; deaerating heaters; and sodium cation exchangers.

Understanding of the basic chemistry of water treatment.

Water Treatment – Water Testing

Types of test procedures used for control of water treatment operations: titration-type tests, including test equipment, reading liquid levels, indicators, standard test solution, endpoint, test factors, and the five steps in a typical titration; colorimetric tests, including special reagents, comparison with color standards, and recognition of equipment used; tests requiring special instruments, including specific conductance and pH, recognition of the equipment used and the five steps in a typical specific conductance test on boiler water; sampling for representative test samples. Importance of cleanliness and good housekeeping.

Basic understanding of water chemistry and boiler feedwater.