Introduction to Power Engineering

Learning Outcome
When you complete this module you will be able to:

Describe the overall industrial background and certification system for Power Engineering.

Learning Objectives
Here is what you will be able to do when you complete each objective:

1. Define the terms Power Plant and Power Engineer.

2. Describe the competency certification system.

3. List the national standards that are used in the Power Engineering industry.
INTRODUCTION

A power plant is many things. For the purposes of this course it may be considered as any process for the generation and utilization of steam. It includes steam generators or boilers, steam turbines, electric generators, motors, refrigeration and air conditioning equipment, control systems, water treatment and fuel handling facilities, emergency and stand-by equipment, and environmental protection equipment.

A power plant provides such output as electric power for light, and steam heat or cooling to condition air. This output may be used to provide climate control of buildings, or to condition air or products in industrial processes.

Many governmental agencies having jurisdiction over construction, inspection, and operation of such plants define the term “power plant” as meaning:

(1) Any one or more boilers in which steam or other vapour is generated at more than 103 kPa (15 psi); or

(2) Any one or more boilers containing liquid and having a working pressure exceeding 1100 kPa (160 psi), and a temperature exceeding 121°C (250°F), or either one of these; or

(3) Any system or arrangement of boilers referred to in subclause (1) or (2); and the engines, turbines, pressure vessels, pressure piping system, machinery, and ancillary equipment of any kind used in connection therewith.

The preceding definition applies equally to a small portable boiler or to a steam generator that may be many stories high, as shown in Fig. 1.

Figure 1
Large and Small Power Plants
POWER ENGINEERING and the POWER ENGINEER

A power engineer is a skilled worker who operates and maintains the equipment in a power plant. On-the-job activity covers the entire process of heat generation and heat utilization. It is usually not necessary to know all design features of all equipment, but in order to make it function safely and economically one must understand basic design requirements and the limitations involved.

In a large plant, the power engineer may function as a supervisor who directs others in safe and efficient operation on a shift. This includes other power engineers operating the steam generators or boilers, those in water treatment sections, and those who operate turbines, engines, pumps and other equipment that utilizes heat or energy. Some of this equipment is illustrated in Fig. 2. Work orders may be issued covering the repair of equipment by maintenance staff. The Power Engineer may recommend purchase of depletable supplies, such as salt, and may be totally responsible for one shift or for all shifts.

Figure 2
Typical Equipment Operated by Power Engineers

(a) (b) (c)
Among other pieces of equipment, a power engineer may be required to operate a small turbine (a), a large feedwater pump (b), or an industrial diesel engine (c).

In a smaller plant, the power engineer may operate and maintain equipment, order supplies, and generally assume full responsibility for the entire plant. There may be no other staff.

**HISTORICAL DEVELOPMENT OF THE VOCATION**

The power industry has long employed automatic devices for both handling and controlling fuels and equipment. Each new power plant exhibits more of the characteristics of automation: increased mechanization, more frequent use of automatic equipment, and continuous monitoring of processes and costs.

It is difficult to establish dates when certification of power engineers first began. Long before the invention of the steam engine, manual firing of furnaces was under legal scrutiny. A royal proclamation by Edward I of England in 1306 prohibited the “use of sea coals in furnaces”, and established a commission which could relax the rules in the case of careful firemen or fine the more careless. In Germany, because of pollution problems, metal plants were scrupulously monitored and sometimes denied the use of coal as early as 1350.

The steam engine, invented early in the nineteenth century, gave mankind the first source of power that was steady and reliable. It was originally used to remove water from mines and thus increase productivity. For many years, it was the practice for the engines to be put together on site. The mechanics who built an engine were loaned by the builder to commission and start up the engine, and often to operate the entire power plant. Frequently they stayed with the new owner.

Owners hired unskilled helpers, who started out doing manual labor, often on the coal pile. Through a system that they called “progression”, these workers were promoted to jobs with gradually increasing levels of skill as they acquired experience. As new plants were built and labour became more mobile, former employers “certified” the state of progression of a person moving to a new plant.

In the trend to greater efficiency, higher boiler pressures were adopted, and this led to serious accidents occurring due to the actions of unqualified personnel. It was natural for insurance underwriters and governments to become involved, and to take responsibility for the certification of both operators and equipment.
In recent years there has been a dramatic increase in efficiency in the modern plant. Close control of the steam generation process and enforcement of anti-pollution regulations has enlarged the responsibility of the power engineer, demanding more knowledge and providing greater opportunity to use his or her talent. For the power engineer who wishes to achieve job satisfaction in this expanding technology, the learning process never ends.

**Nature of the Work**

The government of the province or territory in which an engineer works passes an Act that contains a rule similar to the following:

> The holder of a Certificate of Competency, the classification of which authorizes him/her to act as an engineer, may sketch, construct, install, operate, repair, and give advice on all things pertaining to any power plant in which that person is employed, but is not entitled to perform any welding unless holding a Certificate of Competency permitting him/her to do so.

The beginning engineer is most likely to be involved in operation and repair, until enough knowledge and experience has been gained to perform the other functions outlined in the *Act*.

In very small plants, much of the work may be manual: opening and closing valves, operating pumps, checking the flame, starting electric motors, and determining the time and operation of water softeners. All these tasks may be performed by the engineer working alone.

In larger plants, automatic control systems open and close valves and regulate massive equipment that was formerly controlled by hand. Central control panels, as shown in Fig. 3, and closed circuit television often enable one engineer to operate systems that would require many operators if operated manually.

The engineer’s function is that of an interpreter. Mounted on the control panel are the instruments, which display information required to safely control boilers, generators, industrial processes, and air conditioning equipment. On the basis of that information, changes are made automatically. The engineer analyzes malfunctions and trends promptly, and with simple manipulation of knobs and switches commands the plant to proceed with the desired “steady state” operations.
Working Conditions

Power engineers can expect to have year-round employment without seasonal layoffs. In plants that never shut down, power engineers can usually expect to work eight or twelve hours per day, in rotating shifts on week days, weekends, and holidays. Shifts are arranged so that at some point several days “off” are grouped together in a type of vacation leave.

A common practice in many plants is to operate three shifts, starting at 8 a.m., 4 p.m., and 12 midnight, with four groups handling these three shifts. The pattern of shift rotation permitting three working groups and one “off” group, is essentially a weekly pattern of seven days, rather than the usual five days.

The popular 12-hour shift pattern is a little more complicated. One such schedule is shown in Table 1, involving eight crews plus one relief crew, indicated by (R).

On January 11, for example, Shift 7 in the steam plant works the same daytime hours as Shift 3 in the process plant. On January 12, Shift 7 in the steam plant works the same daytime hours as Shift 4 in the process plant. The same pattern is followed for two consecutive night shifts. On January 15, Shift 7 begins five consecutive days off.
To help promote accident-free performance, most working areas are clean and well-lighted. Central control rooms are frequently air-conditioned.

The power engineer must realize, however, that some plant areas may be dirty; with dust, fumes, smoke, high temperatures, and high noise levels. On occasion, the engineer may be required to work in damp or cold areas, in a crouched or prone position to inspect, adjust, or repair equipment.

Because work must be performed close to boilers, rotating equipment, electrical equipment, piping, and plant processes, the power engineer must guard against burns or other injuries that may occur due to faults in equipment.
Methods and Procedures

All operation, testing, and repair requires rigid adherence to specific methods and practices set out and covered under local plant practice and manufacturer’s instructions. Safety demands that these be followed at all times. The power engineer can expect to share in setting up and obeying all such practices, and to serve as an example to fellow employees or to those under his or her guidance. A sample of general rules employed in a typical plant follows. More specific rules would be formulated for light-up and shut-down of boilers and care of other specific machines.

Summary of Care and Operation of the Boiler

There are a number of general rules for the care and operation of our boiler. Some of these may seem simple, but there are many cases on record where boiler failures have been attributed to neglect in following the most elementary rules of operation.

Rule 1 Know our boiler. Examine it thoroughly and know the function and reason for each part.

Rule 2 Check the fire for stability, color, and turbulence as frequently as other duties will permit.

Rule 3 Maintain the water at proper level.

Rule 4 In case of low water, bank the fires immediately and allow boiler to cool slowly.

Rule 5 When a boiler is out of service for cleaning, the water column connections should be thoroughly cleaned and all scale and mud removed.

Rule 6 Blowdown the boiler at proper intervals. Short blowdowns at frequent intervals are preferred to long ones with more time between.

Rule 7 Use soot blowers frequently enough to keep boiler heating surfaces clean. The accumulation of soot means loss of efficiency and decreased capacity due to increase in exit gas temperatures.

Rule 8 Test safety valves at intervals by increasing the pressure to the point at which they are supposed to blow. If the boiler is equipped with a superheater, be sure that the superheater safety valves blow first.

Rule 9 The boiler will be thoroughly cleaned and washed out annually. Be sure that no large pieces of loose scale are left in the boiler, as serious tube trouble is liable to result.

Rule 10 The baffles should be examined periodically to see that they are tight and in place.

Rule 11 The steam gage will be tested for accuracy at least every time the boiler is down for cleaning.
Rule 12  Each boiler is fitted with an automatic stop-and-check valve on the steam outlet. These should be checked at regular intervals for scale accumulation.

Rule 13  Oil should be kept out of all boilers and feedwater. When oil is mixed with the soft mud found in a boiler it will bake to a very hard scale which causes tubes to burn out. When oil is mixed with water, it causes serious foaming.

POWER ENGINEERING CERTIFICATES

Legal Requirements

In the various governmental jurisdictions it is clearly set out in Acts or Regulations that, with few exceptions, a power plant must be operated:

(1) Under the general supervision of the holder of a Certificate of Competency, the classification of which qualifies the holder to act as chief steam engineer of the power plant, and

(2) Under the continuous supervision of the holder of a Certificate of Competency, the classification of which qualifies the holder to act as shift engineer under the general supervision of a person referred to in clause (1).

A Certificate of Competency is a document issued by a legal authority stating that a power engineer meets certain qualifications and has passed certain required examinations set up by that authority.

In Alberta, the Safety Codes Act establishes the following certificates; other provinces and territories have established a somewhat similar structure.

(1) First Class Engineer’s Certificate of Competency
(2) Second Class Engineer’s Certificate of Competency
(3) Third Class Engineer’s Certificate of Competency
(4) Fourth Class Engineer’s Certificate of Competency
(5) Fireman’s Certificate of Competency
(6) Special Oil Well Operator’s Certificate of Competency
(7) Pressure Welder’s Certificate of Competency
(8) Building Operator’s Certificate of Competency
(9) Such other certificates of competency and any grade or class thereof as may be prescribed in the regulations.
Typical regulations governing the limitations of certificates may include the following:

**Example 1:** A Fourth Class Engineer’s Certificate of Competency qualifies the holder to:

(a) Take charge of the general care and operation of a power plant having a capacity of not more than 1000 kW as chief steam engineer, and to supervise the engineers in that plant.

(b) Take charge of the general care and operation of a power plant consisting of one or more coil-type drumless boilers having an aggregate capacity not exceeding 5000 kW, when used for the sole purpose of underground thermal flooding in oil fields, as chief steam engineer.

(c) Take charge of a shift in a power plant having a capacity of not more than 5000 kW, as shift engineer.

(d) Take charge of a shift in a power plant consisting of one or more coil type drumless boilers having an aggregate capacity of not more than 10 000 kW, when used for the sole purpose of underground thermal flooding in oil fields, as shift engineer.

(e) Take charge of a section of a power plant having a capacity of not more than 10 000 kW, as assistant engineer, under the supervision of the shift engineer in that plant.

(f) Take charge of the general care and operation of a power plant having a capacity of not more than 5000 kW and operating at a pressure not more than 140 kPa.

**Example 2:** A First Class Engineer’s Certificate of Competency qualifies the holder to:

(a) Take charge of the general care and operation of any power plant as chief steam engineer, and to supervise the engineers in that plant.

(b) Take charge of a shift in any power plant as shift engineer.

The student will find the limitations assigned to other classes of certificates in the local Act and Regulations.
Progression to a Higher Certificate

Both experience and educational requirements must be met in order to obtain higher Certificates of Competency. One must already hold a lower certificate than that of the class sought, and in addition must serve a certain number of months in an operating capacity.

An engineer must progress successively through the various classes. For example, it is not possible to move directly from the Fourth Class Certificate to the Second Class Certificate; the candidate must at some time hold a Third Class Certificate.

The progression route is outlined in the Regulations of each jurisdiction over power engineers. With such a clear-cut route, it is anticipated that each student will plan his or her career so as to reach and enjoy a high level of certification. A First Class Engineer’s Certificate of Competency is shown is Fig. 4.
Correspondence Courses

Credits in lieu of plant experience will be granted on successful completion of a course in power engineering satisfactory to the chief inspector. Successful completion means that the student must complete all assignments and pass a final examination. If, for example, a candidate successfully completes such a course for the Fourth Class Certificate, an accredited certificate as shown in Fig. 5 will be awarded, entitling that student to an experience credit of six months. Credits are given for completion of appropriate courses towards all certificates.

The certificate shown in Fig. 5 is issued upon successful completion of a correspondence course.

NOTE: The certificate issued upon successful completion of this course is not a Power Engineer’s Certificate of Competency.

This course and the other Power Engineering correspondence courses offered by this Institute are courses satisfactory to the chief inspector. Furthermore, successful completion of Part A of any one course satisfies the basic educational requirements for the appropriate class of certificate.
This series of Power Engineering courses constitutes the core or “standard” course for almost all of Canada and several U.S. jurisdictions. Students completing this standard material may, if required, obtain credit for its successful completion in other jurisdictions.

NATIONAL STANDARDS

Why Standards are Necessary

Much of the development of modern industrial plants derives from the production and adoption of standards for industry and for power engineers. A standard is a grade or level of accomplishment that is considered desirable for the following reasons:

1. It promotes safety for the public, the plant owners, and the operators. Striving for safety helps to lower insurance costs as well.

2. It helps lower operation and maintenance costs. One can appreciate the confusion that would exist if there were no uniform standards for pipe threads and fittings.

3. It forms the basis of government inspection of plants, and certification examinations of power engineers.

How Standards are Prepared

Standards are issued by national organizations. Within these organizations, committees are established to develop safety codes and standards. These committees are made up of experts from industry, government, professions, and insurance organizations. Since the committees are generally composed of highly qualified people, the codes prepared are adopted as standards, and receive nation-wide recognition by legislation.

The Standards Council of Canada

The Standards Council of Canada functions as the national coordinating body, through which organizations concerned with voluntary standardization may operate and cooperate to recognize, establish and improve standardization in Canada. The following accredited, standards-writing member organizations are considered in the correspondence courses:

PWEN 6001
(1) The Canadian Standard Association (CSA): a non-profit, voluntary membership association that has produced two codes which affect the power engineer:

(a) *CSA B51 Code for Construction and Inspection of Boilers and Pressure Vessels*

(b) *CSA B52 Mechanical Refrigeration Code*

(2) The Canadian Gas Association, which has produced CSA B149.1 *Installation Code for Natural Gas Burning Appliances and Equipment.*

(3) Underwriters Laboratories of Canada issues standards and tests products. Products meeting the standard bear a *ULC* label.

**The American Society of Mechanical Engineers (ASME)**

The ASME is an organization that has developed extensive standards for such equipment as pressure vessels, piping, and valves. The ASME code often forms a basis for provincial boiler and pressure vessels regulations. The following sections of the *ASME Boiler and Pressure Vessel Code* are important:

- **Section I** Power Boilers
- **Section II** Material Specifications - Part “A” Ferrous
- **Section II** Material Specifications - Part “B” Nonferrous
- **Section II** Material Specifications - Part “C” Welding Materials
- **Section III** Nuclear Power Plant Components - Division 1
- **Section III** Nuclear Power Plant Components - Division 2
- **Section IV** Heating Boilers
- **Section V** Nondestructive Examination
- **Section VI** Recommended Rules for Care and Operation of Heating Boilers
- **Section VII** Recommended Rules for Care of Power Boilers
- **Section VIII** Pressure Vessels - Division 1
- **Section VIII** Pressure Vessels - Division 2
- **Section IX** Welding Qualifications
American National Standards Institute (ANSI)

ANSI is similar to the Standards Council of Canada. To a large extent, ANSI recognizes standards developed by groups such as the National Fire Protection Association, American Gas Association, and the ASME.

The following ANSI standards are a valuable reference source:

B. 31.1.0 Power Piping
B. 31.3 Petroleum Refinery Piping
B. 31.5 Refrigeration Piping
B. 16.5 Steel Pipe Flanges and Flanged Fittings
K. 61.1 Safety Requirements for Storage and Handling of Anhydrous Ammonia

Insurers’ Advisory Organization of Canada (IAO)

IAO is an organization of insurance companies with the purpose of minimizing insurance losses through standardization and inspection.

Local Regulations

At the municipal level, enforcement is usually in the field of building codes, fire codes, or health department regulations. For example, such regulations may rule that a cylinder of hydrogen must not be stored in a boiler room. Local regulations may also specify the location of fire-fighting equipment, or of escape routes from a plant. As with all the organizations discussed above, safety is their prime consideration.