•••POWER ENGINEERING

Fourth Class

Edition 3.5

Introduction to Power Engineering and its Governance in Canada

Part A

Unit A-3

PanGlobal
Partner in Education

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March 2026

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UNIT A-3

Introduction to Power Engineering and its Governance in Canada

Unit Introduction

Legislation is a part of everyday life. It regulates the design, support, and materials used for homes, vehicles, and even food. Regulations are also a part of everyday work, addressing diverse areas such as safety, design, transport, and even waste disposal.

Power Engineers deal with regulations that govern all aspects of their work, the equipment they use, and how work is performed. In Canada, there are federal, provincial, territorial, and municipal government jurisdictions. The jurisdictions are responsible for adopting, enacting and enforcing codes, standards, and legislation. Some legislation applies only provincially or territorially, while other legislation applies across the country. It is the responsibility of all Power Engineers to be familiar with, and to understand, the applicable regulations for the jurisdictions they work in.

Power Engineers perform critical roles in the successful operation of power plants throughout industry. Once a Power Engineer takes charge of a shift, he or she must comply with the jurisdiction's regulations. Failure to comply with regulations can result in the Power Engineer being personally charged and fined. If a non-compliance is of serious nature, jurisdictions can revoke Power Engineers' licenses.

The first chapter in this unit looks at the role of the Power Engineer in society, and provides an overview of the profession.

The second chapter looks at common aspects of the Acts and Regulations that apply to pressurized equipment, and to the operators of such equipment, in each jurisdiction. Chapter 2 also includes

- the names of, and contact information for, the Provincial and Territorial Authorities with Jurisdiction
- information on how to access the Acts and Regulations for Power Engineers, boilers, pressure vessels, pressure piping, and pressure welders in each Canadian jurisdiction.

The final chapter introduces the various Codes and Standards that apply to the Power Engineering profession, and explains why they were developed and how they are maintained.

Unit Rationale

This unit is important for Power Engineers because the duties they perform, and the equipment they work with, are governed by acts, regulations, codes, and standards. Failure to follow or meet these requirements can result in catastrophic equipment failure, loss of life, injury to workers and others, damage to equipment and buildings, and personal liability.

Even without sustaining loss, failure to comply with the requirements of the various regulations, codes, and standards can result in serious consequences. Power Engineers can lose their certification or have it downgraded, which can result in economic hardship.

Power Engineers need to be familiar with these legal requirements, and have to be able to find and interpret them when necessary. Each Power Engineer may have different duties. Some will need to be more familiar with codes and standards than others.

Having access to the applicable legislation, codes, and standards is important. The Power Engineer needs to review and become familiar with them to move forward in the certification levels. Although not required for this unit, an understanding of how equipment is designed and built will also assist the Power Engineer to recognize how the codes and standards are applied.

CHAPTER 1

Introduction to Power Engineering

Learning Outcome

When you complete this chapter you should be able to:

Describe the Power Engineer profession.

Learning Objectives

Here is what you should be able to do when you complete each objective:

1. *Describe steam, its uses and the basic steam cycle.*
2. *Describe the role and duties of a Power Engineer.*
3. *Describe how shift work affects sleep patterns, diet, and overall health.*

Chapter Introduction

The Power Engineer's main role is to ensure that the energy needs for industry and society are served well, in ways that make economic and social sense. Power Engineers are often described as the un-sung heroes of industry. However, they are so much more than this.

Power Engineers are the managers of electric power generation processes. A world without Power Engineers is a world without the benefits of widespread and accessible electric power. Without electricity, there would be no hospitals, operating rooms, or advanced medical techniques. There would be no facilities to manufacture metal products, building materials, and pharmaceuticals. There would be no vehicles, and no fuel to power them. There would be no office towers, airports, or large educational complexes. What would communication be like without electricity? How long could food be kept fresh?

Not all Power Engineers are directly involved in electric power generation. Many others work in large, multi-story residential facilities like apartments and condos, large commercial establishments like large shopping centres, office towers, and educational institutions such as schools, colleges and universities. Here, they provide the essentials for human occupancy: heating, cooling, and ventilation. As well, they operate and service potable water and sanitary drainage systems, and monitor life safety systems such as fire alarms and fire suppression systems. Would these facilities be habitable if Power Engineers did not manage the fundamental life support systems that most of the occupants take for granted?

Other Power Engineers work in industry. They generate the high pressure, high temperature steam used to extract heavy oil, and to refine it into useful products, such as gasoline, oil and lubricants. They operate recovery boilers used in pulp and paper mills, to dry the paper and recover valuable process chemicals. They produce high pressure steam for sanitizing equipment in large food processing plants, and for destroying harmful bacteria in medical lab effluent. They operate large refrigeration plants in warehouses used for long-term storage of perishable food products. Would these industries survive were it not for the abilities of Power Engineers?

Power Engineering is an honourable profession, with a long history of providing great service to society. This chapter is a preview of the breadth and depth of what Power Engineers know and do. The remainder of the Units in the PanGlobal Fourth Class Power Engineering Edition 3 textbook cover this content in far greater detail.

Objective 1

Describe steam, its uses and the basic steam cycle.

Producing steam, and controlling the equipment that produces and consumes it, are among the primary duties of Power Engineers. So why is steam important, and why do Power Engineers produce it?

Steam

Steam is water that has been evaporated by adding heat. At home, this is done in kettles and pots. In industry, boilers are used. At home, one kilogram of water may boil in an hour. In a single industrial site, 500 000 kilograms of water may be boiled in an hour, by a single boiler! Power Engineers need to understand the answer to the question "Why does industry use steam?"

All industrial processes transfer energy. Electrical energy is used to drive machines that punch holes in manufactured parts, or stamp metal pieces into their final shapes. In these cases, energy is transferred to machinery that converts electrical energy to mechanical energy needed in metal forming processes.

Many processes, though, rely on the transfer of heat energy. One very effective way to do this is by heating a fluid and moving the hot fluid to where the heat is needed. A good heat transfer fluid should transfer a lot of heat with a small mass. Heat transfer fluids should also be non-toxic. Water (especially in the form of steam) is exactly that sort of fluid. Few heat transfer fluids compare favourably to steam.

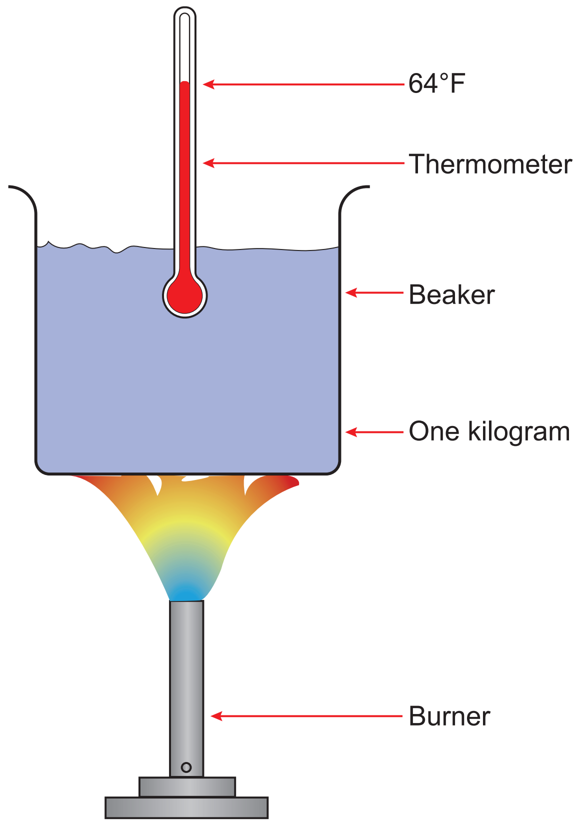
Finally, water has a unique property that makes it ideal for a wide variety of heat transfer applications: when converted to steam, it expands to several hundred times its volume. As a matter of fact, at 100 degrees Celsius, a unit mass of steam is about 1600 times the volume of a unit mass of water! This means that pressurized steam can expand a great deal, and while expanding it can perform a tremendous amount of work.

Boilers

A steam boiler is a closed container, partially filled with water, which evaporates into steam under pressure by the application of heat. This heat is usually obtained from the burning of a fuel, such as natural gas, fuel oil, wood, or coal, in a furnace. In some cases, electrical elements may be used to provide heat. Because they are enclosed, boilers not only generate steam, they generate **highly pressurized** steam.

When water is heated in an open atmosphere, like in Figure 1, the water and steam will not increase in temperature to higher than 100°C. Because boilers are sealed, the pressure of the boiling water increases as steam is generated. This raises the temperature of the water and steam to greater than 100°C.

Figure 1 – Boiling Water



Many boilers take the steam they produce and add additional heat energy. The resulting steam is superheated. Superheated steam can be around 500 °C, and over 16000 kPa pressure!

Uses of Steam

Steam is a very effective heat transfer medium. A small amount of heat contains a tremendous amount of energy! This energy can be used to power turbines that drive electric generators, or other rotating machines like fans and pumps. Steam energy can also be used for the heat it provides. Steam for heat and mechanical power are used in various applications in the following industry sectors (and many others):

- Thermal electric power generation
- Petrochemical processing
- Food and beverage processing
- Building heating systems
- Pulp and paper manufacturing
- Chemical production
- Fertilizer manufacturing
- Sugar refining
- Textiles industry
- Pharmaceutical manufacturing
- Steel industry
- Mining and metal refining
- Vehicle manufacturing

Steam has some varied and fascinating uses. For example, in the food industry, steam is used to peel potatoes. Under the skin of a potato lies a thin film of moisture. In the food industry, large sealed pots of potatoes are pressurized and heated with steam to raise the temperature of this moisture film to above 100°C. Then, the steam pressure is suddenly released. When the pressure drops, the moisture film immediately boils, violently blowing the skin off the potatoes!

Steam can be injected hundreds of metres below ground to heat heavy oil. This valuable oil is too thick to flow when cold. When the oil is hot, it can flow to the surface for processing into a variety of hydrocarbon products. The remaining steam underground assists oil recovery by providing a driving pressure.

Steam is used in many industries to control humidity. Animal hides and pelts shrink when dry. The tanning industry keeps pelts and hides at their maximum size by keeping the plant environment humid. By keeping pelts and hides large, tanners receive maximum payout for their products.

Steam is even used for cooling. Many facilities are equipped with absorption refrigeration cooling systems. These rely on steam as a heat energy source to drive refrigerant through a cooling cycle. Some food and beverage plants use steam for both sterilization and to drive refrigeration compressors.

These are just a few of the fascinating uses of steam that Power Engineers encounter throughout their careers.

The Fundamental Steam Cycle

Steam is vapourized water. When boilers add heat to water, the water boils and turns to steam. The steam travels to machinery or a heat exchanger, and transfers away part of its heat energy. This transfer of heat causes the steam to condense back to water. Condensed steam is called "condensate." Condensate is reused, because it is pure and still contains heat. To reuse the condensate, the water must be pumped back into the boiler, because the boiler operates under pressure. When in the boiler, the condensate again vapourizes, and the cycle repeats.

Figure 2 – Basic Steam Cycle

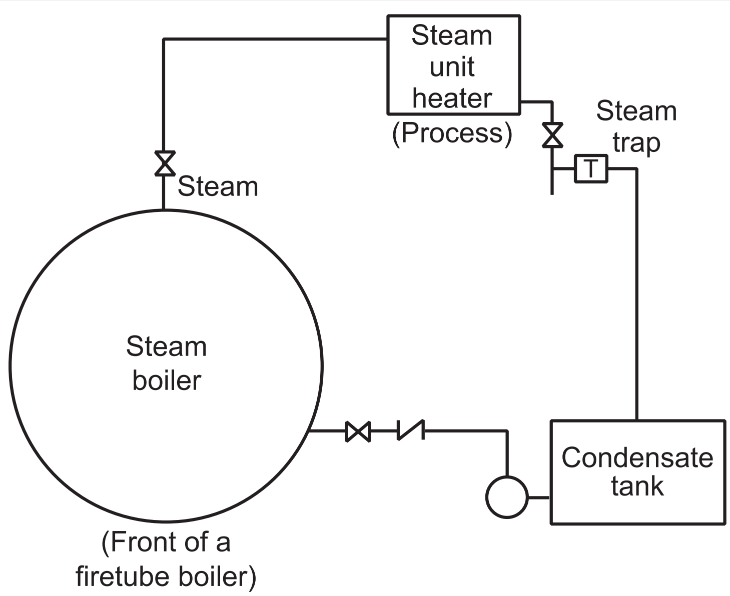


Figure 2 shows the basic steam cycle. The steam flows under pressure from the boiler to a unit heater. In the unit heater, the steam gives off heat, causing it to condense. The condensate naturally flows to the bottom of the unit heater because water is denser than steam.

At the base of the heater is an outlet with a steam trap. The steam trap keeps steam in the heater, and allows only condensate to pass through. Without a steam outlet, the heater would fill up with condensate and would not provide heat. Without the steam trap, steam would flow through the heater unimpeded. It would not spend enough time in the heat exchanger to give up heat and condense. Instead, the steam would flow directly to the condensate tank, where it would vent to atmosphere, wasting heat, water, and chemicals.

Once the condensate is in the condensate tank, it is cool enough to pump back into the boiler for the steam cycle to start over again.

This basic system is similar to most process steam systems, except there may be more stages, higher steam pressures, and multiple steam-consuming processes operating simultaneously. Figure 3 shows the steam cycle in a more complex energy plant.

Figure 3 – Power Plant Steam Cycle

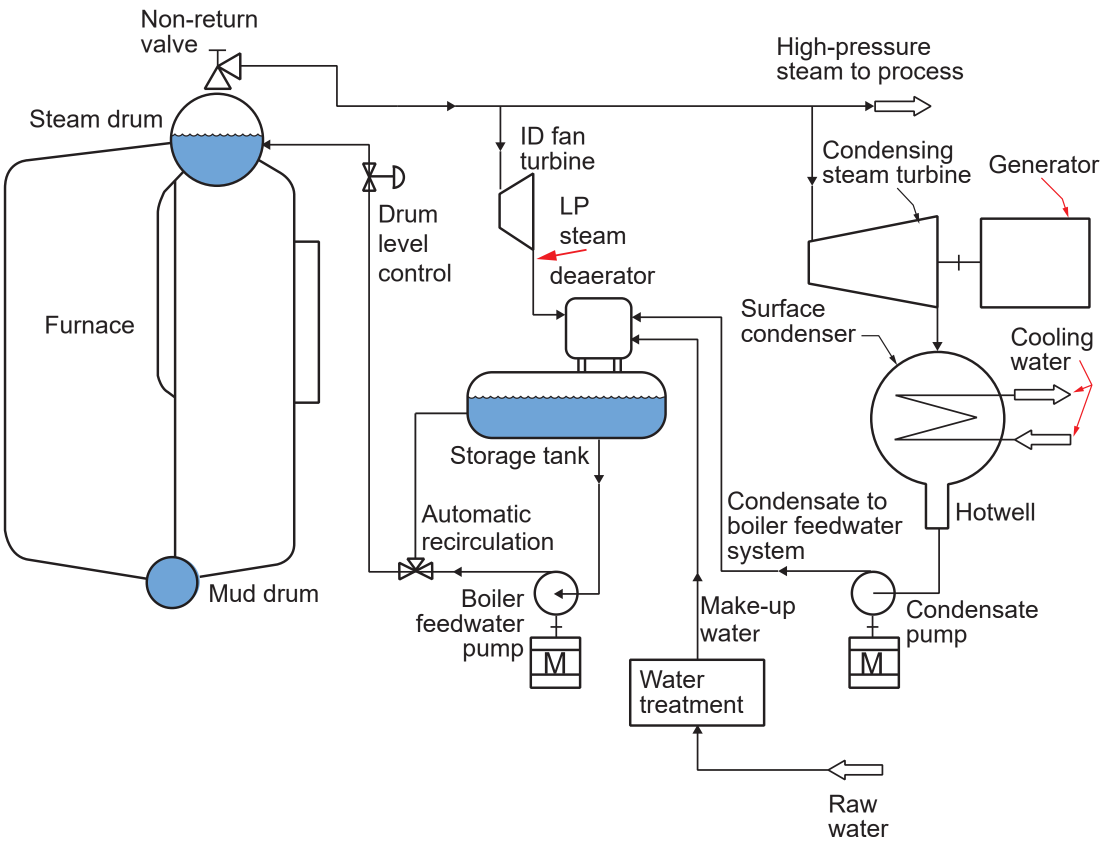


Figure 4 – A Boiler in a Small Power Plant

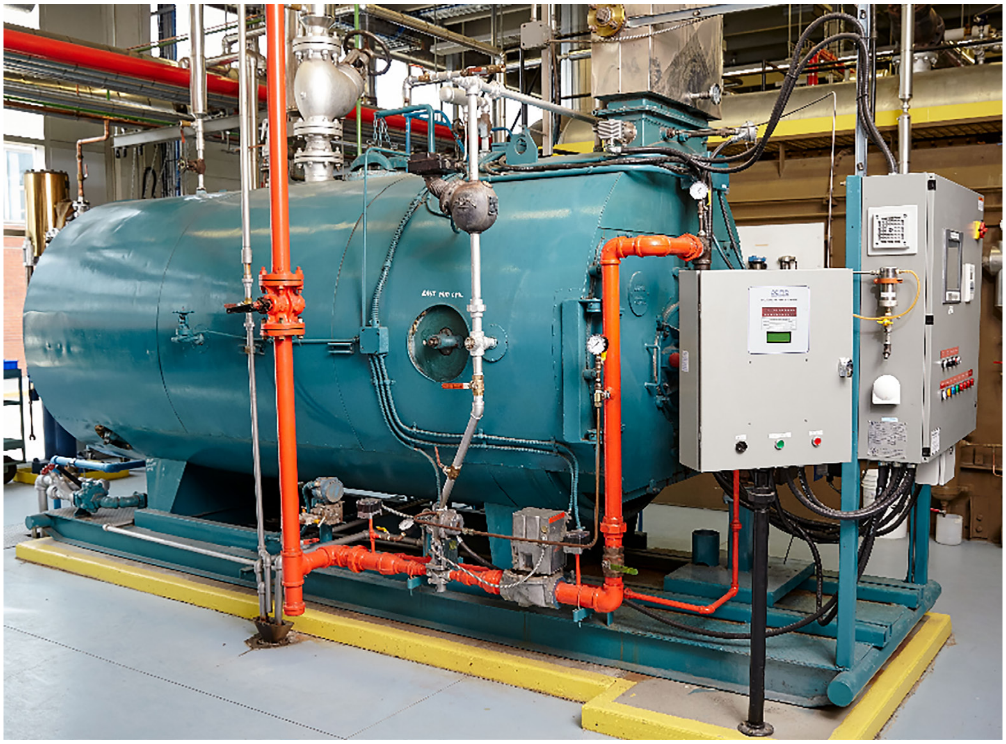


Figure 5 – A Large Thermal Generating Station

(Courtesy of TransAlta)

Objective 2

Describe the role and duties of a Power Engineer.

Power Engineers are skilled and knowledgeable workers who operate and maintain power plant equipment, including boilers. Because of their knowledge and abilities, Power Engineers are ideal candidates for operating sophisticated and potentially dangerous processes and process equipment. In recognition of the need for competent operators, every Canadian jurisdiction has enacted legislation mandating the role of the Power Engineer within industry.

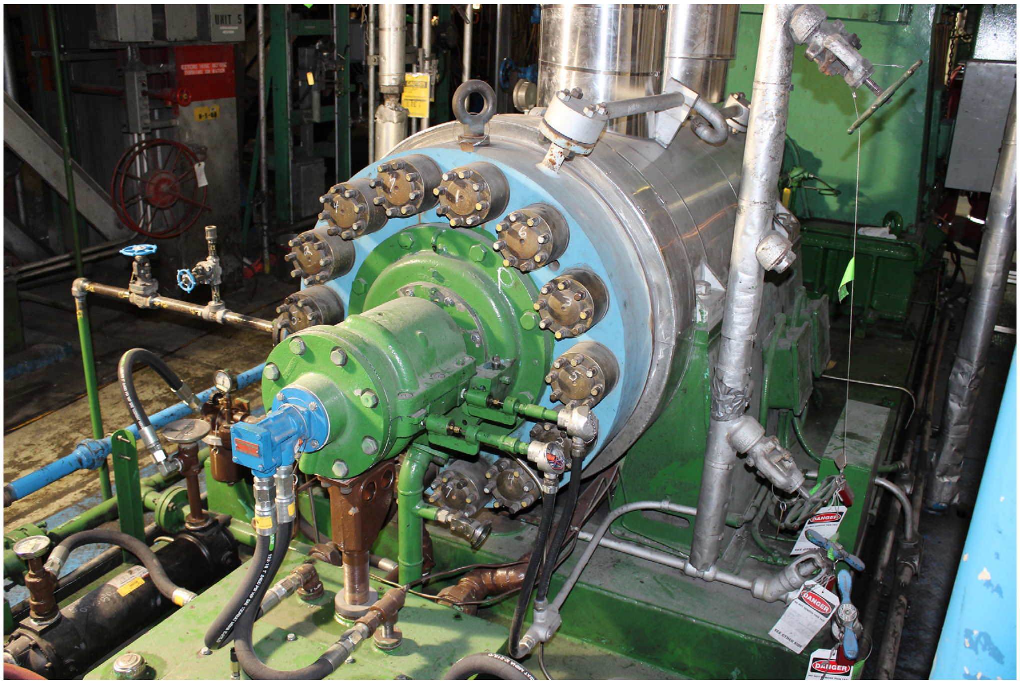
On-the-job, the activities of Power Engineers address the entire spectrum of heat generation and heat utilization processes. To make these systems function safely and economically, Power Engineers must understand equipment operation, process design requirements, and design limitations. It is usually not necessary to know all design aspects. Rather, Power Engineers must be able to comprehend and interpret design specifications, and apply this information to the operation and maintenance of sophisticated and complex controls, equipment and processes.

In large plants, Power Engineers may be supervisors who direct others to safely and efficiently operate a shift. The supervised Power Engineers may be operating:

- steam generators or boilers
- industrial refrigeration and air compression plants
- boiler water, potable water and wastewater treatment facilities
- turbines, diesel engines, generators, switchgear, pumps and other equipment that utilizes, develops or distributes energy.

Some of this equipment is illustrated in Figure 6.

Figure 6 – Typical Equipment Operated by Power Engineers

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1
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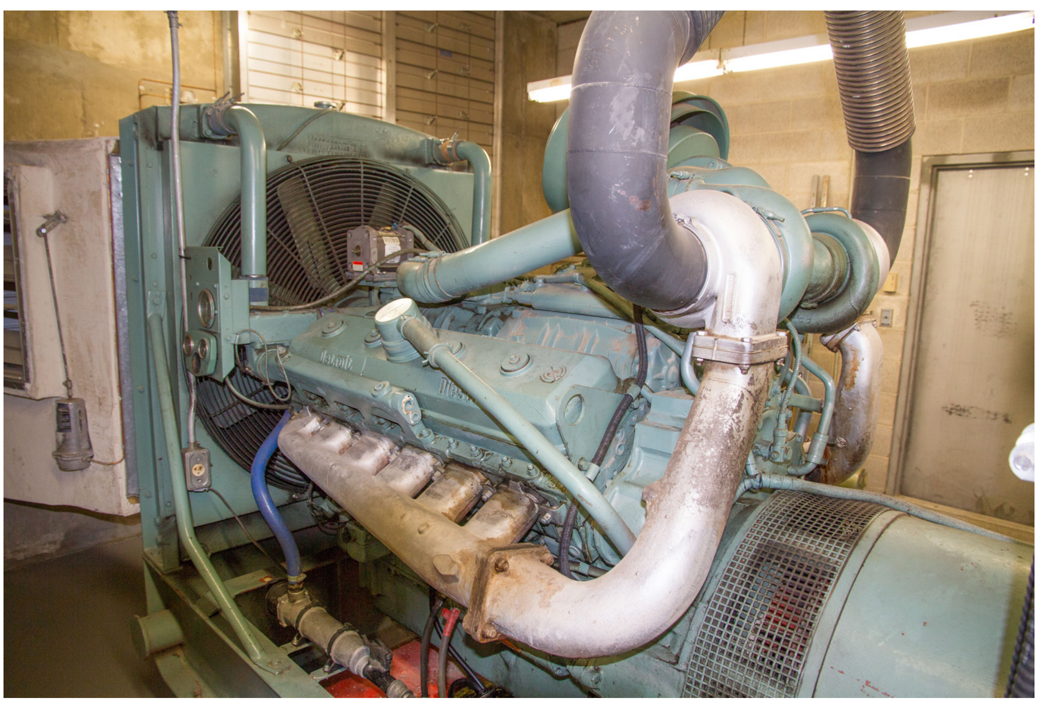
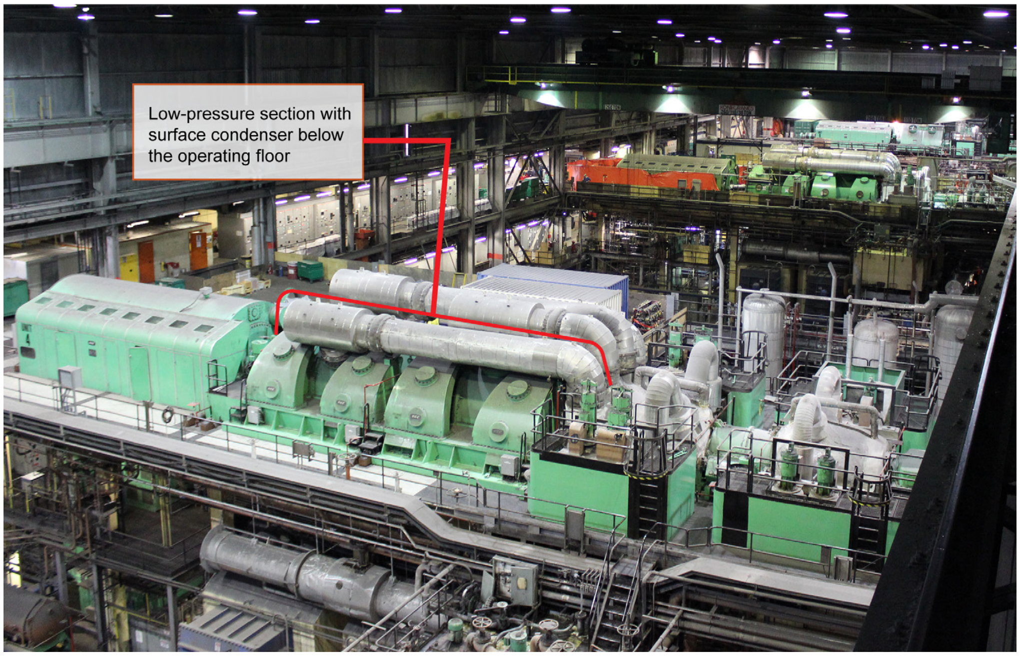
2




Low-pressure section with
surface condenser below
the operating floor

From first to last, Figure 6 shows:

- A high pressure boiler feed pump (courtesy TransAlta)
- A water demineralizer (courtesy TransAlta)
- An emergency power diesel generator
- Control panels for emergency power
- A steam turbine powered electric generator (courtesy TransAlta).

In smaller plants, Power Engineers

- operate and maintain equipment
- maintain inventory and order supplies
- prepare specifications and contracts for purchasing consumables and new equipment.

Generally speaking, in smaller plants, Power Engineers assume total responsibility for the safe and efficient functioning of the plant. There may be no other staff to fulfill these roles.

Power Engineers: Energy Conversion Experts

Power Engineers are experts at energy conversion. An energy conversion expert is someone with a broad range of knowledge and skills, who can operate complicated equipment and processes to convert energy in its many forms, and perform these conversions efficiently, safely, and with minimal environmental impact. As Power Engineers advance in their studies and levels of certification, they become increasingly knowledgeable and adept at the efficient, safe, and environmentally responsible conversion of energy. Because of this, Power Engineers advance to take on increasingly more responsible roles.

Efficient Energy Conversion

To convert energy efficiently, most of the energy entering a process must leave the process, though in a converted form.

For example, consider a thermal electric generating station. Using boilers, Power Engineers take the chemical energy stored in fuel and convert it to heat energy. To do this efficiently, Power Engineers monitor and control burners, and maintain proper combustion conditions.

The heat energy released by the burners is converted to potential energy (steam pressure) by a boiler (a specialized heat exchanger). To do this efficiently, the Power Engineer must know how to keep the heat transfer surfaces of the boiler clean so that maximum heat transfer occurs. The Power Engineer must also be able to recognize when boiler heat transfer surfaces are becoming dirty and what to do to make them clean.

The Power Engineer then converts the potential energy of the steam into mechanical energy, using a steam turbine. The Power Engineer must know how to optimize the efficiency of this energy conversion, by considering things like turbine rotor blade clearances and turbine back pressure.

Finally, the Power Engineer guides the conversion of the steam turbine's mechanical energy into electrical energy.

A 500 MW thermal generating station may burn around 300 000 kg of lignite coal per hour. At $40/tonne, the production cost for fuel is $12,000 per hour. This is around 2.4¢/kWh, just to purchase the coal. An overall plant efficiency increase of only 1% results in a savings of $120 per hour, or $1 million per year!

Not all plants are as sophisticated as thermal generating plants. However, Power Engineers all study the same energy conversion principles that apply in any energy plant, small or large. Through efficient operation, Power Engineers increase the plant profitability, by reducing the overall plant energy, manufacturing, and production costs.

Safe Energy Conversion

The equipment described above converts several million Joules of energy every second! The mishandling of such large amounts of energy poses immediate danger. Power Engineers develop the skills to safely operate very sophisticated and potentially dangerous equipment, including:

- high-pressure boilers
- pressure vessels
- pressure piping systems
- industrial refrigeration plants
- air compressors
- steam turbines
- gas turbines
- high-voltage electric generators
- high-voltage switchgear

Power Engineers recognize unsafe conditions, and intervene appropriately to ensure the safety of plant personnel and the public. In doing so, they protect plant equipment, protect the investment of their owners, and reduce corporate insurance costs.

Environmentally Responsible Energy Conversion

The primary result of efficient energy conversion is a reduction in energy consumption. The secondary result is the accrual of environmental benefits associated with decreased fuel consumption, including:

- Reduced upstream fuel processing activities, with their own environmental impacts
- Reduced fuel delivery activities and resulting emissions
- Reduced consumption of treatment chemicals
- Reduced stack emissions, resulting in less acid rain and climate change impact.

Consider the thermal generating station once again. A 500 MW thermal station operating at full capacity may burn around 300 000 kg of lignite coal per hour. Over the same hour, this plant may produce 785 000 kg of CO_2 emissions. An overall plant efficiency increase of only 1% results in a CO_2 emission reduction of 7850 kg per hour, or 6.8 million kg of CO_2 per year! The percent reduction applies to the emissions of acid-rain forming compounds, carbon monoxide, heavy metals and mercury as well.

Operating a power plant of any size involves

- being aware of waste streams
- reducing waste stream quantities
- treating waste streams to reduce impact on the environment

Power Engineers develop expertise in all these areas.

Power Engineers: Maintenance Experts

In addition to being energy conversion experts, Power Engineers are also skilled at maintaining power plant equipment. In some Canadian jurisdictions, Power Engineers of various classifications can legally maintain and repair electrical equipment, oil burners, and gas burners, in the plants where they are employed. Some jurisdictions permit Power Engineers to certify as Industrial Mechanics or Millwrights. In other jurisdictions, Power Engineers are focused almost entirely on safe and efficient operation.

In jurisdictions where Power Engineers are permitted to perform mechanical repairs and maintenance, extra "maintenance shift" rotations are scheduled. Power Engineers take turns repairing or replacing all manner of equipment, either by themselves or alongside licensed tradespeople.

In jurisdictions or plants where Power Engineers are primarily operators, they still need to understand equipment and process design parameters. This is necessary to recognize when processes and process equipment are operating incorrectly. They also need to know suitable repair methods, despite not being permitted or able to perform the actual repair. For example, Power Engineers that work as boiler inspectors may be poor welders. However, they know and can identify the characteristics of good welds, and can describe proper, code-compliant procedures used in the weld repairs of boilers.

Regardless of where they work, Power Engineers diagnose process abnormalities, identify faulty equipment, troubleshoot causes of equipment failure, and direct tradespeople to suitably repair and maintain equipment. Power Engineers issue work orders covering the repair and maintenance of equipment by tradespeople. Power Engineers can also coordinate the timing and planning of repairs and maintenance, and facilitate these activities by preparing equipment for servicing. Power Engineers on shift also have the authority to stop unsafe work.

Side Track

For more information about the duties of Power Engineers, look up National Occupational Classification 9241 on the Government of Canada website.

Historical Development of Power Engineering

It is difficult to establish the date 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 steady and reliable mechanical power. It was originally used to remove water from mines and thus increase mine output. For many years, it was the practice for the engines to be put together on site. The mechanics who built engines were loaned by the builder for commissioning and start up, and often remained 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 toward greater efficiency, boilers were designed to operate at higher pressure. 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 of modern plants. Close control of the steam generation process and enforcement of environmental regulations has enlarged the responsibilities of Power Engineers, demanding more knowledge and providing greater opportunity to use their talent. For Power Engineers who wish to achieve job satisfaction in this expanding technology, the learning process never ends.

Nature of The Work

Across Canada, and many parts of the United States, the Power Engineering profession is regulated by law. The government of the state, province, territorial or civic jurisdiction may have laws with wording 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.*

The novice engineer is most likely to be involved in equipment operation and repair, until enough knowledge and experience has been gained to perform other functions permitted by local law.

In very small plants, much of the work may be manually performed by the Power Engineer:

- Operating valves and pumps
- Observing and recording levels, temperatures, flows and pressures
- Checking combustion conditions
- Starting electric motors and equipment
- Regenerating water softeners

In larger plants, automatic control systems can perform all of these tasks. Central control rooms, like that shown in Figure 7, enable relatively few engineers to operate automated systems that, if operated manually, would require many engineers.

The engineer's function is that of an interpreter. Displayed on the control room monitors and panel mounted instruments is the information to safely control boilers, generators, industrial processes, and air conditioning equipment. On the basis of that information, changes are made automatically, or with manual operator intervention. The Power Engineer continually monitors and analyzes trends, and anticipates adverse conditions. By promptly interacting with graphical user interfaces and other electrical controls, the control room operator commands the plant to proceed with the desired "steady state" operations.

The power industry has long employed automatic devices for the control of burner systems, feedwater systems and related equipment. Each new power plant employs increasing levels of automation:

- increased mechanization
- more reliance on automatic equipment
- real-time process monitoring

This reality does not change the need for Power Engineers. There are situations when equipment must be operated manually, and the controls used primarily to inform operator decisions (such as when warming a boiler and placing it in parallel operation with other boilers). Plants still require the presence of expert operators that know how processes and equipment ***should*** operate, when controls and instruments are being repaired, maintained, re-programmed or replaced. Power Engineers have adapted to increased automation by increasing in their understanding of control instrumentation.

Figure 7 – Central Control Room

(Courtesy of TransAlta)

Working Conditions

Power Engineers work year-round, without seasonal lay-offs, in plants that rarely shut down. Power Engineers typically work eight or twelve hours per day, in rotating shifts. They work week days, weekends, and holidays. Shifts are arranged so that at some point, several days off are grouped together in a type of "weekend".

At one time, it was common practice to operate three eight-hour shifts, starting at 8 AM, 4 PM, and midnight, with four teams assigned to these three shifts. More common now are 12-hour shift rotations. One type of 12-hour shift schedule is shown in Figure 8.

Figure 8 – Typical 12-Hour Shift Pattern

	SUN		MON		TUE		WED		THUR		FRI		SAT	
	D	N	D	N	D	N	D	N	D	N	D	N	D	N
Week 1	D	B	A	C	A	C	A	C	B	C	B	A	B	A
Week 2	B	A	C	D	C	D	C	D	A	D	A	C	A	C
Week 3	A	C	D	B	D	B	D	B	C	B	C	D	C	D
Week 4	C	D	B	A	B	A	B	A	D	A	D	B	D	B

Plants with 12-hour shifts operate with four or five teams. Figure 8 shows a four-team schedule, with each shift assigned a letter. Follow Team A. Their shift rotation begins on a Monday morning, and lasts three day shifts. Then, they have one full day off. Team A returns on Friday for three night shifts that finish on Monday morning. Then, they are off until Thursday morning day shift. After four day shifts, ending Sunday evening, Team A has seven days off. They return the following Monday for a set of four night shifts. The schedule repeats every 28 days.

With this schedule, each team puts in 168 hours over 28 days. The standard "40 hour" work week schedule is 160 hours over 28 days. Therefore, in this rotation, each Power Engineer logs eight hours of overtime each 28 day cycle. Overtime may be paid out at overtime rate, or "banked" for use as time off at straight rate, depending on the plant's employment agreements.

Other shift scenarios include "week in" and "week out" camp style deployment. This is common in locations where the Power Engineers reside a great distance from the plant, and are flown to or from a work encampment. Some 12-hour shifts have only two or three shifts in a row, and fewer days off between sets.

To help promote accident-free performance, most working areas are kept clean and well-lit. Central control rooms are climate-controlled year-round. However, the plant environment is likely dirty, dusty, smoky, and noisy. Frequently, Power Engineers work in temperature extremes, confined spaces, awkward positions, and at heights, while they inspect, adjust, or repair equipment.

Because work must be performed in close proximity to boilers, rotating equipment, electrical equipment, piping, and plant processes, Power Engineers must guard against burns and other injuries that may occur.

Methods and Procedures

When operating, testing, maintaining, or repairing equipment, Power Engineers must strictly adhere to the methods and practices set out in site-specific policies and procedure manuals. These manuals are developed in accordance with equipment manufacturer's instructions and the results of job hazard analyses. The procedure manuals also incorporate efficiency considerations and environmental requirements.

Power Engineers are expected to obey and participate in setting up policies and procedures, and to mentor junior employees in developing sound practices and good habits.

Objective 3

Describe how shift work affects sleep patterns, diet, and overall health.

Power Engineers work in facilities where production demands require the continuous operation of complex systems and related equipment: thermal power generation plants, heating and cooling plants, refrigeration plants and manufacturing plants, to name a few. Regulations demand that plants be staffed continually while in operation. While operating these plants, Power Engineers are often exposed to temperature extremes, high humidity, noise, hazardous materials, and hazardous environments. Under these conditions, Power Engineers are required to make sound operating decisions, use hand and power tools, and operate heavy equipment. Despite these adverse conditions, Power Engineers must safely and efficiently operate facility processes in accordance with company requirements. This is typical of the profession.

The duration and type of work hours can influence work performance; deterioration can occur very soon after being placed on a shift schedule. The negative effects on performance can be worse in jobs like Power Engineering that require sustained attention, and extended hours. The critical importance of their role requires Power Engineers to carry out their duties with great care and precision, in accordance with established and often regulated safety standards. Being knowledgeable and alert are baseline requirements of fulfilling their role. Power Engineers must understand the many ways shift work impacts both work performance and their lives outside of work, so that they can make the necessary lifestyle adjustments to function optimally.

Shift Work

In addition to working a full-time shift, some Power Engineers may work part-time, on an emergency basis, or planned call-in basis. This is because plants requiring Power Engineers need staffing 24 hours a day, 7 days a week, 365 days a year.

Some Power Engineers do not work rotating shifts. Chief Engineers and Assistant Chief Engineers commonly work regular Monday to Friday office hours. Power Engineers may be assigned to special duties, requiring them to work day shift only. Still others are on “fixed” shifts; they work the same shift without any rotation.

Both rotating and fixed shifts require the scheduling of multiple crews to ensure continuous coverage. In a 12-hour shift rotation, four different crews are commonly used over a 28-day rotation. Power Engineers are often called in on days off to cover shifts of other crew members, who may be off for medical reasons, vacation, or emergencies. In some jurisdictions, the Chief Engineer is not permitted to take over vacant shifts.

Sleep and Shift Work

In Canada, approximately thirty percent of workers are employed in some form of shift work. Shift work involves more than just a work schedule. It has a fundamental impact on the Power Engineer’s working and non-working life, especially adapting to changing sleep patterns, and the potential stresses on health, family, and social commitments.

Humans have a natural, regular cycle of being tired and energized, commonly around the same time each day. This natural, individual cycle is called the circadian rhythm. The body’s physical processes follow this 24-hour clock and regulate most of the body’s functions, such as heart rate, blood pressure and body temperature. During the parts of the cycle requiring low energy (generally at night), the body’s functions slow down to allow the body to rest. During this time, the body’s core temperature lowers, alertness is minimized and reaction time increases. During naturally active times (generally during daylight hours), the opposite is true.

Although circadian rhythms adapt to rotating shiftwork, the amount of time required and the degree of sleep disruption varies from individual to individual. The term “jet lag” refers to the sleep adaptation that travelers must make when visiting different time zones. Consider that shiftwork leaves the body in a state of jet lag at least once a week! When the working day does not match the body’s circadian day, problems can occur including:

- Reduced sleep duration
- Symptoms of insomnia
- Sleepiness throughout the waking period
- Slower performance at work, especially during the first night shift

Dietary Concerns and Shift Work

Meals and dietary considerations are often the first elements of the shift workers’ regular schedule to be neglected. When the shift worker’s schedule does not synchronize with those of family and social contacts, it is difficult to be motivated to make proper meals, especially when alone in the middle of the night. Because of the disruption in circadian rhythm, normal digestion is also disrupted. Meal schedules must be planned to help shift workers stay awake and alert during working hours, and asleep when at home. Common advice on meal schedule preparation includes:

- When able, meals should be high in soluble fibre to aid digestion. This should be aligned with increased water intake.
- Since most shift workers tend to focus on getting to sleep as soon as is practicable after work, caffeinated beverages should only be consumed at the beginning of the shift.
- Utilize normal sleep aids such as a lemon drink, warm milk, or herbal tea just before sleep periods.
- Avoid greasy and spicy food just before sleep.
- Avoid alcohol before sleep periods; it reduces the ability to enter a deep, restful sleep.
- Eat high energy foods or those with complex carbohydrates just before work to provide an energy boost. Always consider this as breakfast time.

Health and Support Recommendations

Studies show that over a 24-hour period, shift workers tend to sleep from one to four hours less than non-shift workers. As a result, they suffer more heart disease, stroke, gastric illnesses, depression, and infertility than people who do not work shift work.

A number of strategies have been developed to help shift workers reduce disruptions in health, performance, and work preparation. Here are some good recommendations:

Personal Habits

- Lead a healthy life style with regular nutritious meals and regular exercise patterns.
- Plan and maintain regular social activities especially those aimed at supporting others.
- Try various methods for completely blocking out the light during daytime sleep periods.
- Actively promote noise reduction during the day (quiet time, white noise machines).
- Lower the thermostat during sleep periods.
- Link lights with wakeup alarm times.

Work Habits

- Maintain an area of bright light in the nighttime working environment.
- Encourage team activities and interaction between workers. This promotes the culture of looking out for each other while on shift. It is good to know that other team members are there to provide backup and support during difficult times on shift, regardless of the time of day, or levels of personal fatigue.
- Provide healthy food options, available at all hours.
- Provide shift and rotation schedules to workers well ahead of time.

CASE STUDY: *One Day Too Many*

Shift workers may suffer from the symptoms of sleep deprivation prior to beginning a shift rotation or during a shift rotation. The symptoms of sleep deprivation are due to an accumulation of stress caused by long term circadian rhythm disruption. The following is a personal account of events that occurred one winter morning.

Now in my fourth year of the plant's rotation, I had worked my way up in experience and certification so that just this fall I was given the opportunity to be one of the four shift supervisors, each managing the control room. No one could have anticipated that my co-worker, on the matching opposite shift, would come in one day to the chief's office with the news of a terrible family matter that would keep him increasingly away. The chief asked me what to do. Being young, single and a team guy, I immediately volunteered to look after the shifts. The plant was looked after and my co-worker could concentrate on his family's needs. It started slow, just a few shifts here and there. I was always mindful of getting in a rest day, but in fact I probably worked forty shifts over two months. I tried to keep a regular regimen, eating well, exercising regularly and sleeping like I should. But working so many shifts my body was thrown out of whack. My stomach seemed upset all the time and I never seemed fresh when I woke up, even after eight hours of sleep.

This day would be my thirteenth straight day on shift, and I was exhausted. Not really straight days, because I did have transitional days between night and day shift, so on paper it looked like I did have a few days off. It really only seemed like thirteen in a row, so because I never really had enough time off to get used to days or nights. It just felt like they ran together. This morning, like every dayshift, I was up at 5 AM and on the road by 5:30. These days it seemed like my truck knew its own way to the plant as my mind was both on the road and preparing for the day ahead. I was maybe about five minutes away from the plant and coming up on a sharp turn. I remember trying to make the turn, but I slid through a patch of black ice that I didn't remember being there the day before. I went off the road, slid down a ten-foot embankment and came to a dead stop at the bottom.

The accident caused a major change in my life. Luckily, I was able to contact emergency services and my buddies at the plant got to me within minutes. It seemed like hours, hanging helpless in the wreckage, supported only by my seatbelt while I waited for help to arrive.

Luck remained with me. After all the emergency procedures and medical diagnoses were complete, the diagnosis was that I had broken my back. It could have been much worse as I was walking again within a few weeks and back to work within a couple of months. I was lucky that day: lucky and grateful to everyone that supported me, looked after me, and helped me move on in my life. I always wonder however if I had worked one day too many...

Chapter Summary

Power Engineers, over their long and esteemed history, have proven to be key players in the ongoing development of efficient, safe, and environmentally responsible industrial workplaces. As energy conversion experts, they lessen environmental impact in part by actively seeking efficiency gains in the processes they operate.

The expertise of Power Engineers is applied in facilities that manage tremendous amounts of energy. For this reason, Power Engineers are mandated by law to operate and maintain processes and equipment that, if mismanaged, can cause the harmful release of energy, injurious to themselves, their co-workers and the greater public.

Fewer occupations perform more valuable service to society, and are therefore more satisfying than Power Engineering.

CHAPTER 2

Jurisdictional Legislation for Power Engineers

Learning Outcome

When you complete this chapter you should be able to:

Describe the application of Jurisdictional Acts and Regulations with respect to boilers and pressure vessels.

Learning Objectives

Here is what you should be able to do when you complete each objective:

1. *Describe how the Power Engineering profession is regulated in Canada.*
2. *Explain the purpose and scope of your Jurisdictional Act and Regulations pertaining to Power Engineering and Pressure Equipment.*
3. *Explain the purpose and intent of the Regulations governing Power Engineers and Pressure Welders.*

Chapter Introduction

Power Engineers are responsible for the care and control of pressurized equipment. Historically, pressurized equipment failure has caused the loss of many lives, and has caused great damage to facilities and equipment. In recognition of the hazards, governments established legislation to protect the public, property, and the environment.

Boiler explosions were a frequent occurrence from the mid 1800's to the early 1900's and for a short time afterward. These were considered to be "unpreventable" accidents. However, people soon realized that these disasters could be prevented by the proper design, construction, inspection, and operation of boilers and pressure vessels. Rules and regulations were formed and adopted by Canadian jurisdictions.

This chapter will look at:

a) The purpose and scope of the legislation which regulates the design, fabrication, and installation of power plant and steam generation equipment.

b) The purpose and scope of the legislation which regulates the operation of power and steam generation equipment.

c) The legislation that regulates the pressure welders who manufacture and repair pressure equipment.

Terms Used in this Chapter

Provinces and Territories will be referred to as "**Jurisdictions**" in this and future chapters.

The term "**Power Engineer**" will be used for a Stationary Engineer or Operating Engineer.

The term "**Inspector**" will be used for a person with authority under the Jurisdictional Act to enforce boiler and pressure vessel safety law, such as a Boiler Inspector, Safety Officer, Enforcement Officer or Safety Codes Officer.

The term "**Chief Inspector**" will be used for a person given overall authority under the Minister for boilers, pressure vessels, and Power Engineers. This person may be called Provincial Safety Manager, Administrator, Director, or similar terms used in jurisdictional Acts or Regulations. This person is appointed by the authority of the government Minister with authority over this aspect of the law.

Objective 1

Describe how the Power Engineering profession is regulated in Canada.

Hierarchy of Legislation

Canada has a "federal system" of government, that divides power between regional and national governments, giving each its own areas of jurisdiction. Power Engineers, and the pressurized equipment they operate and maintain, are "regulated" by (under the control of) the provinces. Therefore, Power Engineering and Pressure Plant regulation are under "Provincial Jurisdiction".

In order to regulate society's activities, enforceable laws must exist. These laws are called "Acts". The word "act" is used because if a problem exists in society, the government must "take action" and pass a law. For example, boiler explosions were common from the mid 1800's to the early 1900's. Laws were enacted to prevent or reduce the number of these explosions.

Acts begin as "bills" which are introduced in the Jurisdictional legislature by an elected person or party. The ruling government party may officially support this bill, or a "private member" may introduce it.

This bill is "read" or "tabled" in the Legislature, and then debated by its members. After the reading, if a bill is found to be inadequate or controversial, it may either be amended or prevented from becoming law. If the bill successfully passes three readings, all members of the Legislature vote on the bill. A simple majority is required to pass a bill into law.

After passing in the Legislature, the bill must receive "Royal Assent" (approval) from the head of state (the Queen of England), who at the provincial level is represented by the Lieutenant Governor. After receiving Royal Assent by the Lieutenant Governor, the bill is then said to have been "enacted" and becomes law.

Acts are written in broad, general terms, so that they may apply to a wide range of circumstances. Narrowly focused laws would not apply outside of a few very specific situations. If too narrow in scope, far too much government time and expense would go into making laws. Also, the number of laws would dramatically increase to an unmanageable level. Therefore, regulations are written to provide public guidance to how Acts will be interpreted, applied, and enforced.

Regulations are said to be "under the Act". This means that regulations refer to specific Acts, from which they get their authority. For example, a jurisdictional government may have something like a "Public Safety Code Act". Several regulations may be under this Act: "The Amusement Rides Regulations", "The Elevator Regulations", "The Power Engineers Regulations", and others. If a regulation is contravened, so is the Act, and the law is broken.

Regulations are not enacted; rather, regulations are made by the Lieutenant Governor in Council (the Lieutenant Governor acting on the advice of Cabinet), by Ministers or boards authorized by the Act. For example, a jurisdiction may have a Power Engineers' Advisory Board, which meets regularly to advise the Minister. Regulations get the force of law after they are published in the jurisdiction's "Gazette," which is the Government's "official newspaper".

Regulations are more focused in their language, and are easier and less costly to revise and update. However, Regulations still become out of date, due to:

- Changes in fees for services (such as inspections, certificates, and permits)
- Changes to fines and penalties
- Changes in technology

To address fees, fines and penalties, revisions are made to the Regulations from time to time. To address technological change, Regulations typically adopt current, up-to-date Codes and Standards, which are revised with regular frequency.

As an example, a "Pressure Plants Regulation" may have a statement like *"The current ASME, ANSI, CSA, NFPA and other codes and standards, as amended from time to time, shall be enforced, as far as is possible and as is consistent with general practice in Canada."* This way, when a code or standard is updated, the Regulation and the Act automatically update and remain current.

A Standard is an agreed, regular, and repeatable way to produce products or perform processes. People often refer to a "standard way" of doing something. This statement captures the purpose of published standards; it implies that there is a standard and correct way of doing something. Standards are published by organizations such as the **Canadian Standards Association (CSA)** to ensure that standard methods are available to manufacturers, suppliers, and installers. Standards tend to be narrow in their focus. Groups that develop standards are usually voluntary and are comprised of industry experts who want to ensure the highest standards are used in the design, manufacture, and operation of equipment.

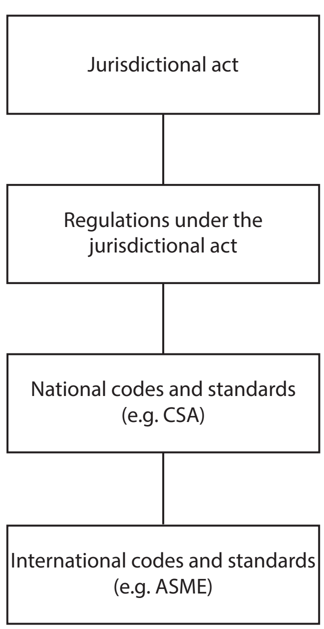
Codes, unlike Standards, are written in such a way that they can be adopted and enforced by government regulatory bodies. Codes often reference many standards, giving them additional weight. Codes may be developed by specific groups or certifying bodies, such as the **CSA** and the **ASME**. They could include members from government, industry, labour, or private specialists. Codes provide more specific instruction than standards do.

There are codes and standards, published by different organizations, which address the same matters, but disagree on details. Codes and standards may also disagree with the regulation that adopts them. There may also be circumstances where the regulations disagree with or contradict the Act. Therefore, a hierarchy of authority will often be stated in the Act or Regulations. Generally speaking, when discrepancies arise:

- The requirements of an Act overrule those of a Regulation, code, or standard.
- The requirements of a Regulation overrule those of a Canadian or international code or standard, and
- The requirements of a Canadian standard or code overrule those of an international standard,

See Figure 1 for an illustration of this hierarchy.

Figure 1 – Hierarchy of Authority



Acts

All jurisdictions in Canada have similar health and safety legislation. Please refer to the specific jurisdictional requirements where the equipment is located.

The various Jurisdictional boiler, pressure plant and Power Engineers Acts have been enacted to ensure that the design, construction, installation, inspection, operation, repair, alteration, and supervision of boilers and pressure vessels results in the highest reasonable standard of safety, and are consistent with good engineering practices.

Depending on the jurisdiction, there may be a single "Safety Standards" or "Safety Codes" Act, with several regulations under the Act. Other jurisdictions may have more focused Acts, such as a "Power Engineers Act" and a separate "Pressure Equipment Act", each with its own Regulation. However, regardless of the jurisdiction, these public safety codes acts have much of the following in common.

a) A list of Regulations under the Act.

b) The scope of the Act, which lists the equipment covered by and excluded from the Act.

c) A statement that permits the government to make Regulations under the Act.

d) Definitions of special terms used in the Act.

e) The purpose of the Act.

f) The Minister's right to appoint Directors, Administrators, and Inspectors; a description of their responsibilities and powers; a description of how their duties will be performed. This may include frequency of inspection, equipment condemnation, testing requirements for individuals and equipment, and certification guidelines for repair and supervisory personnel. Details that are more specific are, by necessity, in the Regulations.

g) A description of what is an "offence" under the Act, and the penalties for not complying with the Act or its Regulations.

h) A statement about the right of an individual to appeal an order made under the Act, and a description of the appeal procedure.

i) A list of fees for services rendered under the Act.

Regulations

Regulations support the Act by providing specific direction to citizens and law enforcement agencies on the interpretation and enforcement of the Act. Regulations also permit more frequent updating since they may be changed by Order in Council, or by the adoption of Codes and Standards that are regularly updated.

Regulations, like Acts, typically begin by defining specific terms. Next, regulations state the adopted codes and standards; they specify that these codes are the "latest editions, as amended from time to time". The **CSA B51** and **B52** codes and the **ASME Boiler and Pressure Vessel** codes are referenced by all Jurisdictional regulations.

Regulations also elaborate on:

a) Operator certification and responsibilities
   i. Classes of operators (Power Engineers)
   ii. Qualification for examination
      - Experience requirements
      - Education requirements
   iii. Maintenance of operating logbook
   iv. Display of certificate
   v. Co-operation with Inspector
   vi. Action when an unsafe condition exists in a plant

b) Plant classifications and methods of determining plant class
c) Obligations of owners
   i. The conditions and circumstances equipment is permitted to operate
      - Satisfactory inspection
      - Display of certificate
      - Qualified operators
   ii. Permissible action upon explosion
   iii. Approval for boiler, pressure vessel or pressure piping repair or alteration
   iv. Maintenance of records
   v. Plant safety compliance
d) Scope and limitations of work, and responsibility of certified operators of various classes
e) Qualification and certification of pressure welders and weld procedures
f) Responsibility of Inspectors

The Chief Inspector of the jurisdiction may interpret and apply the Regulations with flexibility, in recognition that many situations are unique. To permit this flexibility, a Regulation may have wording like "*Where the Chief Inspector considers it necessary for the safe operation of a boiler, the Chief Inspector may order additional safety measures.*" Flexibility must be allowed, but not at the expense of public safety. Again, Acts and Regulations permit appeal, if an individual believes that the Act or its Regulations have not been properly administered.

In summary, the activities and responsibilities of the Power Engineer must comply with all of the acts, regulations, codes, and standards in their jurisdiction. Legislation for each Jurisdiction is available from the jurisdictional "Queen's Printer" or on-line.

Acts, Regulations, Standards, and Codes are regularly updated. To ensure legal compliance and workplace safety, Power Engineers should always make sure that the latest publications are available for reference. Therefore, it is important to frequently check the jurisdictional websites for relevant updates or changes to the laws, and to check that the publication date of on-hand documents correspond with those on the websites.

Training and Certification Committees

Four national groups in Canada - the **ACI**, **SOPEEC**, **IPECC**, and the **IPE** - help jurisdictions develop exams and curricula that meet national industry and regulatory requirements. Inter provincial recognition of Power Engineering qualifications is due to the activities of these groups. They approve all changes to the Interprovincial Power Engineering curriculum.

ACI – Association of Chief Inspectors

Each jurisdiction in Canada has a Chief Inspector or equivalent, who is a member of the ACI. This group meets annually, or more often, depending on situations they believe are important to Power Engineers and pressure vessel safety. As part of their function, ACI has final approval of Power Engineering syllabi and curriculum changes.

SOPEEC – Standardization of Power Engineer Examinations Committee

SOPEEC (www.sopeec.org) meets at least once a year, and has representatives from all jurisdictions in Canada. They discuss and approve IPECC curriculum recommendations, and then forward those recommendations to the ACI.

SOPEEC's mandate is to ensure that the Power Engineering exams meet the needs of all jurisdictions and for all industry in Canada. Once there is inter-jurisdictional agreement, SOPEEC, on behalf of ACI, creates the syllabi for the interprovincial exams. They also produce the Power Engineering certification exams that are to be administered across Canada.

Power Engineers should regularly refer to the SOPEEC website, as well as the SOPEEC reference syllabi.

IPECC – Interprovincial Power Engineering Curriculum Committee

The IPECC (www.ipecc-net.com) is made of representatives from industry, educational institutions, the IPE, the ACI and SOPEEC. Their annual meeting is usually held in conjunction with SOPEEC. IPECC makes recommendations to SOPEEC for the syllabi statements, work experience requirements, and approved reference materials.

IPECC members have a broad base of knowledge and experience. This helps to ensure that the various classes of Power Engineering graduates have the necessary knowledge and skills.

IPECC subcommittees address concerns that deal with specific Power Engineering classes or topic areas within the learning materials. Each subcommittee develops and maintains a national curriculum document that interprets the knowledge expectations for candidates preparing to challenge the national certification exams. A critical element of each sub-committee's work is to discuss whether the approved learning material is keeping up with technological advances, new products and current industry processes. IPECC recommends syllabi changes to SOPEEC, and seeks to gain SOPEEC approval of the IPECC curricula at all levels of Power Engineering. The basis for this approval is that the curricula meet SOPEEC's knowledge requirements for the national examinations.

IPE – Institute of Power Engineers

The **IPE** (www.nipe.ca) is a national association of Power Engineers and associated professionals that provides a unified voice for Canadian Power Engineers. It works to raise public awareness of the role played by Power Engineers in our increasingly energy-dependent economy. Central to its mandate is the promotion of safety and education of operating professionals at all levels in a plant. In many jurisdictions it represents the one consistent voice of the profession on regulatory advisory committees.

Objective 2

Explain the purpose and scope of your Jurisdictional Act and Regulations pertaining to Power Engineering and Pressure Equipment.

Jurisdictional Acts and Regulations

Boilers, pressure vessels, and Power Engineering are all under Provincial jurisdiction; each Jurisdiction has its own legislation. The chart below shows the applicable legislation for each jurisdiction. The "Authority with Jurisdiction" is the provincial regulatory enforcement agency.

It is critical to acquire a copy of the local Jurisdiction's Act and Regulations. Study them and become familiar with their requirements.

Province	Authority with Jurisdiction	Act	Regulations
British Columbia	Technical Safety BC	• Safety Standards Act	• Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation
Alberta	Alberta Boilers Safety Association	• Safety Codes Act	• Power Engineers Regulation • Pressure Equipment Safety Regulation • Pressure Welders Regulation • Pressure Equipment Exemption Order
Saskatchewan	Technical Safety Authority of Saskatchewan	• The Boiler and Pressure Vessel Act • The Technical Safety Authority of Saskatchewan Act	• The Boiler and Pressure Vessel Regulations
Manitoba	Office of the Fire Commissioner	• Power Engineers Act • Steam and Pressure Plants Act	• Power Engineers Regulation • Steam and Pressure Plants Regulation
Ontario	Technical Standards and Safety Authority	• Technical Standards and Safety Act	• Operating Engineers Regulation • Boilers and Pressure Vessel Regulation

Province	Authority with Jurisdiction	Act	Regulations
Quebec	Direction de la qualification réglementée	• Stationary Enginemen Act, R.S.Q. c. M-6	• Regulation respecting stationary enginemen, R.Q. c. M-6, r.1, (Stationary Enginemen Act) • Regulation respecting certificates of qualification and apprenticeship regarding gas, stationary engines and pressure vessels, R.R.Q., c. F-5, r.2, (Workforce vocational training and qualification
New Brunswick	New Brunswick Public Safety Technical Inspection Services	• Power Engineer Licenses • Boiler and Pressure Vessel Act	• Boiler and Pressure Vessel Regulation- 84 • New Brunswick Regulation 84-175 under the Boiler and Pressure Vessel Act
Newfoundland and Labrador	Department of Advanced Education and Skills, Apprenticeship and Trades Certification Division	• An Act Respecting Boilers, Pressure Vessels and Compressed Gas	• Boiler, Pressure Vessel and Compressed Gas Regulations, under the Public Safety Act
Nova Scotia	LAE-Technical Safety Division Power Engineers Section	• Technical Safety Act	• Power Engineers Regulation • Boiler and Pressure Equipment Regulations
Prince Edward Island	Boiler and Pressure Vessel Inspection Environment, Labour and Justice	• Power Engineers Act	• Power Engineers Act Regulations
Northwest Territories	Government of Northwest Territories Public Works and Services	• Boilers and Pressure Vessels Act	• Boilers and Pressure Vessels Regulations
Nunavut	Community and Government Services Protection Services Division	• Consolidation Of Boilers and Pressure Vessels Act	• Consolidation Of Boilers and Pressure Vessels Regulations
Yukon	Yukon Department of Community Services Building Safety Branch	• Boiler and Pressure Vessels Act	• Power Engineers Regulations • Pressure Welders' Regulations • Design, Construction and Installation Of Boilers and Pressure Vessels Regulations

Jurisdictional (Provincial and Territorial) Acts

What follows is a general discussion of the portion of the Acts that apply to pressure vessels and their operation.

Definitions

All Acts and Regulations define the technical terms used in the Act. These words have very specific meanings that may be different from their commonly-used meaning. Examples of these words include: "heating surface", "pressure vessel", "hot water heater", "shift engineer", and "power plant".

Exceptions

Acts and Regulations will also list what is exempt from the legislation. Exemptions may exist due to any of the following:

a) The equipment is considered too small to present a significant hazard.
b) The equipment may be under a federal or municipal jurisdiction.
c) The equipment may fall under another provincial act.

Examples of equipment that may be exempt are:

a) Boilers that operate below a specific pressure.
b) Boilers that are below a certain heat output capacity.
c) Non-hazardous piping that is small in diameter, does not contain toxic materials, or is under low pressure.
d) Pressure vessels less than a certain internal diameter or internal volume.
e) Pressure vessels that operate below a specified pressure.
f) Refrigeration systems that are below a certain cooling capacity.
g) Refrigeration systems that use air or water as the cooling agent.

Responsibilities

The Act defines the responsibilities for inspectors, operators, designers, vendors, and owners of the equipment for which the Act applies. For example, the manufacturer must comply with the Act in the design, registration, and construction of the equipment.

The operator must comply with the Act in the operation and maintenance of the equipment. The operator must also disclose any known unsafe conditions to the Inspector.

The Inspector must not falsely certify any plant, boiler, or pressure vessel. The Inspector must also not permit an unsafe boiler or pressure vessel to operate.

The owner of a plant must ensure the plant is adequately staffed. The owner shall not permit the plant to be operated if the plant's operating certificate has expired.

Design, Construction and Sale

This section deals with the approval and registration of the design of boilers and pressure vessels to be constructed in the jurisdiction; or those that are to be brought into the jurisdiction. Any boiler, pressure vessel, or pressure piping system must be constructed from a design registered in the jurisdiction where it will be installed.

Fittings

All fittings constructed in the jurisdiction for use in that jurisdiction, or brought into the jurisdiction, must be registered in the same way as boilers and pressure vessels.

Boiler and Pressure Vessel Identification

In some jurisdictions, before issuing the initial certificate of inspection, the inspector must make sure that the jurisdiction's identification number is stamped on the boiler or pressure vessel.

Construction, Installation and Sale of Boilers, Pressure Vessels, and Fittings

This section regulates the construction, installation, and sale or disposal of boilers, pressure vessels, fittings, and pressure piping systems.

Inspections

This section lists the rules regarding:

a) The inspector's powers and authority.
b) How frequently inspections should take place.
c) Orders issued by the inspector.
d) The responsibilities of the owner or person in charge of the equipment, with regard to assisting the inspector.

Persons designated by the minister can enter any premises to which the act applies and carry out an inspection. They can review documents, interview workers, review test data, and if necessary make recommended changes for the protection of persons and property. Responsibilities of the owner are described for the inspection process in this section. It is forbidden to prevent or hinder inspectors who are carrying out their duties.

The certificate of inspection is described in this section. As well, this section describes the responsibilities of the owner or person in charge to retain and display the operating certificate.

Operation and Supervision

This section explains the certificate of competency requirements for a power plant's Chief Power Engineer, Shift Engineers, or Assistant Shift Engineers. The exceptions to this requirement are also detailed.

If a plant does not require supervision by a Power Engineer, then the owner of the plant is responsible for the proper care and safe operation of the plant.

Accidents and Investigations

This part of the Act explains the procedures to be followed by the owner or person in charge in the event of an accident that involves the boiler, pressure vessel, or power plant. These types of accidents may be investigated by the Chief Inspector of the Authority with Jurisdiction, or by other Inspectors directed to do so.

The Chief Inspector or Inspector has the authority to conduct investigations to:

a) Identify unsafe conditions.
b) Determine the causes of fire or accidents.
c) Develop recommendations for accident prevention or reoccurrence.

Certificates of Competency

The various Power Engineers' certificates of competency are listed, as are the details of the duties that the certificate holder is authorized to perform. Certificates may be mentioned under the act, but will be more detailed in the regulations.

The act describes the requirements for certificates. It allows for the suspension or cancellation of certificates if:

a) The act is not complied with.
b) The person no longer meets the requirements to hold a certificate.

Progression to Higher Certificates of Competency

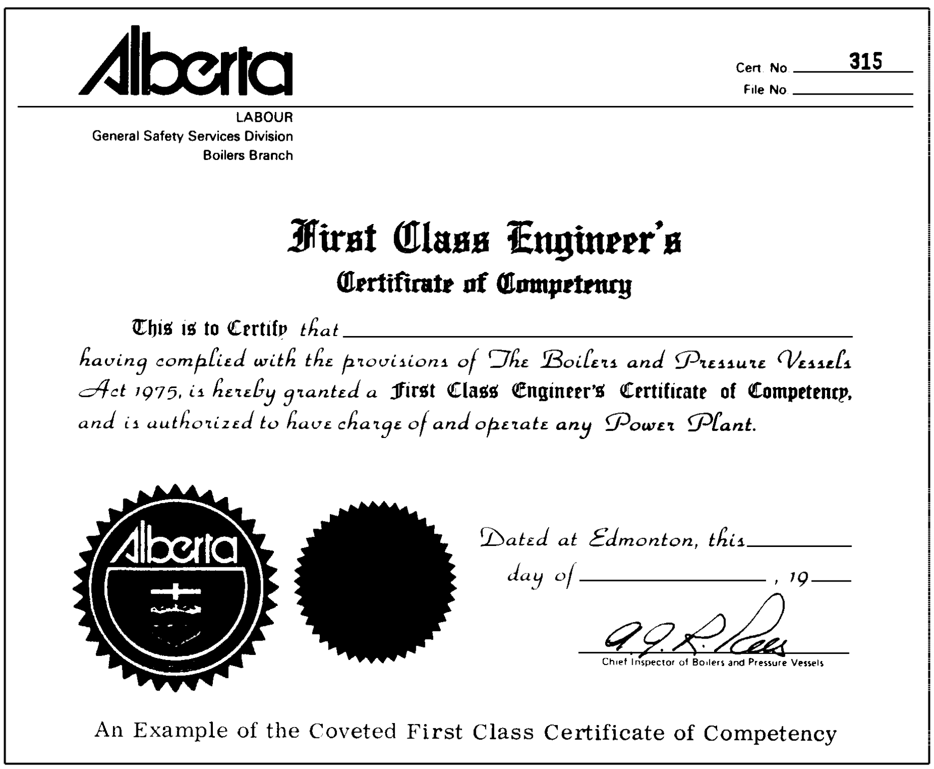
To progress from one class of certification to the next, the candidate needs 4 things.

- A valid Power Engineering Certificate at the level one lower than the examination to be attempted. In other words, an examination candidate for Third Class must have a valid Fourth Class license.
- Education, either from High School or through an approved Power Engineering course of studies
- A specified amount of work experience in a plant of the required class ("Steam Time"), and
- Successful completion of the SOPEEC examinations.

Power Engineers 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 Power Engineers Regulations of each jurisdiction. Unlike a trades license, there is no expectation for Power Engineers to continue through to a final level of certification (a "Journeyperson"). Instead, every level of Power Engineering is an "exit point." A Fourth Class Power Engineer can have a fulfilling and rewarding life-long career as a Fourth Class Power Engineer, without furthering his or her studies. Despite this, most Power Engineers advance their studies, so that they may take upon more challenging roles. A Sample First Class Power Engineer's Certification of Competency is shown in Figure 2.

Figure 2 – Sample Certificate of Competency



Alberta

Cert No 315

File No

LABOUR
General Safety Services Division
Boilers Branch

First Class Engineer's
Certificate of Competency

This is to Certify that ______
having complied with the provisions of The Boilers and Pressure Vessels Act 1975, is hereby granted a First Class Engineer's Certificate of Competency, and is authorized to have charge of and operate any Power Plant.

Dated at Edmonton, this ______
day of ______, 19__

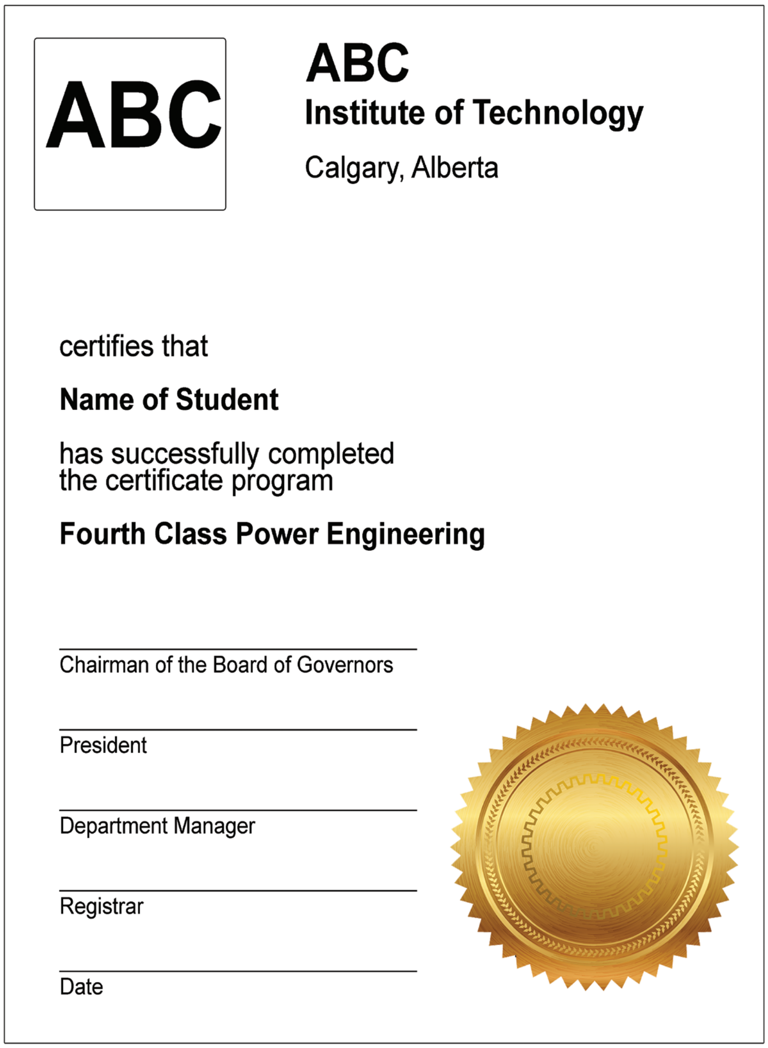
Chief Inspector of Boilers and Pressure Vessels

An Example of the Coveted First Class Certificate of Competency

Educational Program Completion

Depending on the jurisdiction and certificate applied for, credits in lieu of plant experience may be granted on successful completion of a learning program in Power Engineering satisfactory to the Jurisdictional Chief Inspector. Typical successful completion means that the student must complete all assignments, meet the educational institution's attendance requirements, and pass a final examination. If, for example, a candidate successfully completes a course for the Fourth Class Certificate, an accredited certificate like that shown in Figure 3 will be awarded, entitling that student to an experience credit of a certain number of months. Credits are given for completion of appropriate courses towards most certificates.

Figure 3 – Certificate issued upon Completion of Program


ABC

ABC
Institute of Technology
Calgary, Alberta

certifies that

Name of Student

has successfully completed
the certificate program

Fourth Class Power Engineering

Chairman of the Board of Governors

President

Department Manager

Registrar

Date

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

Complaints, Investigations, and Disciplinary Action

The Chief Inspector will conduct a preliminary investigation, if a complaint is made against a Power Engineering certificate holder accused of:

a) Acting incompetently, negligently, dangerously, or improperly, or
b) Is incapable of performing the duties of the position.

If the preliminary investigation justifies a further investigation, a committee of inquiry will be established. After the completion of its inquiry, the committee will then prepare a written report on the matter.

If the committee finds that the certificate holder is at fault, then the committee may either suspend or cancel that person's certificate of competency.

The person may appeal this suspension or cancellation by following the jurisdiction's appeal procedure.

This may be mentioned under the Act, but will be more detailed in the Regulations.

Administration

The Minister may transfer the responsibilities for the administration of the Act to a director, administrator, or safety codes officer. This gives the designated person the authority to act on behalf of the Minister. This involves conducting the activities regarding inspection and ensuring there is compliance with the legislation.

Chief Inspector / Inspectors

The Inspectors are persons appointed by the Minister or the Minister's designate. They have the power and the duty under the legislation to conduct inspections, issue orders, and enter premises to conduct their activities.

Orders and Offences

In cases of noncompliance, the inspector can order the operator, owner, manufacturer, installer, or designer to:

- Stop work or operations
- Limit work or operations
- Take immediate corrective actions so that they comply with the Act

The person who has received an improvement order may appeal. If the appeal is rejected, the person who received the order is expected to comply. If the person does not comply with the order, he or she may be fined or imprisoned.

Regulations

This part of the Act states that the governing body of the jurisdiction may make regulations with respect to the registration of design, construction, testing, installation, inspection, operation, and repair of boilers, pressure vessels, power plants, and fittings. Other regulations pertaining to Power Engineers and pressure welders may also be mentioned.

Objective 3

Explain the purpose and intent of the Regulations governing Power Engineers and Pressure Welders.

The Act permits the Regulations it references to be enforceable. The Acts deal with generalities. The Regulations provide instruction that is more specific. For example, in Alberta the Safety Codes Act does not deal with Power Engineer certification, responsibilities, or supervisory requirements. This information is found in the Power Engineer's Regulations under the Safety Codes Act. Legislation from other jurisdictions is similar. Far more enforcement detail is found in the Regulations than the Acts.

The Regulations content can be different between Jurisdictions. For example, in Alberta the requirements for Pressure Welders are found in the Pressure Welders Regulation. In Ontario and Manitoba, the requirements for Pressure Welders are found in their jurisdictional Boiler/Pressure Vessel/Pressure Plant Regulations.

What follows is generalized content from the various regulations. Be aware that this is a general approach only. It is important to be familiar with the actual jurisdictional regulations.

Boiler and Pressure Equipment Safety Regulation

Definitions

All Regulations list and define terms they use. Some of the definitions will include shift engineer, types of certificates, and plant descriptions.

Exclusions and Exemptions

The various types of equipment that are exempt from the provisions of the Act and or the Regulation(s) are listed.

Adoption of Codes and Standards

To standardize requirements across Canada, it is simpler for the Jurisdictions to adopt existing codes, such as the CSA, ASME, NFPA, and API codes. This eliminates duplication and makes the regulations more responsive to technological changes. These codes are developed and modified by committees, with representatives from each Jurisdiction.

When codes and standards are adopted in the regulations, they are enforceable under the Act.

Registration and Approval of Fittings, Pressure Vessel Designs and Weld Procedures

Each jurisdiction retains the right to approve equipment design, before the equipment is used in the jurisdiction. This includes the design of boilers, pressure piping systems, pressure vessels, fittings, or weld procedures.

The Chief Inspector, or designate (a government design engineer), must review and approve the manufacturer's design drawings and calculations for the equipment or fittings. Once approved, the equipment or fittings are then registered in the jurisdiction, and permitted to be used in the jurisdiction. The regulation stipulates the approval and registration process.

The Chief Inspector or designate must approve any changes to a registered design. This includes any repairs or alterations made to a pressure vessel, pressure piping system or boiler.

Boiler and Pressure Vessel Fees

The regulations stipulate fees for the following.

a) Register boiler, pressure vessel, pressure piping, or fitting designs.
b) Register weld procedures.
c) Conduct shop inspections of boilers or pressure vessels being manufactured.
d) Conduct initial inspections of boilers, pressure vessels or pressure piping systems.
e) Conduct regular inspections of in-service boilers and pressure vessels.
f) To have existing equipment certified for operation.

Construction Inspections

This section deals with the requirements that relate to the construction of boilers or pressure vessels in the jurisdiction. These requirements include

a) The submission of drawings, calculations, and specifications.
b) Quality control programs in place during construction.
c) The Manufacturers' data reports.

In-service Inspection

This section deals with the frequency of inspection for boilers, pressure vessels, and pressure piping systems.

Power Engineers' Regulations

The items that follow are an overview of typical Power Engineers regulations.

Definitions

Definitions for:

- Chief engineer (Power, Steam, or Operating)
- Shift engineer
- Assistant engineer
- Assistant shift engineer
- Fireman
- Building operator

The pressure plant definition, and the method of determining capacity, is critical in Power Engineering regulations. Staffing is determined on this basis.

Certificates of Competency

The classes of Power Engineering certificates are listed in this part of the regulations. Their duties and responsibilities are outlined. To determine staffing requirements, given the particulars of any given plant, the regulation will specify the following.

a) The class of plant.
b) The class of Chief Engineer required.
c) The class of Shift Engineer required.
d) The class of Assistant Engineer required.

The regulations mandate staffing and supervision requirements. The majority of the operating power plants must be under 24-hour continuous supervision of a Shift Engineer. However, there are a few exceptions for the supervision requirements. For details, consult the regulations specific to the local jurisdiction.

Most plants require Chief Engineers who have the same or higher class as the plant classification. Shift Engineers are required to have a class of certificate of not less than one class lower than the plant classification.

The responsibilities of the Chief Engineer, Shift Engineer, and Assistant Shift Engineer are defined in this section.

The regulations state that Power Engineers working in the plant must display their certificates in an operating area of the plant (often in the control room).

The application procedure and issuance of temporary certificates of competency may be addressed here, as well as the duration of such a certificate.

Qualifications and Examinations

To obtain a certificate of competency, a person must pass an exam set by the jurisdiction issuing the certificate. To qualify to take this exam, the candidate must meet certain requirements, with regard to previous work experience and education. The candidate must already hold a certificate of competency one class lower than that for which he or she is applying.

Other information in this section deals with:

a) Pass mark for exams.
b) Credits which may be granted in lieu of operating experience.
c) Credits which may be granted to a holder of a Power Engineering Diploma issued by an educational institute.
d) Credits for other technical courses.

This section also deals with the issuing of equivalent certificates of competency to persons from other jurisdictions.

Conduct during Examinations

The regulations identify which code books and calculators may be used during an exam. Candidates who do not observe these restrictions may be penalized, as noted in the regulations.

Application for Examinations

This section details the procedure for submitting exam applications. As well, the regulations specify the documentation an exam candidate must provide with the application (e.g. proof of operating time and education).

Examination and Certificate Fees

The fees for writing the various certificates of competency exams are listed; as well as, fees for re-marking exam papers. Other fees listed include those for temporary and duplicate certificates.

Pressure Welders' Regulations

Definitions

Regulations for Pressure Welders define terms such as performance qualification card, pressure welder, and pressure welding.

Classification of Certificates

The various certificates for pressure welders and weld inspectors are listed, as well as what each certificate holder is allowed to perform.

Prohibition

The regulations emphasize that it is illegal for an unqualified person to weld on a boiler, pressure vessel, or pressure piping system. It is illegal to permit an unqualified person to weld on a boiler, pressure vessel or pressure piping system.

Performance Qualification Tests

A welder performance qualification test requires the candidate to pass a practical exam, under the supervision of a certified weld inspector. The jurisdiction issuing the certificate sets the exam.

To qualify to take this exam, the candidate must meet the requirements set out in the regulations.

Certificate Expiry Dates

Pressure welders must re-qualify within the time limits stated in the regulations. This involves re-taking a performance qualification practical test.

Miscellaneous

Pressure welders are required to identify their weldments with a unique symbol, stamped on the surface of the weld or adjacent to it.

Fees

The regulations stipulate fees for:

- Practical exams
- Duplicate certificates of competency
- Duplicate performance qualification cards
- Special exams

Chapter Summary

Canada's exemplary safety record with boilers and pressure vessels is highly recognized worldwide. This is, in part, because Canada has legislation to govern the design, construction, operation, repairs, and disposal of pressure equipment and boilers. This helps to protect people and property. Each jurisdiction in Canada has enacted its own legislation. Each jurisdiction has government departments or special operating agencies to enforce these laws.

The Act has the overall authority in each jurisdiction. It identifies the scope of the authority and the application of the legislation. Regulations are in place under the Act to identify and enforce specific requirements, and to ensure compliance with the Act. Codes and standards help to create uniformity of legislation, and to keep legislation up-to-date with technological changes.

The provinces and territories each have their own laws. However, organizations such as the ACI, SOPEEC, and IPECC work to standardize jurisdictional requirements in Canada for boilers, pressure vessels, and Power Engineers. This helps to ensure the highest level of safety and protection of people and property.

Chapter 3

Codes and Standards for Power Engineers and Pressure Vessels

Learning Outcome

When you complete this chapter you should be able to:

Describe the purpose of boiler and pressure vessel Codes and Standards.

Learning Objectives

Here is what you should be able to do when you complete each objective:

1. Discuss the history of how codes and standards became necessary in the pressure equipment field.
2. Explain the content and use of the CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code.
3. Explain the content and use of the CSA B52 Mechanical Refrigeration Code.
4. Explain the content and use of ASME Boiler and Pressure Vessel Code (ASME BPVC) Section I Power Boilers.
5. Explain the content and use of ASME BPVC Section VII - Recommended Guidelines for the Care of Power Boilers.
6. Explain the content and use of ASME BPVC Section IV - Rules for Construction of Heating Boilers.
7. Explain the content and use of ASME BPVC Section VI - Recommended Rules for Care and Operation of Heating Boilers.
8. Explain the purpose, intent, and limitation of ASME CSD-1 (Controls and Safety Devices) Standard.

Chapter Introduction

Legislation is comprised of Acts and Regulations. They are written by government officials, go through a parliamentary process, and are passed into law by elected officials. National and international bodies establish Standards and Codes. They do not go through the same process, but can be enforced the same as an Act or Regulation, if they have been adopted.

This chapter will look at the intent and purpose of specific codes and standards under the various Acts and Regulations that govern Power Engineers and pressure vessels. It is necessary for Power Engineers to work with and be familiar with this legislation.

The **Canadian Standards Association** has formed and published many standards that relate to boilers and pressure equipment. Though standards are only recommendations, they carry the force of law when they are officially adopted by a jurisdiction. Two of these standards are of importance to Power Engineers, and have been adopted by Canadian jurisdictions.

1. **CSA B51 Boiler, Pressure Vessel and Pressure Piping Code**
2. **CSA B52 Mechanical Refrigeration Code**

The **American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code** has been adopted by many jurisdictions in the world, including Canadian provinces and territories. It has established the rules of safety for the design, construction, and inspection of boilers and pressure vessels. The **ASME Boiler and Pressure Vessel Code** is essential reference material in the heating, electric power-generation, and petrochemical industries.

Objective 1

Discuss the history of how codes and standards became necessary in the pressure equipment field.

Jurisdictional governments passed legislation for the protection of the public and the safety of workers. However, officials did not have the knowledge and experience to determine the best methods to design, fabricate, install, and operate pressure equipment. Each Jurisdiction enacted its own rules and requirements. Jurisdictions varied greatly in their requirements and in their level of protection.

In 1911, the **American Society of Mechanical Engineers** (**ASME**) formed a committee, called the **Boiler and Pressure Vessel Committee**, to address these variations. This committee worked towards establishing uniformity for pressure vessel and boiler designs. The mandate of the Boiler and Pressure Vessel Committee was to:

a) Establish rules of safety for the design, fabrication, and inspection during construction of boilers and pressure vessels.

b) Interpret these rules when questions arise.

The rules they developed are called the **ASME Boiler and Pressure Vessel Code**, which has been adopted by all Canadian Jurisdictions.

National Standards

Why Standards are Necessary

Modern industry has developed in safety and efficiency due to, and concurrently with, the development and adoption of industry standards. A standard is a minimum grade or quality, having widespread recognition and implementation, developed by industry experts. Standards are needed for the following reasons:

- To promote safety for the public, plant owners, and operators. Striving for safety helps to lower insurance costs as well.
- To facilitate lower operation and maintenance costs. Imagine the confusion if there were no uniform standards for pipe threads and fittings.
- To form the basis of plant inspection and certification, and the certification process for Power Engineers.

How Standards are Prepared

Standards are issued by national and international organizations. They have various committees and subcommittees that develop safety codes and standards. These committees are made up of experts and professionals from industry, government, and insurance companies.

Since the committees are generally composed of highly qualified people, the codes prepared are adopted as standards, and may receive nation-wide recognition if made into law.

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.

ASME

Founded in 1880, the **American Society of Mechanical Engineers (ASME)** is a professional technical society. It has a membership of over 115 000 practicing engineers and associated scientists. Its purpose is to:

- Develop and disseminate technical information
- Promote high standards of engineering design and education
- Encourage personal and professional development
- Foster ethical conduct
- Provide creative solutions for technical problems

In 1914, the ASME Boiler and Pressure Vessel Committee published its first Boiler and Pressure Vessel Code (**BPVC**). This single volume contained standard rules for the construction of steam boilers. Because of the ASME's knowledge, broad membership and widespread support, the code was rapidly adopted by manufacturers and regulatory authorities.

The objective of the BPVC rules was to:

a) Establish minimum standards that would apply to all jurisdictions.
b) Afford reasonable certain protection of life and property.
c) Provide reasonable long life and a safe period of usefulness for boilers and pressure vessels.

To form its rules, the **BPVC** considers the needs of the users, manufacturers, and inspectors of pressure vessels and boilers. The objective is to:

a) Provide reasonable protection of life and property.
b) Provide a safety margin for in-service deterioration.

The safety margin ensures a lengthy period of safe use of the boiler or pressure vessel. The **BPVC** also recognizes advancements in materials and designer experience.

The ASME does not approve, certify, rate, or endorse any item, construction, proprietary device, or activity. As well, the ASME does not act as a consultant on engineering problems or general application of the code.

The ASME publishes twelve different codes within the BPVC. The following sections are of the greatest interest for students for Power Engineering:

Section I	Rules for Construction of Power Boilers
Section IID	Materials Properties
Section IV	Rules for Construction of Heating Boilers
Section V	Nondestructive Examination
Section VI	Recommended Rules for Care and Operation of Heating Boilers
Section VII	Recommended Guidelines for the Care of Power Boilers
Section VIII	Rules for Construction of Pressure Vessels (Div. 1 and 2)
Section IX	Welding and Brazing Qualifications

The ASME also publishes other codes of great interest to Power Engineers. These include:

ASME B31.1	Power Piping
ASME B31.3	Process Piping
ASME B31.5	Refrigeration Piping and Heat Transfer Components
ASME B16.5	Pipe Flanges And Flanged Fittings

CSA

In Canada, The **Canadian Standards Association (CSA)** has developed codes for boilers, pressure vessels, pressure piping, and mechanical refrigeration. The CSA consists of members from industry, scientists, engineers, and consumers. It is a non-profit organization and is independent from the government. CSA produces thousands of standards, ranging in topics from safety boot manufacturing to electrical installations.

The development and use of CSA boiler, pressure vessel and refrigeration codes, along with Jurisdictional legislation, provides protection to the public and operators working with pressure vessels and boilers. They ensure that the design, fabrication, materials, construction, operation meets a minimum standard for protection.

ANSI

The American National Standards Institute (**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 (NFPA), the American Society for Testing and Materials (ASTM), the CSA, and the ASME. ANSI K61.1 Safety Requirements for Storage and Handling of Anhydrous Ammonia is a valuable reference source for Power Engineers.

Local Regulations

Building codes, fire codes, and health department regulations typically fall under local municipal regulations. For example, such regulations may rule that flammable liquids must not be stored in boiler rooms. 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.

Objective 2

Explain the content and use of the CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code.

Background

One of the adopted CSA standards that apply to pressure equipment and piping is **CSA B51**. Established in 1939, **CSA B51** has undergone many revisions. This code is essential for Power Engineers in the workplace and during examinations. SOPEEC permits the use of the current **CSA B51** code during examinations.

With each new edition, the Technical Committee reviews and revises the standard to meet the following

a) Address technological change.
b) Ensure safe boiler and pressure vessel design and installation.
c) Ensure all jurisdictions have uniform requirements.

The **CSA's Technical Committee** on **Boilers and Pressure Vessels** works with other committees, such as **ASME** and the **National Board of Boiler and Pressure Vessel Inspectors (NBBI)** in both Canada and the USA, to keep the code up to date.

The CSA standard makes reference to other standards and codes. For example, **CSA B51** refers to standards published by the **American National Standards Institute (ANSI)**, the **American Petroleum Institute (API)**, and the **Manufacturer Standardization Society of the Valves and Fittings Industry (MSS)**.

The Standard is divided into sections, subsections, and clauses.

CSA B51 - Boiler, Pressure Vessel, and Pressure Piping Code

A CSA committee on boilers and pressure vessels produces this code. This committee consists of representatives from:

- Provincial and territorial jurisdictions
- Boiler and pressure vessel manufacturers
- Insurance companies

The committee is well qualified to make rules and regulations regarding boiler and pressure vessel construction and inspection.

This code has two purposes.

1. It provides for the safe design, construction, installation, operation, inspection, testing, and repair of boilers and pressure vessels.
2. It promotes uniform requirements among the jurisdictions.

1 - Scope

The scope lists the type of equipment to which this code applies, as well as exceptions.

2 - Reference Publications

This section lists all of the publications referred to by **CSA B51**.

3 - Definitions

Various terms are listed and defined here. For example, the term Act is defined as meaning the Boilers and Pressure Vessels Act, Regulation, or Ordinance of the respective jurisdictions.

4 - General Requirements

4.1 to 4.7 Administrative Requirements

This section covers the requirements for registering boiler, pressure vessel, or fitting designs. It describes the **Canadian Registration Number (CRN)** system of provincial and territorial design registration. It gives examples of CRNs for vessels and flanges that are registered in different provinces or territories. Also discussed are the requirements for weld procedure qualification, manufacturers' reports, and in-service repairs and alterations.

4.8 to 4.16 Technical Requirements

This section covers:

- Fabrication
- Inspection
- Quality control program implementation
- Non destructive examination
- Water tanks
- Liquefied petroleum gas services
- Piping testing and data reporting

5 - Identification

This section covers the nameplate and stamping requirements for boilers and pressure vessels and related fittings. This includes original equipment or those with alterations.

6 - Boilers and Related Equipment

CSA B51 discusses requirements for:

- Water gauges
- Low-water cut-offs
- Fusible plugs
- Vessel access
- Outlet dampers
- Blowoff vessels

7 - Pressure Vessels

The pressure vessels discussed in this section include:

- Blowoff tanks
- Hot water tanks
- Hydropneumatic tanks
- Cushion tanks

Also addressed are the requirements for vessels in:

- Anhydrous ammonia service
- Liquefied petroleum gas (LPG) service
- Natural gas service

The **CSA B51** also covers the specific requirements of buried pressure vessels.

8 - Piping and Fittings

This section lists the standards which govern pressure piping and fittings. As well, the requirements for assembling and registering pipe fittings are covered.

9 - Refrigeration Equipment

This section refers to the requirements of the **CSA B52 Mechanical Refrigeration Code** for:

- Design
- Installation
- Inspection
- Testing
- Repair

10 - Pressure Coils in Petroleum and Chemical Plant Fired Heaters

This section directs the user to other equipment standards that are specific to the petroleum and chemical industries. They include requirements for:

- Design
- Fabrication
- Installation
- Inspection
- Testing
- Repair

11 - Repairs and Alterations

Before pressure equipment can be repaired or altered, there must first be approval by the regulatory authority in the jurisdiction where the equipment is used. Repair or alteration must also conform to the requirements of the equipment's original design code.

Objective 3

Explain the content and use of the CSA B52 Mechanical Refrigeration Code.

The **CSA B52 Mechanical Refrigeration Code** is revised every 3 to 5 years. Therefore, always refer to the most current Code identified on the CSA website.

According to CSA, the **B52 Code** was developed to "*minimize the risk of personal injury by providing minimum requirements for the design, construction, installation, inspection, and maintenance of refrigeration systems.*"

CSA B52 - Mechanical Refrigeration Code

Like **CSA B51**, a committee called the **Technical Committee on Mechanical Refrigeration Code** produces the **B52 Code**. The committee consists of representatives from:

- Provincial and territorial jurisdictions
- Professional engineers' associations
- Refrigerating and air conditioning institutes
- Other interested groups

The **CSA B52** has two purposes.

1. It provides for the safe design, construction, installation, operation, and repair of refrigerating and air conditioning equipment and systems, and related equipment.
2. It promotes uniform requirements among the provinces and territories.

1 - Scope

The scope lists the type of equipment to which this code applies, as well as the equipment to which it does not apply.

2 - Reference Publications

This section lists all of the publications referred to by **CSA B52**.

3 - Definitions and Abbreviations

This section lists and defines terms related to refrigeration and air conditioning equipment.

4 - System Selection and Application Requirements

The requirements for system selection and application are discussed. It also includes the various system classifications.

Occupancy Classification

This part of the code defines five different building occupancies. They include:

1. Commercial
2. Institutional
3. Industrial
4. Residential
5. Public assembly

Refrigerating System Classification

Refrigeration systems are classified by the method used for extracting heat (e.g. direct, double direct and indirect). Each classification is described. Sketches are given to assist in these descriptions.

Refrigerant Classification

Based on toxicity and flammability, the refrigerants used are listed and divided into six safety groups. Group 1 refrigerants are the least flammable. Group 3 refrigerants are the most flammable. Group A refrigerants are the least toxic. Group B refrigerants are the most toxic. Therefore, refrigerants are grouped into A1, A2, A3, B1, B2, or B3.

5 - Equipment Design and Construction

This section is extensive. It deals with drawings, specifications, and data reports for refrigeration pressure vessels, piping and fittings. Parts of section 5 refer the user to relevant **CSA B51** code section. As well, this section discusses:

- Minimum design pressures
- Materials of construction
- Provisions necessary for servicing
- Pressure testing
- Nameplate requirements

6 - Installation

This section primarily covers the requirements for machinery rooms.

- Refrigerant leak detection systems
- Ventilation systems
- Fire ratings
- Electrical ratings
- Duct work
- Provision for safe egress
- Location of piping, piping supports
- Emergency discharge systems

7 - Overpressure Protection

This section lists the regulations regarding pressure vessel and compressor overpressure protection. It also includes pressure **limit controls** and **pressure relief valve** installation. Pressure relief valve set points, capacities, and discharge piping are covered. As well, section 7 addresses rupture disk and fusible plug use for pressure relief.

8 - Maintenance of Systems

These are the rules for charging and discharging refrigerants, system maintenance, and posting of instructions.

9 - Precautions

These rules refer to the jurisdictional requirements for personal protective equipment, such as breathing apparatus. It also covers the special egress hazards of enclosed refrigerated spaces.

Objective 4

Explain the content and use of ASME Boiler and Pressure Vessel Code (ASME BPVC) Section I Power Boilers.

Section I: Rules for Construction of Power Boilers

Power boilers are defined as boilers in which steam or other vapour is generated at a pressure greater than 100 kPag. This also includes boilers that produce hot water above 120°C. **ASME Section I** contains the rules and general requirements for all methods of construction for power boilers used in stationary service. Its scope also includes power boilers used in locomotive, portable and traction service. The **PanGlobal ASME Academic Extract** contains the sections of **ASME I** most referred to by Power Engineers.

Contents of ASME I

ASME I is divided into several parts, each of which addresses a particular aspect of boiler design and construction. All parts in **ASME Section I** are prefixed with the letter "P" for "Power." These Parts are:

- Part PG General Requirements for all Methods of Construction
- Part PW Requirements for Boilers Fabricated by Welding
- Part PR Requirements for Boilers Fabricated by Riveting
- Part PB Requirements for Boilers Fabricated by Brazing
- Part PL Requirements For Locomotive Boilers
- Part PWT Requirements for Watertube Boilers
- Part PFT Requirements for Firetube Boilers
- Part PFH Optional Requirements for Feedwater Heater
- Part PMB Requirements for Miniature Boilers
- Part PEB Requirements for Electric Boilers
- Part PVG Requirements for Organic Fluid Vaporizers
- Part PFE Requirements for Feedwater Economizers
- Part PHRSG Requirements for Heat Recovery Steam Generators

As well, **ASME I** has a set of Mandatory Appendices and Non-Mandatory Appendices to provide details on application of the code. The **PanGlobal ASME Academic Extract** contains the most relevant Code sections for Power Engineers.

ASME has used a "soft" conversion for most of the conversions between SI units and **USCS (United States Customary System)**.

Table 1 – ASME Conversions

Imperial	Soft Conversion	Hard Conversion
15 PSI	100 kPa	103.0 kPa
250°F	120°C	121°C
14.7 psi		101.3 kPa
160 psi	1100 kPa	1103 kPa

The scope of ASME Code Section I covers superheaters, economizers, and other pressure parts connected directly to the boiler with no intervening valves. These parts are referred to as Boiler External Piping. **ASME I** does not address any other steam, blowoff or feedwater piping.

Part PG - General Requirements for All Methods of Construction

Part PG covers the fundamentals of all power boiler designs. This part deals with:

a) Materials used for boilerplate, forgings, castings, pipes, and tubes.

b) Basic design calculations for cylindrical parts under internal pressure. This includes shells, drums, headers, and boiler piping.

c) Basic design calculations for cylindrical parts under external pressure. This includes furnace tubes and firetubes.

d) Dished and flat heads.

e) Requirements for reinforcing openings in shells, heads, and headers.

f) Methods of attaching pipes and nozzles to vessel walls.

g) Inspection openings and stayed surfaces.

h) Requirements for miscellaneous pipe, valves, and fittings.

i) Requirements for feedwater supply.

j) Requirements for boiler and superheater pressure relief valves. This includes mounting, testing, capacity, set point, and operation of pressure relief valves.

k) Fabrication rules for the cutting and identification of plate, defects in materials, tube holes and tube ends, and holes for threaded stays.

l) Rules for the qualifications of inspectors.

m) Procedures for hydrostatic tests.

n) Details for the stamping of boilers, pressure piping, and pressure relief valves.

Part PW - Requirements for Boilers Fabricated by Welding

This part covers general rules for welded boilers.

a) Materials of construction.

b) Design of welded joints, heat treatment, radiographic and ultrasonic examination of welds.

c) Weld efficiencies, opening adjacent to welds, and minimum requirements for attachment welds.

d) Rules for fabrication. This includes welding processes, welding qualifications, base metal preparation, and assembly.

e) Preheating, post-weld heat treatments, and repair of weld defects.

Part PWT - Requirements for Watertube Boilers

This part deals with specific rules for design and construction of watertube boilers. These specific rules are used together with the general rules of **Part PG**.

Part PFT - Requirements for Firetube Boilers

This part deals with specific rules for the design and construction of firetube boilers. These specific rules are used together with the general rules of **Part PG**.

a) Design rules for minimum thicknesses and maximum allowable working pressures of tubesheets, reinforced and corrugated furnaces, stayed surfaces, and waterlegs.

b) Furnace and tube attachment.

c) Inspection openings, access, and firing doors.

d) Steam domes, settings, fittings, feedwater piping, and blowoff piping.

Part PFH - Requirements for Feedwater Heaters

This short part defines a feedwater heater falling within the scope of **Section I**, and discusses its design requirements. These specific rules are used together with the general rules of **Part PG**.

The **PanGlobal ASME Academic Extract** does not include this section.

Part PMB - Requirements for Miniature Boilers

Miniature high-pressure boilers are typically of such low capacity that they do not require licensed operators. These specific rules are used together with the general rules of **Part PG**.

The **PanGlobal ASME Academic Extract** does not include this section.

Part PEB - Requirements for Electric Boilers

In this Part, electric boilers are defined. It deals with specific rules for design and construction of electric boilers. Specific design rules are discussed for:

- Welding
- Inspection openings
- Pressure gauges
- Pressure relief valves

These specific rules are used together with the general rules of **Part PG**.

The **PanGlobal ASME Academic Extract** does not include this section.

Part PVG - Requirements for Organic Fluid Vaporizer Generators

Organic Fluid Vaporizers are similar to steam boilers. However, they boil hydrocarbon-based fluids to produce high-pressure vapour. This Part has general rules for the materials and design of organic fluid vaporizers. There are specific rules for level gauges, pressure relief valves, and rupture discs. These specific rules are used together with the general rules of **Part PG**.

The **PanGlobal ASME Academic Extract** does not include this section.

Appendices

The Mandatory Appendices provide additional information. These are necessary to properly apply the code. The Non-Mandatory Appendices also provide additional information. However, they are only required when specifically referred to in the rules of the code.

The Mandatory Appendices cover topics such as:

a) Standard units for use in equations

b) Local thin areas in cylindrical shells and heads

c) Additional rules for boilers fabricated by riveting

The Non-Mandatory Appendices cover topics such as:

a) Efficiency of riveted joints
b) Method of checking pressure relief valve capacity
c) Use of automatic water gauges
d) Fusible plugs
e) Acceptance criteria for welds
f) Manufacturer's Data Reports
g) Repairs to existing boilers
h) Reinforcement calculations for openings in vessels

Objective 5

Explain the content and use of ASME BPVC Section VII - Recommended Guidelines for the Care of Power Boilers.

ASME Section VII: Recommended Guidelines for the Care of Power Boilers

ASME Section VII contains rules that assist power boiler operators in the safe operation of power boilers. The Introduction of **ASME VII** covers some of the scope of this code.

> *"The term power boiler in this Section includes stationary, portable, and traction types, but does not include locomotive and high temperature water boilers (**Section I**), nuclear power plant boilers (**Section III**), heating boilers (**Section IV**), miniature boilers (**Section I**), or pressure vessels (**Section VIII**)."*

As well, **Section VII** applies to superheaters, reheaters, economizers, and other pressure parts connected directly to the boiler without intervening valves. **Section VII** also provides guidelines for operating auxiliary equipment that affect the safe and reliable operation of power boilers.

Section VII is divided into nine subsections, plus several appendices, and a glossary of terms. Each of these is briefly described as follows.

Subsection C1 - Fundamentals

This subsection provides general descriptions of steam generation and boiler types, such as:

- Firetube
- Watertube
- Electric
- Packaged
- Field-assembled boilers

It also describes some of the essentials of **combustion** and factors that affect boiler efficiency.

Subsection C2 - Boiler Operation

This extensive set of guidelines covers the procedures for the safe operation and maintenance of steam boilers.

a) Operator training
b) Preventing explosions
c) Maintaining water level and furnace pressure
d) Preparing for operation (including waterside, fireside, and external inspections, hydrostatic testing)
e) Actual start-up guidelines
f) Monitoring during operation

Also covered are boiler shutdown, cleaning, and lay-up.

Subsection C3 - Boiler Auxiliaries

These guidelines cover the operation and safety considerations for the auxiliary systems and equipment which support and are part of the overall boiler system. The major headings in this section include:

a) Preparation of auxiliaries for start-up
b) Fuel burning equipment, including preparation and operation of:
   - Gas systems
   - Oil systems
   - Coal systems
   - Fires in pulverized coal systems
   - Boiler tube failures
c) Air heaters, economizers
d) Boiler feed pumps
e) Draft fans
f) Dampers

Subsection C4 - Appurtenances

Appurtenances are devices or components that are directly connected to the boiler, for specific purposes. These guidelines relate to the safe operation and maintenance of these appurtenances.

a) Pressure relief valves
b) Pressure gauges
c) Fusible plugs
d) Feedwater regulators
e) Soot blowers
f) Blowdown/blowoff valves

Subsection C5 - Instrumentation, Controls and Interlocks

Instruments that monitor and control the various operating parameters of the boiler must be treated and maintained. In some cases, they need to be tested to ensure their accuracy and reliability. The same is true for interlocks, which protect the boiler from dangerous situations.

This section provides guidelines specific for their operation, maintenance, and testing.

a) Indicators and recorders (such as steam flow and drum level)
b) Controls (such as combustion, feedwater, and superheat)
c) Interlocks (such as flame failure and low water level)

Subsection C6 - Inspection

These guidelines are intended to help owners and operators to properly and safely inspect their power boilers. They do not take precedence over jurisdictional inspection requirements.

The main topics covered by these guidelines include:

a) Inspection frequency
b) Preparation for inspection (water side, fire side, external)
c) Internal inspection items for watertube and firetube boilers
d) External inspection (including piping, pressure relief valves, and appurtenances)
e) Record keeping
f) Hydrostatic testing
g) Authorized inspectors

Subsection C7 - Repairs, Alterations, Maintenance

These guidelines are intended to assist boiler owners and operators to assess and make repairs or alterations to the boiler or its related components. There are very strict guidelines on who may authorize and carry out the repairs.

The main topics in this subsection include:

a) Repairs and alterations
b) General maintenance
c) Specific boiler maintenance
d) Detailed maintenance checklists for watertube and firetube boilers

Subsection C8 - Control of Internal Chemical Conditions

These guidelines are for the control of chemical conditions in boilers, in order to promote safety in operation.

Topics covered include:

a) Internal cleaning of boilers
b) Laying up of boilers
c) Deposits of solid material on internal surfaces
d) Corrosion of internal surfaces in boilers and auxiliary equipment
e) Corrosion cracking of boiler steel
f) Steam contamination

Also included are guidelines for:

a) Water sampling
b) Water testing
c) Analysis of fireside deposits and corrosion

Subsection C9 - Preventing Boiler Failures

These guidelines are for the prevention of boiler failures due to overpressure, structural weakening, and operator error.

The main topics in this section include:

a) Overpressure, including the care of:
    - Pressure gauges
    - Water glasses
    - High and low water alarms
    - Automatic trips

b) Weakening of structure, including:
   - Pressure parts
   - Supports
   - Mechanical damage
   - Discussion on boiler startup and shutdown, water level control, erosion and corrosion

c) Operation of combustion equipment, including:
   - Furnace explosions
   - Furnace implosions

Appendices

These follow the Subsections above. **Section VII** contains several Mandatory and Non Mandatory Appendices. The Non-Mandatory Appendices are of greater interest to the Power Engineer.

a) Non-Mandatory Appendix A - Procedures for Care and Operation of Package Boilers

b) Non-Mandatory Appendix B - Watertube Boilers - Maintenance Checks

c) Non-Mandatory Appendix C - Watertube Boilers - Operating Checks Relating to Maintenance

d) Non-Mandatory Appendix D - Firetube Boilers - Maintenance Checks

e) Non-Mandatory Appendix E - Firetube Boilers - Operating Checks Relating to Maintenance

f) Non-Mandatory Appendix F - Guidance for the Use of US Customary and SI Units in the ASME Boiler and Pressure Vessel Code

Glossary

Section VII concludes with a comprehensive glossary of terms. This covers:

- Boilers
- Fuels
- Fuel burning equipment
- Combustion
- Water treatment

Objective 6

Explain the content and use of ASME BPVC Section IV - Rules for Construction of Heating Boilers.

ASME Section IV: Rules for Construction of Heating Boilers

This section covers the minimum safety requirements for the design, fabrication, installation and inspection of steam and hot water boilers intended for low-pressure or low temperature service (maximum 100 kPag steam pressure or maximum 120°C water temperature).

It also contains appendices which cover:

- Approval of new material
- Methods of checking pressure relief valve capacity
- Definitions relating to boiler design and welding
- Quality control systems

The code is divided into four parts, plus an appendix. A brief description of each of these follows. Each Part of **ASME IV** is prefixed with the letter "H" for "Heating". The **PanGlobal ASME Academic Extract** contains the sections of **ASME IV** of most importance to the Power Engineer.

Part HG - General Requirements for All Methods of Construction

Part HG covers the fundamentals of all heating boiler designs.

a) Materials used for boiler plate, forgings, castings, pipes, and tubes.
b) Basic design calculations for cylindrical parts under internal pressure. This includes shells, drums, headers, and boiler piping.
c) Basic design calculations for cylindrical parts, dished heads, flat heads, and covers.
d) Requirements for openings in shells, heads, and headers and reinforcement required for these.
e) Methods of attachment of pipes and nozzles to vessel walls.
f) Inspection openings and stayed surfaces.
g) Outlets and external piping, and application requirements for the boiler proper.
h) Requirements for miscellaneous pipe, valves, and fittings and the feedwater supply.
i) Boiler pressure relief valve testing, capacity, mounting, and operation.
j) Fabrication rules regarding cutting and identification of plate.
k) Defects in materials, tube holes, and tube ends.
l) Holes for threaded stays.
m) Rules for the qualification of inspectors.
n) Procedures for hydrostatic tests.
o) Details for the stamping of boilers, pressure piping, and pressure relief valves.

Part HF, Subpart HW - Requirements for Boilers Fabricated by Welding

This Section of **ASME IV** covers:

a) General requirements for boilers fabricated by welding.
b) Material requirements for boilers and small parts.

Welding processes and qualifications:

a) Design of weldments.
b) Fabrication requirements, including base metal preparation and repair of weld defects.
c) Inspection during and after construction.

Part HC - Requirements for Boilers Constructed of Cast Iron

This Section of **ASME IV** covers:

a) Material requirements for cast-iron boilers.
b) Design requirements for maximum allowable stress on boiler parts.
c) Requirements for testing to design pressure, bursting test procedure, and hydrostatic test procedure.
d) Rules for quality control and inspection.

Part HLW - Requirements for Portable Water Heaters

This Section of **ASME IV** covers:

a) Materials required for tank lining, pressure parts, flanges, and pipe fittings.
b) Basic design calculations for all parts of a heater.
c) Design of welded joints.
d) Required pressure testing including proof tests and hydrostatic tests.
e) Details regarding inspection and testing of heaters.
f) Rules required for controls, temperature controls, limit controls, and electric wiring.
g) Requirements for installation.

Appendices

Like **ASME I**, **ASME IV** has several Mandatory and Non-Mandatory Appendices. The Mandatory Appendices provide additional information. These are necessary to properly apply the code. The Non-Mandatory Appendices also provide additional information. However, they are only required when specifically referred to in the rules of the code.

The Mandatory Appendices address items such as:

a) Codes and standards referred to by **ASME IV**
b) Nameplate attachment
c) Vacuum boilers
d) Standard units
e) Rules for mass production of heating boilers

The Non-Mandatory Appendices cover topics such as:

a) Estimating pressure relief valve capacity
b) Method of checking pressure relief valve capacity
c) Calculating the dimensions of a ring-reinforced furnace
d) Reinforcement calculations for openings in vessels
e) Quality control
f) Manufacturer's Data Reports

Objective 7

Explain the content and use of ASME BPVC Section VI - Recommended Rules for Care and Operation of Heating Boilers.

ASME Section VI: Recommended Rules for the Care and Operation of Heating Boilers

This section covers the latest specifications, terminology, and fundamentals for steel and cast iron boilers, limited to the operating range of **ASME Section IV**, **Heating Boilers**. It also includes guidelines for associated controls and automatic fuel burning equipment.

Various illustrations show typical equipment, components, and how equipment should be installed. This section also includes an extensive glossary of terms associated with heating boilers, controls, and fuel burning equipment.

This code contains rules to assist operators of heating boilers in maintaining their plants in a safe condition. These rules apply to the boiler proper and to pipe connections up to and including any valves required by the ASME code. Like **ASME VII**, **ASME VI** provides rules for the safe operation of heating boiler auxiliary equipment, such as feedwater pumps and draft fans.

ASME VI is divided into nine subsections, plus appendices. Each of these is briefly described below.

General

This subsection is primarily a glossary of terms. Terms included for:

- Boilers
- Fuels
- Fuel burning equipment
- Combustion

Types of Boilers

This subsection covers the different classification of heating boilers. Plus, it indicates which types of boilers are in each classification.

Accessories and Installation

These rules are for the installation of accessories for heating boilers. They include:

- Pressure relief valves
- Low-water fuel cut-offs
- Condensate return pumps
- Circulators
- Expansion tanks
- Pressure gauges
- Water columns and water glasses
- Piping and valve requirements

Fuels

This subsection discusses the different types of boiler fuels for heating boilers.

Fuel Burning Equipment and Fuel Burning Controls

This subsection describes the different types of fuel burning equipment found on heating boilers.

They also include the controls found on automatic fired boilers.

- Operating controls
- Limiting controls
- Safety controls
- Programming controls
- Spare parts
- Power for electrically operated controls
- Air for pneumatically operated controls
- Venting of gas controls

Boiler Room Facilities

These rules are for the boiler room facilities, to maintain the facility in a safe operating condition.

Topics include:

- Inspection of a new boiler
- Safety
- Lighting
- Ventilation
- Water and drain connections
- Fire protection
- Housekeeping
- Posting of certificates
- Record keeping and logs

Operation, Maintenance, and Repair of Steam Boilers

These rules govern the procedures to perform the ordinary duties of operating, maintaining, and repairing steam boilers.

These rules cover such things as:

- Starting a new boiler and heating system
- Starting a boiler after lay-up
- Condensation
- Cutting in an additional boiler
- Operation of boiler auxiliaries
- Removing a boiler from service
- Maintenance of boiler and auxiliaries
- Boiler repairs
- Testing and inspection of steam heating boilers

Operation, Maintenance, and Repair - Hot Water Boilers and Hot Water Heating Boilers

These rules govern the procedures to perform the ordinary duties of operating, maintaining, and repairing hot water boilers.

These rules cover such things as:

- Starting a new boiler and heating system
- Starting a boiler after lay-up
- Condensation
- Cutting in an additional boiler
- Operation of boiler auxiliaries
- Removing a boiler from service
- Maintenance of boiler and auxiliaries
- Boiler repairs
- Testing and inspection of hot water boilers

Water Treatment

These recommended procedures cover the treatment of water in steam and **hot water heating boilers**.

These rules cover:

- Boiler water troubles
- Chemicals used
- Function of chemicals
- Treatment alternatives
- Blowdown
- Feeders
- Procedures

Appendices

The appendices follow the Subsections above. **Section VI** contains Mandatory and Non-Mandatory Appendices. Mandatory Appendix I is of more interest to the Power Engineer. It includes:

a) Typical log sheets for routinely testing and inspecting the controls of steam and hot water boilers.
b) Test procedures for flame safeguards.
c) Combustion efficiency test methods.
d) **Safety limit control** test procedures.
e) Pressure relief valve test procedures.

Objective 8

Explain the purpose, intent, and limitation of ASME CSD-1 (Controls and Safety Devices) Standard.

Introduction

In 1977, the **ASME** published a code to address the main hazards that are related with the operation of smaller, automatically fired boilers:

- Low water
- Overpressure
- Over-temperature
- Furnace explosion

The code is called **Controls and Safety Devices for Automatically Fired Boilers (CSD-1)**. **CSD-1** has been adopted by numerous jurisdictions across North America.

The ASME intended to address the following facts:

a) Small boilers (under 300 **boiler horsepower**) are the most commonly installed boilers. They are found in dry cleaners, apartment heating, plants, schools, shopping malls, recreation facilities and so on.

b) They are **automatically fired**; therefore, these boilers may not receive attention by licensed or trained operators and maintenance personnel.

c) Because of the two facts above, small automatically fired boilers pose a greater risk to the public than larger boilers.

ASME realized that rules were necessary for the assembly, installation, maintenance, and operation of the controls and safety devices of automatically fired boilers. This provides additional safety when licensed and trained operators do not continuously attend the equipment. In the words of **CSD-1**:

> *"It is believed that improved instrumentation, controls and safety devices, proper operating procedures, and a clearer understanding of installation requirements by the manufacturers, installers, and operators can greatly reduce the chances of personal injury, damage to property, and loss of equipment from accidents."*

In its scope, **CSD-1** covers automatically fired:

a) Hot water and **low pressure steam heating boilers**

b) High-pressure steam ("power") boilers

CSD-1 only applies to:

a) Boilers that operate on gas, oil, or electric power

b) Boilers under 300 boiler horsepower

Note: **CSD-1** does not apply to hot water heaters or direct gas-fired swimming pool heaters.

Larger boilers fall under other codes, such as **NFPA 85**. Boilers under 422 022 kJ per hour input (400,000 Btu per hour input) that are labelled by a certified testing agency may also be recognized as meeting **CSD-1**.

Low Water

CSD-1 Part CW requires all automatically fired boilers to undergo a **safety shutdown** (shut off their fuel/heat input) if the water within the boiler falls to below what the boiler manufacturer deems safe. A "low water cut-off" is the device that reacts to the boiler water level, and causes a safety shutdown. The low water cut-off may also cause a **lockout**. This means that the boiler cannot restart after the water level is restored, unless an operator is present to reset the control system.

The low water cut-off has an important role. It must never be bypassed either mechanically (i.e., using isolation valves) or electrically (i.e., with a bypass switch or jumper wires).

CW-120: Low Pressure Heating Boilers

Each automatically fired, low-pressure steam or vapour system boiler shall have at least two automatic **low-water fuel cut-offs**. One of these may be a **combined feeder/cut-off device**. A low water condition shall cause a safety shutdown.

CW-130: Hot Water Heating Boilers

Each automatically fired, hot-water heating boiler shall be protected by a low-water fuel cutoff. This should be located any place above the lowest permissible water level established by the boiler manufacturer. A low water condition shall cause a safety shutdown and lockout, requiring manual reset.

CW-140: High-Pressure Steam Boilers

Each automatically fired, **high-pressure steam boiler** shall have at least two automatic low water fuel cut-off devices. The lower of the two controls shall cause safety shutdown and lockout, requiring manual reset.

CW-200: Forced Circulation Boilers

Some small hot water boilers rely on forced circulation to prevent them from overheating. CW-210 permits these coil-type tubular boilers to have a **flow switch** at the boiler outlet. If the forced circulation pump fails, or if the heat exchanger is blocked or ruptured, the reduction in outlet flow will cause a safety shutdown. This will prevent the boiler from restarting until adequate water flow is restored. However, many jurisdictions also require a low water cut-off in addition to the flow switch.

Over Pressure

To paraphrase **CSD-1 Part CW-300**, steam boilers require pressure limit controls as follows.

> *"Each automatically fired steam boiler shall have at least one steam pressure control device that will shut off the fuel supply to each boiler when the steam pressure reaches a preset maximum operating pressure. In addition, each individual automatically fired steam boiler shall have a high steam pressure limit control that will prevent generation of steam pressure greater than the maximum allowable working pressure. Functioning of this control shall cause safety shutdown and lockout."*

A boiler may have additional pressure controls that are used to modulate the boiler firing rate during routine operation. The pressure controls must be protected from the effects of live steam with a water-seal, such as that provided by a "pigtail" siphon. Like the low-water cut off, **CSD-1** does not permit any mechanical or electrical means whereby the high-pressure cut-off can be bypassed or defeated.

Part CW-500 requires that all boilers have pressure relief valves. The pressure relief valve is the last line of defense against over-pressurization. For a steam boiler, the pressure relief valves operates if the high pressure cut-off fails to cause a safety shutdown and lockout of the boiler. This situation could also occur to a cold hot water heating boiler, if fired to its temperature set point with its supply and return valves shut. **CW-510** directs the reader to the applicable ASME code for determining pressure relief valve requirements (**ASME I or IV**).

Over Temperature

To paraphrase **CSD-1 Part CW-400**, hot water heating boilers require temperature limit controls as follows:

> *"Each automatically fired hot-water boiler shall have at least one temperature-actuated control to shutoff the fuel supply when the system water reaches a preset operating temperature. In addition, each individual automatically fired hot-water boiler unit shall have a high temperature limit control that will prevent the water temperature from exceeding the maximum allowable temperature. The upper set point limit of the selected control shall not exceed the maximum allowable temperature. This control shall cause safety shutdown and lockout."*

A boiler may have additional temperature controls that are used to modulate the boiler firing rate during routine operation. Like the low-water cut-off, **CSD-1** does not permit any mechanical or electrical means for the high- temperature cut-off to be bypassed or defeated.

Furnace Explosion

If a **burner** control system fails – either electrically or mechanically - gas and oil fired boilers may accumulate explosive mixtures of fuel and air if an ignition source is absent. When an ignition source is introduced, the mixture will ignite causing an explosion. **CSD-1 Part CF** is focused on automatic burner operation and controls, to prevent this explosive "**delayed ignition**."

The requirements of **Part CF** depend on the input rating of the burner, the type of fuel being burned, and the combustion air delivery method (**mechanical** or **natural draft**). The largest burners require the most stringent safety requirements, because they present greater hazard.

Tables **CF-2** and **CF-3** outline the burner safety control requirements for mechanical and natural draft boilers firing gaseous fuels. Table **CF-4** outlines the burner safety control requirements for oil-fired boilers. These tables outline permissible:

a) Ignition systems and their application
   - **Continuous**, **Intermittent** or **Interrupted pilots**
   - Direct ignition
   - Hot surface ignition

b) Combustion air proving

c) Furnace **pre-purge** and **post-purge** requirements

d) **Flame failure response**

Part CF also covers **fuel train** components needed for safe automatically fired boiler operation. These components include:

- Pressure gauges
- Manual shut-off valves
- Pressure regulators
- Fuel pressure relief valves
- Vent lines
- Test ports
- **Bleed valves**
- **Control valves**
- **Safety shut-off (SSOV) valves**

CSD-1 has several figures to illustrate fuel train configurations for burners of various capacities, fuels, ignition, and draft systems. **CSD-1** may require a fuel piping system to have switches that shut down the burner in the event of high or low fuel pressure.

CF-310 describes the **primary safety control**. It is designed to monitor for the existence of flame and to commence safety shutdown and lockout if one of the following applies.

a) A flame exists when the SSOVs are closed (indicating mechanical failure of the SSOV).

b) No flame exists, when the SSOVs are open (indicating "flame failure").

These primary controls with extra functionality are commonly called "combustion programmers" or "programmed combustion controls." A programmed combustion control satisfies the primary safety control requirements of **CSD-1**.

Lastly, in Non-Mandatory Appendix D, **CSD-1** recommends daily, weekly, monthly, semi annual, and annual preventative maintenance. Some of the maintenance activities are listed below.

a) Check gauges, monitors, and indicators.

b) Test low-water fuel cut-off, including a "slow drain test."

c) Test low draft, fan air pressure, and damper position interlocks.

d) Check **low-fire start** interlock.

e) Test high and low fuel pressure and fuel temperature interlocks.

f) Check:
   - Burner flame
   - Igniter
   - Flame signal strength
   - Firing rate control
   - Flame failure detection system

g) Check flue, vent, stack, or outlet dampers.

h) Inspect burner components.

i) Test high-limit and operating temperature or steam pressure controls.

j) Replace vacuum tubes, scanners, or flame rods in accordance with manufacturer's instructions.

k) Conduct a combustion analysis test.

l) Perform leakage test on pilot and main gas and/or oil fuel valves.

m) Test **purge air switch** in accordance with manufacturer's instructions.

n) Clean oil-fired burners, atomizers, and oil strainers.

o) Test safety / **safety relief valves** in accordance with **ASME Boiler and Pressure Vessel Code, Sections VI and VII.**

Summary

ASME CSD-1 is a valuable reference for Power Engineers when ordering new or replacement boilers, or seeking guidance on maintenance or control system repair. For example, a combustion programmer may fail, requiring replacement. **CSD-1** will guide the boiler owner on the:

- Ignition style
- Purge timing
- Low fire start requirements
- Post-purge requirements
- Other important operating parameters

A replacement programmer can then be selected with the necessary features. A certified trade person must configure the programmer, in order to operate the boiler safely and in accordance with **CSD-1**.

However, it is important for the Power Engineer to remember the limitations of **CSD-1**. Many jurisdictions have not adopted **CSD-1** as law. Because of this, many boilers currently in-service were never equipped with controls that meet the requirements of **CSD-1**.

If properly inspected and maintained, few if any of these boilers operate unsafely. However, a Power Engineer may want to upgrade the controls and safety devices on an existing gas-fired boiler to meet **CSD-1**.

In Canada, if any modifications are made to a gas burner control system, the **CSA B149.3** "**Code for the Field Approval of Fuel-related Components on Appliances and Equipment**" takes precedence over **CSD-1** requirements, and must be consulted first.

Finally, **CSD-1** does not apply to boilers larger in capacity than 300 boiler horsepower. For larger boilers, different codes need to be consulted.

Chapter Summary

The Power Engineer must be familiar with the various standards and codes that apply to the pressure vessels and equipment they are working with. This includes:

- Operation
- Design
- Construction
- Maintenance
- Repairs

Jurisdictions that have adopted the ASME and CSA codes and standards have provincial officers to enforce compliance. These officers are responsible for enforcing the various pressure vessel acts and regulations.

Power Engineers need to understand this knowledge. It will assist to:

a) Ensure that equipment is working as it was designed to work.

b) Repairs are made according to standards and codes that govern the equipment.

c) Ensure the safe operation of the equipment.

The ASME and CSA codes were established to provide minimum standards that must be followed. This ensures that each jurisdiction provides the highest level of safety and protection for property and the public. These standards and codes were in response to significant accidents that occurred since the power of steam was first captured.

The **Canadian Standards Association (CSA)** developed the **CSA B51 Code**. It has been adopted in all jurisdictions in Canada. This code ensures pressure equipment is properly:

- Designed
- Constructed
- Operated
- Maintained
- Repaired

This offers a prescribed and predictable level of safety for the protection of the public and workers.

The **CSA B52 Code** applies to mechanical refrigeration systems being installed and operated that use a refrigerant gas. For specific requirements, always refer to the standard text published by CSA.

The **American Society of Mechanical Engineers (ASME)** has also published Codes specific to pressure vessels. Each section applies to a different aspect of the vessels. Each section includes:

- Design
- Construction
- Installation
- Inspection
- Operation

These Codes were designed to provide safety and protection for Power Engineers and the companies that employ them. The ASME codes provide rules for the:

a) Construction of power and heating boilers (**Sections I and IV**).

b) Care of these boilers (**Sections VII and VI**).

c) Requirements for the boiler controls and safety devices (**CSD-1**).

The Power Engineer is strongly encouraged to obtain copies of these documents, review them, and become familiar with their requirements. Always ensure that the most up to date version of the standards and codes are being referred to.

Unit Summary

Power Engineers play a key, though often un-recognized, role in society. So important is this role, that Canadian jurisdictions have enacted similar laws to regulate the profession.

This unit introduced the applicable Acts, Regulations, Codes and Standards that are common to most Canadian jurisdictions. It also described the rationale for legislation, the interrelationship between acts, regulations, codes and standards, and their hierarchy of importance. The enforcement of acts and regulations, and the development and codes and standards, were also covered in this unit. With this information, Power Engineers can relate the various legal requirements to the demands of their jobs.

This unit also provided direction to the acts and regulations of the local Canadian jurisdictions. Power Engineers must own, and be familiar with, copies of their local jurisdiction's acts and regulations. Power Engineers seeking certification, and those already certified, must study and revisit their local acts, regulations, standards, and codes to ensure compliance throughout their careers.

A self-assessment tool is available on MyPower LMS. Login using the unique user ID and password found on the inside front cover of Unit 1.

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UNIT A-3

KNOWLEDGE EXERCISES AND UNIT GLOSSARY

Knowledge Exercises – Chapter 1

Name: ______________________ Date: ______________________

Instructor: ______________________ Course: ______________________

Objective 1

1. What three properties make water and steam a popular heat transfer fluid?

2. List five industries that use steam.

3. Describe the fundamental steam cycle.

Objective 2

4. What is an energy conversion expert?

Chapter 1 (Cont.)

5. Identify the energy conversions that take place in a thermal electric generating station, beginning with the stored energy in the fuel.

Objective 3

6. Why must shift workers deal with shift work issues immediately?

7. Assuming an average 40-hour work week, what is the minimum number of shift crews required to cover an industrial operation, assuming a 12-hour shift rotation is in place?

8. What is circadian rhythm?

9. When is breakfast for a shift worker?

10. Why is teamwork important to shift workers?

Knowledge Exercises – Chapter 2

Name: ______________________________ Date: ________________________________

Instructor: ___________________________ Course: ______________________________

Objective 1

1. Describe the hierarchy of legislation.

Objective 2

2. Identify three common items found in an Act.

Objective 3

3. What is the difference between an act and a regulation?

Chapter 2 (Cont.)

4. State one topic found in the Engineers' Regulation. Describe how it applies to Power Engineers.

Knowledge Exercises – Chapter 3

Name: ______________________________ Date: ________________________________

Instructor: ___________________________ Course: ______________________________

Objective 1

1. Explain why the ASME was formed.

Objective 2

2. What sectors do the members of the **CSA B51 – Boiler, Pressure Vessel, and Pressure Piping Code** committee represent?

Objective 3

3. What is/are the purpose(s) of **CSA B52**?

Chapter 3 (Cont.)

Objective 4

4. List the **ASME Section 1 Parts** with a brief description of each.

Objective 5

5. List the types of boilers covered in **Subsection C1 – Fundamentals** of the **ASME Section VII**.

Objective 6

6. Describe the contents of **ASME IV**.

Chapter 3 (Cont.)

Objective 7

7. Describe the contents of **ASME VI**.

Objective 8

8. What are the hazards addressed in the **ASME CSD-1** with relation to the operation of smaller, automatically fired boilers?

UNIT A-3 GLOSSARY

Term	Definition
Automatically fired boiler	A boiler that will start and stop depending on operating conditions, unless a control in the safety circuit drops. An operator must then intervene to correct the problem before the boiler can be restarted.
Bleed valve	A valve with a small opening inside which permits a minimum fluid flow when the valve is closed.
BoHP	See *boiler horsepower*.
Boiler horsepower (BoHP)	One BoHP is equivalent to 9.81 kW (33475 BTU/h). This is the amount of energy required to evaporate 15.65 kg (34.5 lb) of fresh water in one hour under atmospheric pressure (101.3 kPa or 14.7 psi) and from water at 100°C (212°F).
Burner	Device used to mix fuel and air for combustion.
Canadian registration number (CRN)	A registration number, allotted by a provincial regulatory authority, that allows a boiler, pressure vessel, or fitting to be used in the province.
Combined feeder/cut-off device	A device that regulates makeup water to a boiler in combination with a low-water fuel cutoff.
Combustion	A rapid chemical reaction in which oxygen combines with a fuel and releases heat and/or light.
Continuous pilot	A pilot that burns without turndown throughout the entire time a burner is in service, whether or not the main burner is firing.
Control valves	Automatic or manual device used to stop, start, and/or regulate flow of gas, liquid and/or electricity.
CRN	See *Canadian registration number*.
Flame failure response time	The time between a primary safety control flame failure detection device sensing a flame is out and de-energizing the fuel system.
Flow switch	A device used to detect the flow of liquids and gases.
Fuel train	The series of pipes, valve controls, and regulators that control the fuel flow to a burner.
High pressure steam boiler	A boiler in which steam or vapour is generated at a pressure greater than 15 psig (100 kPa gauge).
Hot water heating boiler	A boiler in which no steam is generated and from which hot water is circulated for heating purposes.
Intermittent pilot	A pilot that lights automatically each time there is a call for heat. It burns during the entire period the main burner is firing.
Interrupted pilot	A pilot that lights automatically each time there is a call for heat. The pilot fuel is cut off automatically at the end of the main burner flame establishing period.
Limit control	A control responsive to changes in liquid level, pressure, flow, or temperature. It is set beyond the operating range to prevent the operation beyond design limits.
Lockout	A condition that requires a local, manual procedure to restart the equipment (see also Safety Shutdown).
Low fire start	The requirement for a burner to have its fuel and combustion air flows at their minimum respective settings prior to ignition. Burners with proven low fire start use interlock switches to prevent ignition if the fuel and air are not in low fire position.

Term	Definition
Low-pressure steam boiler	A boiler in which steam or vapour is generated at a pressure less than or equal to 15 psig (100 kPa gauge).
Low-water fuel cut-off	A safety device that will shut off a boiler if its water level becomes too low.
MAWP	See *maximum allowable working pressure*.
Maximum allowable working pressure (MAWP)	The maximum pressure a boiler, pressure vessel, or pressure piping system can be safely operated at, according to its design.
Mechanical draft	Combustion air supplied to a burner via mechanical means, such as a fan
Natural draft	Where no mechanical means is used to provide air for combustion. Airflow into the combustion chamber is the result of warm air being less dense than cool air.
NFPA	National Fire Protection Association.
Pilot burner	A small burner used to ignite a large burner.
Post-purge	Air that blows through a furnace to remove any unburned fuel that may be present after the combustion process stops.
Pre-purge	Air that blows through the furnace to remove any unburned fuel that may be present prior to lighting up.
Pressure relief valve	A safety device designed to protect a boiler, pressure vessel, or pressure piping system against pressure in excess of design pressure. This category of devices includes pressure relief valves, safety relief valves, and relief valves.
Primary safety control	A control device mainly used for detecting the presence of a flame in a burner system, and forces the shutdown of the burner in a safety shutdown. Operator intervention is required in a safety shutdown. Operator must review the problem prior to resetting and restarting a burner.
Purge air switch	A device used to prove adequate air flow during a pre-purge.
Relief valve	An automatic pressure-relieving device designed for liquid-filled vessels, such as hot water tanks. The valve opens proportionally to the vessel's increase in pressure.
Safety limit control	Is sometimes called a limit or safety circuit. This type of control will shut down a piece of equipment that is operating outside of its normal safe operating parameters. It causes a safety shutdown, requiring operator intervention.
Safety relief valve	An automatic pressure relieving device characterized by rapid opening or pop action, or by gradual opening proportional to the pressure increase, depending on the application. It may be used either for vapour or liquid service.
Safety shutdown	Shutting off all fuel and ignition energy to the burner by means of a safety control or primary safety control (*see also Lockout*).
Safety shut-off valve (SSOV)	A fast-closing valve that automatically and completely shuts off the fuel supply. This is in response to an operating limit or a safety limit.
Safety valve	An automatic pressure-relieving device actuated by the static pressure upstream of the valve. It is characterized by full-opening pop action. It is used for gas or vapour service including steam.
SSOV	See *safety shut-off valve*.

Additional Workspace

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