•••POWER ENGINEERING

Fourth Class

Edition 3.5

Introduction to Plant and Fire Safety

Part A

Unit A-4

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Partner in Education

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March 2026

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UNIT A-4

Introduction to Plant and Fire Safety

Unit Introduction

The need for operational safety of energy plants needs to be considered in all phases of their life cycle. Prior to initial commissioning, the main safety considerations focus on equipment and system design. Will the systems perform as expected? Will equipment meet the process requirements? Will the system and its equipment meet regulatory requirements? Most importantly, is the system safe?

Once a plant is in operation, however, safety considerations are expanded to address safe, on-going operation and maintenance of processes and equipment. Typical safety considerations of plant personnel may include the following areas:

- Plant operating characteristics, requirements and procedures,
- Plant system commissioning and maintenance procedures,
- Plant safety programs, and
- Plant personnel safety training including:
    - Site specific safety training
    - Dangerous materials handling
    - Site specific hazards
    - Use of appropriate personal protective equipment
    - Site specific equipment isolation procedures, and
    - Site specific fire safety and equipment.

The use of appropriately developed and properly installed technology is key to the safe and efficient operation of all plant processes. Original and replacement equipment are designed and are expected to work within original design parameters for many years. Over time, operational and environmental factors may degrade system components and their ability to respond effectively in critical situations. For example, a valve that has gradually corroded for over twenty years may not be functional during a lockout. A well thought out safety program integrates equipment and technology operation with operator understanding of conditions and hazards to protect both equipment and systems from failure.

Unit Rationale

Ongoing plant safety is the responsibility of all operations staff. Operating parameters for plant systems and equipment are most often established by design and regulatory requirements. The Power Engineers' basic responsibility lies in ensuring that plants are operated safely and efficiently, and in compliance with regulatory requirements.

A secondary but equally important responsibility is for operators to fully participate in the ongoing development and implementation of plant safety programs. The development of personal knowledge of critical regulations (such as those for handling of dangerous goods or the appropriate use of safety equipment) is an operational role to which each Power Engineer can contribute.

CHAPTER 1

Introduction to Plant Safety

Learning Outcome

When you complete this chapter you should be able to:

Describe general plant safety as it relates to Power Engineers.

Learning Objectives

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

1. *Discuss the cost and effects of workplace accidents.*
2. *Describe the basic hazards that may be in an energy plant, and the basic personal protective equipment that may be required.*
3. *Define, give examples of, and describe common power house hazards.*
4. *Describe industrial health and safety management systems.*
5. *Describe hazard assessment and control programs.*

Chapter Introduction

This chapter explores the many costs associated with workplace injuries. These costs include both the devastating physical, psychological, and social consequences for the injured worker, and the production and insurance costs for employers. Workers, supervisors, and managers are all personally impacted when a workplace injury occurs. Businesses must work to identify and eliminate workplace hazards to prevent worker injuries. Companies, workers, and society as a whole bear the consequences of unsafe workplaces.

Some of the business costs related to workplace accidents and injuries can be offset through Worker's Compensation coverage and other insurance policies. However, the larger costs associated with these incidents are difficult to measure and usually not insurable. These include:

- Lost production
- Incident investigation
- Training of replacement staff
- Damage to equipment and tools
- Potential loss of business

The human costs related to injuries include:

- Loss of life
- Chronic pain and discomfort
- Loss of income
- Retraining costs
- Loss of self-esteem
- Breakdown in personal relationships

The human cost extends beyond the injured worker to his or her family and friends as well.

Workers should expect that the tasks or operations they are to perform can be done in a safe manner. Legislative requirements and safe work procedures have been continually evolving over the years to ensure workplace safety.

Power Engineers, in recent years, have enjoyed safer workplaces due to legislation and effective workplace safety measures. Adherence to safe work procedures saves lives and prevents injuries. Impacts on workplace related injuries and safety measures are described in the following sections of this chapter.

Objective 1

Discuss the cost and effects of workplace accidents.

This chapter refers to material available from the **Canadian Centre for Occupational Health and Safety (CCOHS)**. The CCOHS describes federally legislated Acts, Codes, and Regulations that are applicable to all the provinces and territories. This information will be used as a reference for all provinces and territories, as they are similar in legislation.

Still, there are some variations between the local jurisdictions. Some differences may be identified in this chapter; however, the CCOHS is recognized as presenting a federal standard for other provincial and territorial legislation. Thus, the CCOHS material is a good primary resource for study material. Make sure to review the jurisdictional **Safety Acts, Codes, and Regulations** legislation as well.

Effects of Workplace Accidents

Financial Implications

One of the functions of the **International Labour Organization** (a United Nations agency) is to promote labour rights. It estimates that four percent of the world's gross domestic product (US $1.25 trillion) is lost due to the economic burden of work-related injuries and diseases. This cost is 20 times greater than all official development assistance to developing countries.

Canadian business is not exempt from these costs. For example, in 2011 the financial burden to Ontario businesses was more than $6 billion. Similar details are available on the various provincial and territorial **Workers' Compensation Board (WCB)** websites.

The main costs to businesses are:

- Capital Costs
- Administrative Costs
- Employee Associated Costs
- Insurance Costs
- Production Costs

Capital costs include:

- Repair of damaged equipment and machinery
- Purchase and installation of replacement equipment
- Loss, removal, and disposal of damaged raw material or product
- Site cleanup costs

Administrative Costs include:

- Incident investigation
- Dealing with inspectors and improvement order
- Filing and managing the claim process
- Managing return to work or modifying work
- Rescheduling and reassigning staff
- Replacement staff recruitment
- Developing new safe work procedures, health and safety policies, hazard awareness protocols, and job specific training

Employee Associated Costs include:

- Higher absenteeism and turnover
- More overtime to cover production shortfalls
- Wage supplements and benefits to injured workers and their families
- Wages and benefits of replacement workers

Insurance Costs include:

- Increases to Workers Compensation premiums
- Payments to Workers' Compensation for penalties or surcharges
- Increases to short and long term disability benefit premiums

Legal and Regulatory Costs include:

- Legal costs and fines
- Cost of compliance with Jurisdictional Safety and Health Department orders

Production Costs include:

- Loss of skilled productive workers
- Lower-skilled, less experienced and less productive replacement workers, resulting in lower quality product
- Reduced productivity of injured worker after returning to work
- Low worker morale, resulting in lower productivity or product quality

It is evident that the financial impact to businesses, and to the economy as a whole, is tremendous. This is why prudent businesses invest heavily to reduce and eliminate workplace accidents. The cost of the investments is far less than the cost of the accidents.

Personal Impact

Although the financial costs associated with workplace injuries are very high, they do not compare with the personal costs for a worker who gets injured. The worker often feels they are to blame for the accident. This results in loss of confidence and self-esteem, and problems with personal relationships. Although workers do not usually cause their own injuries, it is important to recognize that in many cases the worker's and supervisor's actions directly impact the situation.

The worker's attitude both before and after a workplace injury occurs has a large impact on the outcome of the incident. In some cases, a worker's attitude deteriorates. This may result in difficulties with personal relationships, and possible family breakup.

Social Implications

Because of the strain on personal and family relationships that result from workplace injuries, social programs that provide support for injured workers are necessary. The Workers' Compensation Board (WCB) provides support programs designed to help rehabilitate workers. In some cases, more help is required when workers are unable to resume their careers.

The long-term social implications of losing many workers from the industrial work force, usually at the most productive time of their careers, cannot be easily measured. Note that most injuries are among young workers in the 16 – 25 year old age group.

Legal Implications

In cases where a serious or fatal injury occurs, an Occupational Health and Safety (OH&S) officer will issue a "stop work" order. The work being carried out must be stopped until the officer conducts an investigation, and determines that no further risk of injury exists. The investigation will vary in length, depending upon the type of work being carried out and the type of injury that occurred.

The officer will want to determine:

a) Who was responsible for conditions at the site.
b) Who were the contractors involved.
c) Who was the "principal contractor" (the contractor with the most control of the worksite).
d) What were the arrangements for dealing with health and safety concerns, at all levels of responsibility.

The law usually requires that the scene of a serious accident remain untouched until an **OH&S** officer has conducted an investigation. The scene may be disturbed only if it is necessary to attend to injured workers or to prevent further injury.

The officer will conduct a thorough investigation of the scene. This usually includes:

a) Taking photographs.
b) Interviewing witnesses.
c) Talking to workers, supervisors, and management at the work site who may have information regarding the circumstances leading to the incident.

The OH&S officer has the authority under the law to look at records, diagrams, and other documents pertaining to the health and safety of workers at the site. Often, this will involve examining training records to determine if workers involved received adequate training to carry out their jobs safely.

Documents may be inspected, copied, and temporarily removed from the site for copying. These documents would pertain to:

- The safe use and maintenance of equipment
- Engineered drawings
- Plans
- Procedures
- Other related items

Rehabilitation

Finally, supervisors must understand the impact that their relationship with an injured worker can have on the worker's recovery and eventual return to work. In all cases, close communication should be maintained between the supervisor and the worker.

The supervisor must let the injured worker know that blame is not being placed on the worker, and that the company does care about the injury. The supervisor must show that the company wants to do everything possible to assist the worker to return to work as soon as possible. The supervisor should inform the worker about the progress of the investigation. The worker should be asked for assistance in determining what could be done to prevent a similar occurrence in the future.

Sometimes the worker may require assistance in rehabilitation and retraining. Management should help the worker to obtain the services and supports that are available.

Objective 2

Describe the basic hazards that may be in an energy plant, and the basic personal protective equipment that may be required.

In a plant, there are numerous hazards that may be present. Employees must be protected. The following are commonly encountered in the Power Engineer's workplace.

- Hot surfaces and substances
- Chemicals
- Mists
- Fumes
- Explosive fuels
- Pressurized piping and vessels
- High voltage electricity

Safety training must be provided, and exposure to these hazards must be reduced as much as possible. To reduce exposure to hazards, the employer must provide the employee with protective equipment.

Personal protective equipment (PPE) is designed to give the worker maximum protection for the specific part of the body for which it was designed.

The **Canadian Standards Association (CSA)** publishes standards for a variety of personal protective equipment, including:

- Protective headwear Z94.1
- Protective eyewear Z94.3
- Hearing protection Z94.2
- Respiratory protection Z94.4
- Protective footwear Z195

The various CSA standards are referred to in this chapter. If PPE meets the CSA standard, it will be clearly marked. Make sure all PPE used meets these minimum safety standards. This way workers can be assured a reasonable level of protection.

When dealing with personal protective equipment, both employer and employee have certain responsibilities. The employer must provide workers with the appropriate personal protective equipment specified for each particular job and work location. The employer shall ensure that the workers use the PPE. On the other hand, it is the workers' responsibility to wear and maintain the equipment.

Personal Protective Equipment

Industrial Protective Headwear (CSA Z94.1)

Where there is a danger of head injury, a hard hat must be worn. In most industries, this means that hard hats must be worn at all times while the worker is within plant boundaries.

Protective headwear must be assembled and fitted in accordance with manufacturer's instructions. Workers wearing hard hats should check the fit of the hardhat from time to time to ensure proper fit is maintained. Part of a fit check includes ensuring the manufacturer's recommended clearance between the head/webbing and the shell of the hat.

Workers should never paint their hard hats, because paint weakens plastic hats. For the same reason, only approved stickers or labels should be placed on hard hats. If a hard hat cracks, or has been involved in an accident, it must be replaced. In order to protect the wearer, the hard hat absorbs energy and becomes damaged. Damaged hard hats cannot absorb much energy, so they cannot protect the wearer.

The hardhat should be appropriate for the hazards encountered. In a power plant, there are electrical hazards, high temperatures, and impact hazards. The hat must provide electrical resistance and must not soften or melt in high temperature locations. The suspension is just as critical as the shell of the hard hat itself. The manufacturer of the helmet may recommend replacing the suspension more often than replacing the shell.

Figure 1 – Hard Hat

Bandanas, handkerchiefs, welders' caps, and hairnets may be worn under a hard hat, as long as they contain no metal parts, are worn smoothly on the top of the head, and do not compromise the fit of the hardhat. Baseball-style caps cannot be worn under protective headwear.

Eye and Face Protection (CSA Z94.3)

Where there is danger of injury to, or irritation of, an employee's eyes, the employer shall ensure that appropriate and properly fitting eye protection is worn. There are three different types of eye protection used. The choice depends on the type of job hazards.

Safety Glasses - Spectacles

Safety glasses protect against flying objects and particles. Some may have tints for **UV** protection. The lenses are made of shatter resistant glass or plastic. Some are designed to be worn over prescription eyeglasses. Most safety glasses are fitted with side shields for additional protection. To prevent scratching the lenses, safety glass lenses should be cleaned only with approved cleaners and wipes.

Figure 2 – Safety Glasses and Side Shields

Safety Goggles

Goggles are contoured to provide full facial contact around the eyes. This provides much better protection from:

- Flying objects
- Dust
- Mists
- Liquid splashes

There are many different types of goggles available. They should be selected according to the type of protection required. Vented safety goggles are less prone to fogging; however, they provide little protection from vapours, mists, and dusts. Where these hazards exit, non-vented safety goggles may be used.

The monogoggles shown in Figure 3 are fitted with clear acetate lenses. They are used for exposure to:

- Dust
- Fumes
- Chemicals
- Acid

Figure 3 – Monogoggles

Goggles for welders and foundry workers are like those shown in Figure 4.

CAUTION

Safety goggles do not protect facial skin except around the eyes. If full-face protection is needed, goggles can be combined with face shields.

Figure 4 – Welding Goggles

Face Shields

The third type of eye protection (which may also be classified as facial protection) is a face shield. Face shields should be used when working in areas where chemical and acid splashes are more likely to occur, and when performing operations like grinding.

Figure 5 shows an example of a face shield ready for use at a grinding station. Welding helmets (shown in Figure 6) have specialized face shields with impact-resistant lenses and special dark welding filters. These protect welders when chipping slag, grinding, or welding.

Figure 5 – Face Shields Ready at a Grinding Station

Figure 6 – Welding Helmet

Hearing Protection (CSA Z94.2)

Continuous exposure to industrial noise can result in serious hearing loss. Workers must wear adequate hearing protection when exposed to noise. The CCOHS states the occupational exposure limit for noise exposure. Hearing protection must be worn when sound pressure levels are 80 dB or higher.

The two main types of ear protection devices used in the workplace are the earmuff (Figure 7) and the earplug. The earmuff is scientifically designed to reduce harmful high frequency noise. Some earmuffs are designed to attach to hard hats, so they are always accessible to the worker.

Earplugs may be disposable or custom molded. Disposable earplugs come in various styles and sizes, to provide comfortable fit for a variety of ear sizes and shapes. For very loud environments, such as near coal pulverizers or compressors, it may be necessary to wear both earmuffs and earplugs. Hygiene is very important when using earplugs. Earplugs, if re-used, may cause ear infections.

Figure 7 – Earmuff Sound Protector

While wearing hearing protection, the worker must be able to hear voices and plant alarms. Hearing protection must not interfere with important communication.

Protective Footwear (CSA Z195)

Where there are hazards which may injure a worker's foot, the employer must ensure that the worker wears appropriate safety footwear. The footwear should provide crush protection to the toes and puncture protection to the sole of the foot. There are many types of specialized footwear available. Workers should ensure that their protective footwear is in good condition and appropriate for the job.

The Power Engineer is required to wear CSA approved steel toe footwear. Approved footwear comes in many styles. There are:

- Low profile protective running shoes
- High topped heavy duty work boots
- Rubber boots
- Winter boots

Running shoe styles are lightweight and comfortable, but offer no protection to the side of the ankle. Steel toe high top boots offer the most protection in warm, dry environments. Rubber boots may be necessary to protect feet from moisture, caustic, or acidic materials. Some boots offer additional metatarsal protection, to protect the top of the foot from impact. The majority of protective footwear has oil and acid resistant soles.

Arc Flash Protection (CSA Z462)

Arc flash is a type of electrical explosion that occurs when electrical energy passes from a high-voltage source, through the air, to a low voltage conductor. Arc flash can release an extreme amount of heat, which produces a hazardous pressure wave. Safety concerns include burns, visual impairment, deafness, and injuries from flying debris. Arc flash is rare, but Power Engineers may encounter it when operating electrical circuit breakers or disconnects.

The risk of arc flash can be significantly reduced through proper installation of electrical equipment, preventative maintenance, and reliability programs. Breakers that are not cycled or cleaned of loose dust and debris are at a higher risk of arc flash. The best protection is to limit the interaction that operators have with electrical equipment through controls and procedures.

The severity of the arc flash potential is measured in Joules of thermal energy released per centimetre squared (J/cm^2) at a particular distance from the arc flash. This value is used to select the proper PPE, which must meet or exceed the thermal energy that could be released during an incident. Arc flash clothing is rated by an arc thermal performance rating (ATPR) which is based on the same J/cm^2 measurement, as determined through an arc flash hazard analysis.

CSA Z462-18: Table 3 specifies electrical safety requirements in the workplace and includes precautions regarding arc flash safety. Flash suits, flash hoods, face shields, and gloves are examples of arc-rated PPE. The arc-rated clothing must meet or exceed the estimated incident energy potential.

Figure 8 shows an electrician with proper arc flash PPE.

Figure 8 – Operating an Electrical Disconnect Switch with Arc Flash PPE

(Mohd Nasri Bin Mohd Zain/Shutterstock)

CAUTION

Be sure to follow site specific policies, procedures, and training requirements. Consult local jurisdictional regulatory requirements regarding protection against arc flash incidents.

Other PPE used in Power Plants

PPE should protect against anything from minor scrapes and burns to major exposure to hazardous conditions.

Work Clothing

Power Engineers must wear long sleeves and long pants or coveralls in all operating areas. The clothing should be of natural or synthetic fire-resistant fibres. In many industrial sites, the clothing must have a specific "fire resistant" rating, and be branded with the letters "FR." This includes items like toques and balaclavas worn in cold temperatures.

Chemical splash outerwear provides whole-body protection against chemical exposure. When working in an area with hazardous chemicals, the Materials Safety Data Sheet (MSDS) will direct the worker as to what outerwear must be used.

Any equipment from flame retardant coveralls and reinforced wrist protectors to fire resistant body suits can be part of the PPE used on the job. A Self-Contained Breathing Apparatus (SCBA) can be implemented when the atmosphere contains harmful components. Some sealed suits have built-in SCBAs.

Safety Belts, Harnesses and Connecting Hardware (CSA Z259.1 and Z259.12)

Fall protection is required when:

a) A worker may fall 3 metres or more.

b) There is unusual risk of injury if a worker falls less than 3 metres.

Workers must remain 2 metres away from unguarded edges.

Usually, guardrails, work platforms, or scaffolds are installed to protect workers when working at heights. Whenever these fall restraint controls are not practical, workers must wear full body harnesses and **lanyards** (fall restraint ropes). The lanyard must be attached to a secure anchor point.

A lanyard may have a built-in shock absorber to cushion the shock should a fall occur. If the lanyard does not have a shock absorber, the fall must not exceed 1.2 metres. The shock absorber permits free falls of up to 2 metres.

Workers using fall arrest equipment must be trained in the following:

- Fitting
- Care
- Use limitations
- Hazards
- Inspection
- Maintenance of the equipment

Harnesses should be attached so that the harness and connecting hardware do not accidentally disconnect during use. They must be sturdy enough to handle the weight of the individual and the stresses that the apparatus may encounter during a fall arrest. All fall protection systems must be inspected prior to use to ensure that the system is adequate for the task being performed. Follow the manufacturer's inspection guidelines.

An example of a safety harness is shown in Figure 9.

Figure 9 – Safety Harness for Working at Heights or in Confined Spaces

Respiratory Protection (CSA Z94.4)

Respiratory protective equipment includes **air purifying respirators** and air-supplying equipment like SCBAs. In any workplace that may have respiratory hazards, the workers must be trained in the use and care of respiratory protective equipment. Workers must not have any facial hair that will interfere with the ability of respiratory protective devices to seal against the face. For this reason, most Power Engineers are clean-shaven.

Reasonable steps must be taken to eliminate respiratory hazards. In cases where they are still present, respiratory protective equipment must be used.

To ensure that the respiratory equipment fits properly, the user must be fit tested.

Respiratory protective equipment must be worn:

a) When airborne contaminants are in a concentration higher than the occupational exposure limits.

b) When the atmosphere contains insufficient oxygen (less than 19.5%).

Considerations

When deciding what type of respiratory protective equipment to use, the following considerations should be made.

a) The nature of any contaminants, including dusts, mists and gasses, and their concentration.

b) The need for mobility and emergency escape.

c) The oxygen content.

d) The warning properties of the contaminants (smell or colour).

e) The likely duration of the workers' exposure.

Respiratory equipment may be combined with other PPE. For example, an SCBA may be used with a total body containment, to protect the skin as well as to provide air to breathe.

All respiratory equipment requires regular inspection, testing, and verification of proper operation by qualified technicians. This type of testing can include:

a) Fit testing using capsules of scented gas to determine if the worker can smell the scent (indicating a leak).

b) Verifying that the supply air for a self-contained breathing apparatus is properly pressurized and free of contaminants.

Safety equipment should be kept in a clean and protected condition ready for use when required.

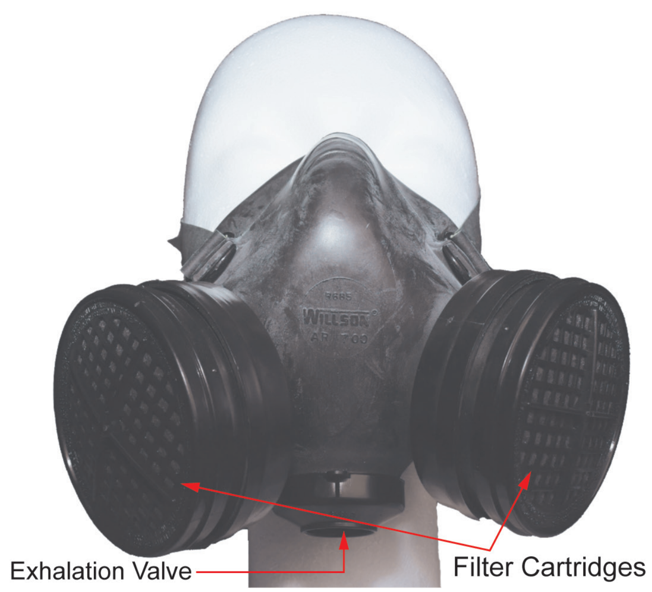
Respirators used by Power Engineers

Filter Type Respirators

There are many possible airborne contaminants at industrial sites. For example, dust generated by handling materials such as sand or sawdust can be referred to as **nuisance dusts**. They are neither poisonous under normal circumstances, nor are they capable of producing fibrous tissue in the lungs. However, they are obviously nuisances that cause discomfort.

Nuisance dusts are commonly removed with filters, which may be added to a respirator like the one shown in Figure 10. This Figure shows a half-mask respirator that can be used with a variety of filter cartridges designed to match the expected hazard.

Figure 10 – Respirator



Mineral dusts and mists containing silica, such as those from sandstone, flint, diatomaceous earth, and quartz, can turn healthy lung tissue into fibrous scar tissue. This causes a disease known as **silicosis**. A similar disease arising from asbestos dust exposure is "**asbestosis**."

Toxic dusts are poisonous. They originate from materials such as lead, arsenic, and chromium. These dusts dissolve and enter the blood stream, and they can cause injury to body organs.

Mists are wet fogs, such as air, containing oil or water droplets, which may contain toxic or lung damaging particles suspended in them. A significant mist hazard is associated with cooling tower operation. The mist from a cooling tower may contain the bacteria that causes the deadly **Legionnaire's disease**.

Most dusts and mists can be filtered from the air stream. Workers should make sure that the correct respirator filters are being used. The filter cartridges must be changed on a regular basis to ensure that maximum protection is provided. The straps of the respirator should be checked to make sure they are operating correctly and are in good condition. The sealing surfaces need to be checked for cracks and nicks which could prevent a proper seal between the respirator and the face.

Air Purifying Respirator

When work is to be done in an area where gases, vapors, or chemical fumes are present, a filter type of respirator is inadequate. Cartridges or canisters containing activated chemicals must be used. These respirators are known as "air purifying respirators," because they remove toxic gases from the breathing air. These respirators may be half-mask or full-face types. Where dusts are also a breathing hazard, air-purifying cartridges may be used in combination with filter cartridges.

All air-purifying respirators and their component parts have limitations.

a) They do not completely eliminate exposure to contaminants. However, they will reduce exposure to below hazardous levels.

b) They do not supply oxygen and must not be used in atmospheres that contain less than 19.5 % oxygen by volume.

c) They cannot be used in atmospheres that are **Immediately Dangerous to Life or Health (IDLH)**.

d) They cannot be used where chemicals have poor warning signs such as no taste or odor.

Powered Air Purifying Respirator

Powered air purifying respirators have built-in fans that filter and purify air, and deliver it to the wearer's mask. They are used in atmospheres where they may be removed without danger of inhalation injuries (due to lack of oxygen or airborne toxins). They have the same limitations as the air-purifying respirator. Their advantage is that positive pressure is maintained under the facepiece, which prevents infiltration of contaminants between the facepiece and the worker's face.

Most power plants utilize a Self-Contained Breathing Apparatus (SCBA) for this and other purposes listed below. However, welders and sandblasters sometimes use the powered air purifying respirators, especially when working inside a workshop.

Supplied Breathing Air Systems

Supplied breathing air systems must be used if:

a) Airborne contaminants cannot be filtered or handled by the air-purifying cartridges.

b) The atmospheric oxygen is below 19.5%.

These systems are designed to address specific workplace situations. They include the **Self-Contained Breathing Apparatus (SCBA)**, the **Supplied Air Breathing Apparatus (SABA)** and the **Supplied Air Respirator (SAR)**. These systems supply compressed air of breathing-grade purity to the worker.

The SCBA and SABA both use compressed breathing air in cylinders. The process of air compression causes atmospheric water to condense. This condensed water dissolves airborne contaminants, and must be removed from the breathing air.

Oil-lubricated compressors release carbon monoxide and oil mists to the compressed air. Therefore, all compressed breathing air must be dried and purified before it is bottled and delivered to the end user.

All breathing air suppliers must have the correct drying, purification and testing equipment to ensure they produce breathable air. **CSA Z180.1** code outlines the very high standards for compressed breathing air purity.

Self-Contained Breathing Apparatus (SCBA) and Supplied Air Breathing Apparatus (SABA)

An SCBA must be used where conditions at the work site are or may become immediately dangerous to life or health because of:

a) Reduced oxygen content of the air, or

b) Other contaminants that may cause acute toxic effects.

The employer must ensure that employees wear a self-contained breathing apparatus or remote supplied air apparatus that:

a) Will maintain positive pressure in the facepiece at all times.

b) Has a capacity of at least 30 minutes.

c) Provides full-face protection, where the contaminants are irritating to the eyes.

d) In the case of a remote supplied air breathing apparatus, it is fitted with an auxiliary supply of breathable air. The auxiliary supply should be of sufficient quantity to enable the worker to escape from the area in an emergency.

e) In the case of a self-contained breathing apparatus, is fitted with an audible and tactile low air alarm warning.

Some SCBAs offer the option of an air line connection to a fixed air supply, through a hose up to 100 m long. The user can use the fixed air supply or the SCBA cylinder. This allows workers to spend more time in the workspace, without being concerned about how much breathing air remains in the cylinder.

Self-Contained Breathing Apparatus (SCBA)

SCBAs are respiratory protective devices that require the wearer to carry a supply of compressed air in a cylinder. The air is regulated to the facepiece and fitted with an alarm to warn when the air supply is low. The supply air permits work to take place for short periods of time, in toxic or oxygen-deficient atmospheres.

Figure 11 shows an SCBA designed to provide extensive mobility. It can be used with either a 30 or 60 minute air cylinder, charged to 31 MPa. An SCBA equipped with a 60 minute cylinder is about 5 kg heavier than one equipped with a 30 minute cylinder.

Cylinders are aluminum pressure vessels, wrapped in fiberglass or carbon fibre for additional strength. Carbon fibre wrapped cylinders are lighter than fiberglass-wrapped cylinders, but are more costly.

The cylinder is locked into the backpack and can be easily changed without tools. This type of equipment is designed for total portability for emergency use such as isolating equipment and rescue operations. It can also be used for maintenance jobs that can be accomplished in a short time.

Figure 11 – Self-Contained Breathing Apparatus (SCBA)

The compressed breathing air leaves the cylinder and passes through a high-pressure hose to a pressure regulator. The pressure regulator supplies air at reduced pressure to a facepiece mounted pressure demand regulator. The pressure demand regulator maintains a slight positive pressure under the facepiece to keep contaminated air out. The regulator senses the pressure under the facepiece, and supplies air each time the worker inhales.

In supplying air only on demand, the regulator helps conserve the air in the cylinder. The regulator also contains a warning device to alert the user when the air supply is running low. The regulator makes a sound and vibrates, which is especially important when working in noisy environments.

The regulator has an automatic shut-off that reduces airflow while putting on or taking off the facepiece, or if the facepiece becomes dislodged. This prevents unnecessary loss of air. Some regulators have a "donning valve." By pressing this valve before donning the SCBA, the worker can stop airflow to the facepiece. Once the regulator is mounted on the facepiece, the donning valve releases breathing air as soon as the worker inhales.

Supplied Air Breathing Apparatus (SABA)

An SABA has a full facepiece supplied air respirator. It is equipped with a pressure demand regulator identical to the SCBA, connected by an air-supply hose to an air source (either a compressor or bank of large air cylinders). When connected to the air source, the respirator delivers a supply of air to the worker.

SABAs have both a supplied air respirator and small escape-sized breathing air cylinder (Figure 12). If the fixed air supply fails, the worker can switch to the escape cylinder air supply and leave the contaminated area. The escape cylinder has a low profile that does not interfere when entering or exiting tight places. This makes it suitable for entering and working in dangerous atmospheres. The airline allows for extended work activity, and can be detached quickly. The escape cylinder provides 5 to 15 minutes of emergency escape breathing air.

Like SCBAs, SABAs may be used for areas Immediately Dangerous to Life and Health (IDLH), because they have escape air cylinders. If the main supply air hose is severed or crimped, or if the air compressor fails, the air supply to the worker would also fail. Despite having small capacity, the escape bottle has enough air to allow the worker to escape to fresh air.

Supply Air Respirators (SARs) are like SABAs in that air is supplied to the worker via airline. However, SARs differ from SABAs because they do not have escape air cylinders. Therefore, SARs cannot be used in IDLH environments.

Figure 12 – Supplied Air Breathing Apparatus with an Escape Cylinder (SABA)

Training

The training of personnel who are required to use breathing apparatus cannot be overstressed. The manufacturers of the equipment provide excellent guidelines.

CAUTION

Improper use of any breathing apparatus in a hazardous atmosphere may result in injury or death. Personnel must receive adequate training prior to use.

Objective 3

Define, give examples of, and describe common power house hazards.

Hazards in a Power Plant

The first step in eliminating hazards is identifying them. The identification and elimination of hazards is the subject of **CSA Z1002 - Occupational Health and Safety - Hazard Identification and Elimination and Risk Assessment and Control**. This code provides reference material for this objective.

Some of the hazards a Power Engineer may be exposed to in the workplace are listed and described in the table below. It has been prepared with reference to **ISO International Standard 14121 Risk Assessment**, on which **CSA Z1002** is based.

Table 1 – A Partial List of Workplace Hazards

Hazard	Origin	Consequence
Mechanical hazards	• Kinetic energy – flying objects, moving machinery like overhead cranes or suspended equipment • Potential energy – objects or tools falling from heights, high pressures, falls from height, falls due to slippery surfaces • Sharp, angular parts – like exposed sheet metal • Cutting tools • Unguarded rotating equipment	• Being run over • Being thrown • Being crushed • Being cut • Severed body parts • Being drawn in or trapped • Being entangled • Scrapes, bruises • Stabs and puncture wounds
Electrical hazards	• Arcs and arc blasts • Live parts • Unsafe distance to live equipment under high voltage • Overloads • Parts which have become live under fault conditions • Short-circuits • Thermal radiation	• Burns • Effects on medical implants • Electrocution • Falling, being thrown • Fires • Projection of molten particles • Shock
Thermal hazards	• Flame • Objects or materials with a high or low temperature, like steam lines, emulsion lines, boiler venting systems and refrigerant piping • Radiation from heat sources like hot refractory	• Burns and scalds • Dehydration • Discomfort • Frostbite

Hazard	Origin	Consequence
Noise hazards	• Pump or valve cavitation • Exhaust and ventilation systems • Gas leakage • Manufacturing processes (e.g. stamping, cutting) • Grinders, crushers, and pulverizers • High speed moving equipment, like turbines • Scraping surfaces • Unbalanced rotating parts • Worn parts	• Discomfort • Loss of awareness • Loss of balance • Permanent hearing loss • Stress • Tinnitus • Fatigue • Any other hazard consequence, due to noise interfering with speech communication or with other audible signals
Vibration hazards	• Pump or valve cavitation • Misalignment of moving parts • Mobile heavy equipment operation • Unbalanced rotating parts • Vibrating tools • Worn parts	• Discomfort • Carpal tunnel syndrome • Neurological disorders • Trauma of the spine • Vascular disorders
Radiation hazards	• Ionizing radiation, from natural ground sources or radiographic testing • Low frequency electromagnetic radiation, from high voltage AC equipment • Optical radiation (infrared, visible and **ultraviolet**), including laser and weld flash • Radio frequency electromagnetic radiation	• Burns • Damage to eyes and skin • Effects on reproductive capability • Genetic mutation • Headaches, insomnia
Material/ substance hazards	• Aerosols • Biological and microbiological (viral or bacterial) agents, from cooling tower water or biological contactors • Combustibles • Dusts • Explosives • Fibres, such as asbestos or silica bearing materials • Flammable vapours and gases • Fumes • Toxic gases, such as H_2S • Mists • Oxidizers • Refrigerants	• Breathing difficulties, suffocation • Cancer • Corrosion of skin • Effects on reproductive capability • Explosions and fires • Infections • Burns • Frostbite • Mutations • Poisoning • Sensitization

Hazard	Origin	Consequence
Environmental Hazards	• Dust and fog • Lightning • Moisture • Pollution • Snow or hail • High or low temperature • Water and ice • Wind • Lack of oxygen	• Burn • Sunburn • Frostbite • Sickness • Slipping, falling • Suffocation
Ergonomic hazards	• Poor access • Design or location of indicators and visual displays units • Design, location or identification of control devices • Effort to perform a task • Inadequate lighting - flicker, dazzling, shadow, stroboscopic effect • Mental overload • Posture • Repetitive activity • Poor visibility	• Discomfort • Fatigue • Musculoskeletal disorder, such as carpal tunnel syndrome • Stress • Human error

As can be seen, there are numerous hazards in a power plant that need to be identified and mitigated. The previous table is not exhaustive; many other hazards may be added to the list. Also, real workplace hazards are usually combined hazards, where multiple hazards increase the overall hazard. Every situation is unique.

Side Track

There is a wide range of working conditions that the Power Engineer can be exposed to, depending on the type of occupation.

For example, in a pulp and paper mill, conveyors transfer hog fuel (wood waste) to the boiler. Some hog fuel falls off the conveyors. Crews, using shovels and pitchforks, place the fuel back onto the moving conveyors. There is a serious risk that tools or workers may get caught in the conveyors.

As well, black liquor recovery boilers may momentarily lose ignition and then re-ignite, causing a momentary pressure rise in the furnace. The result is that fire and burning particles of fuel can “blow back” through observation ports, smelt spouts and burner nozzle openings. An unsuspecting operator could be burned during such an excursion.

All boilers are explosive containers. Even in small commercial buildings, schools or hospitals, hot water and steam boilers may explode – either through the expansion of water into steam, or from the explosion of the fuel used to fire the boiler.

A special requirement for implementation of safety measures should fit the special conditions, such as those encountered when working in a plant. Power Engineers will find themselves working in environments such as described above that are not in other professions’ responsibilities.

Objective 4

Describe industrial health and safety management systems.

Health and Safety Management Systems

Jurisdictions across Canada require worksites to develop health and safety management systems to reduce workplace related injuries and illnesses. Key components for the successful implementation of the system are the commitment, leadership, promotion, and support of the management teams in the organization.

To demonstrate this, an effectively written site-specific policy must be established. It has to provide clear guidelines of the health and safety expectations of the organization. The policy should include:

a) Stated commitment of the management on health and safety for all those working in the organization.
b) Clearly defined goals and objectives of the health and safety program.
c) Clearly stated compliance requirements with local jurisdictional legislation and the health and safety standards of the organization.
d) Clearly defined roles and responsibilities for management, workers, contractors, and visitor while at worksite.

The following are some of the general examples of roles and responsibilities at a worksite.

Health and Safety is Everyone's Responsibility

The Workplace Safety and Health Act supports every worker's right to a safe and healthy workplace. It reinforces the idea that workplace injuries are preventable. To prevent injuries, everyone at the workplace needs to recognize their responsibilities for health and safety at the worksite.

All members of a workplace should remember workplace safety is everyone's responsibility.

Worker Responsibilities

Every individual at the workplace has a personal and shared responsibility to prevent occupational injuries and illness. Workers are responsible for their own actions or inaction.

This involves all workers:

a) Taking reasonable care to protect themselves and others who may be affected by their actions or omissions.
b) Properly using safety equipment, clothing, and devices.
c) Following safety and health rules and safe work procedures at the workplace.
d) Co-operating with the workplace safety and health committee or representative.
e) Co-operating with other people on workplace safety and health matters.

Employer Responsibilities

Because they have the greatest degree of authority and control over the workplace, employers (the company or organization that hires workers and oversees the supervisors and management team) have the greatest degree of responsibility for workplace safety and health.

Employers' legal safety and health responsibilities include:

a) Taking necessary precautions to ensure the safety, health, and welfare of workers.

b) Providing and maintaining a safe workplace, including equipment, tools, and systems.

c) Ensuring all workers and supervisors are aware of hazards in the workplace, as well as precautions necessary for protection.

d) Providing workers with competent supervision.

e) Providing training necessary to protect workers' safety and health before they begin a new job.

f) Taking precautions to ensure others are not exposed to workplace safety or health risks.

g) Consulting and co-operating with the workplace safety and health committee or representative.

h) Co-operating with other people on workplace safety and health matters.

Supervisor Responsibilities

Statistics show the majority of serious incidents occur during a worker's first year on the job. Supervisors play an important role in training workers and acting as a resource so incidents can be prevented.

A supervisor is any person who has authority over a worker, is in charge of a workplace, implements management policies, or directs the work of others. Supervisors oversee workers and legally must ensure:

a) All precautions are taken to protect the safety and health of workers.

b) Workers understand and follow the safe work procedures for their job duties, and use proper safety equipment, clothing, and devices.

c) Workers are advised of safety and health risks in the work area and are trained before working with new/updated equipment or starting a new task.

Joint Workplace Health and Safety Committee

A critical element of the management commitment to worksite health and safety is to establish a functional Joint Workplace and Safety Committee. The committee membership consists of personnel representing every part of the organization. The primary purpose of this committee is to promote active participation to address health and safety issues and concerns. This includes setting site-specific health and safety policy.

Functions and Responsibilities of the Joint Health and Safety Committee

Committees and representatives have specific responsibilities for safety and health matters at the workplace. The following are included in the legal duties of Workplace Safety and Health Committees and representatives.

a) Make safety and health recommendations to the employer, including committee training.

b) Deal with the safety and health concerns of the workers.

c) Co-operate with workers, supervisors, and employers on safety and health matters.

d) Participate in developing and promoting safety and health precautions, as well as education and training programs.

e) Conduct regular workplace inspections to proactively identify potential hazards, and confirm effective hazard controls are in place or implement new ones.

f) Participate in incident reporting and investigations.

Incident Reporting and Investigations

It is important to report all incidents related to health and safety, including those that do not result in worker injury. Incidents without injuries are referred to as "near misses." Most worksites have clearly defined incident reporting policies and procedures for actions and documentation. The incident reporting is normally initiated by the person involved in the incident or an observer of the incident, particularly with a "near miss" situation.

After an investigation, the incident process begins and must follow the worksite policies and procedures. A trained safety supervisor often leads this process. Others that may also participate in the process include:

- Managers
- Supervisors
- Joint Workplace Health and Safety committee members
- Those with specialized investigation training

In Canada, all worksites must have incident reporting and investigating policies and procedures that are in compliance with the local jurisdictional requirements. Always consult and follow worksite policies and procedures.

Worksite Health and Safety Administrative Program

A Health and Safety Management System needs to be effective. There must be administrative procedures in place to record, track, maintain, and communicate information.

- Inspection records
- Incident reporting and investigation records
- Safety meeting minutes
- Employee training records

The information can also be useful for trending measurements. This can help to determine overall workplace health and safety performance.

a) Leading indicators – these measure the initiatives taken by the organization to reduce health and safety incidents.

b) Lagging indicators – these help to analyze the frequency, type, and severity of health and safety incidents took place.

The data collected is useful for both internal and external audits. It indicates the overall effectiveness and the regulatory compliance of the Worksite Health and Safety Management System.

Objective 5

Describe hazard assessment and control programs.

Hazard Identification and Assessment

Hazard Identification and Assessment Process

A good hazard identification and assessment process is key to create an effective Health and Safety Management System. Canadian Occupational Health and Safety legislation requires employers to identify and assess the existing and potential hazards in a worksite before any work starts.

The data collected from the hazard identification and assessment can be useful to develop Health and Safety Management Systems. This data

- Forms the basis of a Worksite Inspection checklist.
- Identifies the critical areas required for an Emergency Response Plan.
- Helps the Incident Investigation process by determining whether the incident is the cause of the system failure.
- Helps to determine the requirements for job-specific training, and health and safety orientation for new and returning workers.

1. Hazard Identification

Hazards at a worksite are generally divided into two categories:

1. Safety hazards that can cause worker injury. For example, icy footpaths can lead to trips and falls.
2. Health hazards that may produce long-term health effects. For example, noise can produce gradual long-term hearing loss.

CSA Z1002 outlines hazards, hazard identification and hazard assessment procedures. Refer to Table 1 for samples of workplace hazards that must be identified.

2. Hazard Assessment

There are many types of hazard assessments. Some are directly related to a job or task, some to a process, and some to operations. The key is to realize that hazards are everywhere. Some hazards can be eliminated, whereas others need to be mitigated through training.

Brief descriptions of the two categories of hazard assessments that are common to the workplace follow below. They include general steps in conducting the assessments.

2a. Formal Hazard Assessment

The formal hazard assessment is a process that identifies potential hazards and levels of risk associated with all job tasks performed at a specific worksite. This process provides critical information for the implementation of controls for the hazards and risks identified.

The information collected is documented within the Health and Safety Management Administrative Program and on the worksite. Specific **Standard Operating Procedure (SOPs)** are created for each job task.

Formal hazard assessment – general steps (with alignment to the SOPs process).

1. Establish an inventory of all job tasks performed by workers at the worksite.
2. Identify potential hazards and risks associated with each job task.
3. Determine control methods to eliminate, remove, and reduce hazards and risks associated with the specific job task.
4. Update, review, and re-assess whenever there is a change or a scheduled review of the SOP associated with the specific job task.

2b. Field Level Hazard Assessment

Field level hazard assessment is conducted just before work begins. Often this is done as part of the **Safe Work Permit (SWP)** process. The following are the general steps for conducting the assessment:

a) Workers perform the job task to identify potential hazards. This takes place just before work begins, especially if working under new and unfamiliar environments.

b) Hazards that have been identified and assessed must be eliminated. Risks are controlled and managed to a safe level before work begins.

Many worksites employ Hazard Identification Cards to support the hazard assessment process. Workers are encouraged to report unsafe work practices and conditions they have observed at the worksite. The report along with suggestion for improvements can be recorded on the card and dropped off in a suggestion box. The suggestions and ideas are then reviewed and, if required, implemented in a timely manner.

3. Job Safety Analysis (JSA)

In addition to the field level hazard assessment, the **Job Safety Analysis (JSA)** process provides the following:

- Identifies the hazards and risks of specific jobs
- Evaluates the potential hazards
- Determines the safest way to do the work

JSAs are also known as Job Hazard Analyses or Job Hazard Breakdowns. A JSA focuses primarily on the health and safety aspects of a job. Often operators experienced in the JSA process are involved in the development of standard operating procedures (SOPs) to ensure job tasks are done correctly and safely.

There are great benefits to doing a Job Safety Analysis. While performing a JSA, safety committee members and skilled operators both discuss and observe the actual job, to uncover and mitigate the many hazards. Once developed, the JSA becomes a useful standardized training tool for supervisors to direct the employees performing a task. Safe Work Procedures are developed directly from JSAs. In the case of an accident, the JSA can be referred to in an investigation.

There are four basic steps in conducting a JSA:

1. **Rank jobs according to their hazards.** This step is called a risk analysis. Workers and management list all the jobs that workers do. Then the most critical jobs are ranked. Critical jobs are ones that:

   a) Are done most often.

   b) Have a high probability for accidents to occur.

   c) Have severe consequences if an accident does occur.

   Jobs that are done infrequently, have changed in procedure, or are new jobs are also potentially hazardous. The JSAs are completed for the most critical jobs first. All jobs must be examined.

2. **Identify the job steps**. Each job should have no more than 10 basic steps, listed in the order that the actual job is performed. For example, the basic steps in starting up a Boiler Feedwater Pump are shown in left column of Table 2.

3. **Identify potential hazards**. All hazards are listed in the JSA beside the job step, under "Potential Accidents or Hazards."

4. **Determine Preventative Measures**. Eliminate or control the hazards that were identified in the job action. These are listed beside the job step and the related hazard. There are a variety of ways to implement preventative measures.

   a) **Eliminate the hazard.** Redesign the equipment, modify the process, lockout, and de-energize the equipment that is creating the hazard.

   b) **Contain the hazard.** Install temporary shielding, install guards and covers.

   c) **Revise the work procedures.** Change the process, implement extra measures (some plants that have presses will not allow the press to operate until the operator has each hand on two buttons separated from each other).

   d) **Reduce the exposure.** The last line of defense, but effective – use required PPE, install eyewash fountains, create walkways to navigate around equipment, install platforms and guardrails.

It is interesting to note that for three similar pumps there could be three significantly different procedures, depending on the type of hazards unique to each pump. One pump could be close to a traffic area and at risk of exposure to mobile equipment. Another one farther away could be difficult to access without a work platform.

The procedures listed in Table 2 were adopted from guidelines set by the **Canadian Centre for Occupational Health and Safety.**

Table 2 – Example of Chart of JSA for Feedwater Pump

	Sequence of Events	Potential Accidents or Hazards	Preventative Measures
i	Evaluate area prior to performing start up	Unintended exposure to heat, hot water.	Verify area is clear, equipment connected securely.
ii	Close drain and vents (if open)	Spray with hot water if open.	Close drain. Vent before opening inlet/outlet valves.
		Possible exposure to hazardous elements due to previous work activities not completed.	Inspect and repair as required all valves, fittings, lines, etc. for safe configuration.
		Pump could start up remotely from control room, surprising operator performing tasks.	Prepare for possibility of pump start, also de-energize breaker if practical.
iii	Open inlet valve	Exposure to hot water from leaking packing.	Stand slightly off to the side while opening.
		Strain/scrape while opening valve	Wear gloves, safety glasses, use proper wheel wrench.
iv	Open outlet valve	Same hazards as opening inlet valve.	Same preventative measures as opening inlet valve.
v	Open minimum flow control valve	Same hazards as opening inlet valve.	Same preventative measures as opening inlet valve.
vi	Prime pump if necessary	Hot water spray.	Wear gloves, safety glasses.

	Sequence of Events	Potential Accidents or Hazards	Preventative Measures
vii	Energize breaker	Remote possibility of electrical hazard when energizing breaker.	Look away (to avoid electrical flash). Breathe out (so as not to be surprised and breathe in possible fumes generated). Use 'other' hand to close breaker (just in case door blows open) to prevent damage to primary hand. Stand out of possible 'swing range' of door.
viii	Press start button	Jumping at start due to noise, vibration, jarring.	PPE, be prepared for surprise, have finger hovering over stop button for quick stop.
ix	Observe operation of pump	Hot water leaks, heat.	Wear PPE, stand back.

4. Hazard Control

The methods used to control potential work related hazards are based on the data collected by hazard identification and assessments. Canadian Occupational Health and Safety legislation requires employers to take reasonable steps to eliminate or control identified hazards to make the workplace safe.

To ensure the safety of the workers, exposure to hazards must be eliminated or controlled. This is done in three ways. They can be used separately or in combination.

1. Engineers can design new equipment or modify equipment designs to make them safer.
2. Supervisors can ensure that only trained and certified employees do work that requires specialized training.
3. If a hazard cannot be completely eliminated or controlled by design or workforce management, personal protective equipment (PPE) must be used to reduce exposure to workplace hazards. All workers must always use their assigned PPE for the specific job task. It is the worker's last line of defense for safety in a workplace.

Hazard controls are developed by using the information collected from the hazard assessment process. This usually starts with the job tasks that have the greatest risk potentials to the workers. Then, the best possible controls for the identified hazards are determined.

Some of the best resources are the experienced workers who are the most familiar in performing the job tasks. Their knowledge and understanding will greatly benefit the development of control measures and encourage the acceptance of other workers. Often these same workers are the ones driving the implementation of the change by submitting a request for engineering controls through design and modification.

Hazard re-assessment is performed after controls are fully implemented to assess the safety of the controls. Review and further assessment are scheduled at acceptable intervals. These include inspections and preventive maintenance scheduling to ensure established controls are sound and adequate.

Chapter Summary

In conclusion, power plant employees should be aware of all conditions affecting workplace safety. They should be appropriately trained to do the job tasks safely. This requires that Power Engineers recognize and report workplace hazards, follow safe work procedures, and ensure the use of PPE for the safety of all plant workers.

The goal is for all workers to have safe shifts.

CHAPTER 2

Plant Safety Programs

Learning Outcome

When you complete this chapter you should be able to:

Describe common safety programs generally applied in plants.

Learning Objectives

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

1. *Describe common occupational health and safety (OH&S) programs found in most plants.*
2. *Describe industrial safety programs in which Power Engineers may require additional training.*
3. *Discuss safe work permits.*
4. *Describe methods of equipment isolation and lock out.*

Chapter Introduction

Plant Safety Programs

Overview

Plant safety programs include both general programs found in every jobsite, as well as some site-specific programs. Federal, provincial, and territorial law require these safety programs to be in place. Central to this legislation are the **Occupational Health and Safety** programs described in this chapter. Each jurisdiction has safety and health legislation similar to the federal regulations.

This chapter identifies the general elements of occupational, health, and safety programs used in most industrial plants. These include some of the common safety programs specifically designed to address the workplace activities with the associated risks and hazards.

The Canadian Centre for Occupational Health and Safety (CCOHS) website (www.ccohs. ca) provides extensive information regarding guidelines and requirements for safe work. The CCOHS rules and guidelines, combined with safety standards written by the **Canadian Standards Association (CSA)** and jurisdictional requirements, provide the basis of plant work safety programs.

Objective 1

Describe common occupational health and safety (OH&S) programs found in most plants.

Occupational Health and Safety (OH&S) Program

An occupational health and safety program in a workplace can be defined as an organized plan of action to:

- prevent work related accidents and occupational diseases,
- respond to emergencies, and
- proactively identify and control hazards.

Many industrial plant sites have their own specific health and safety program focuses and requirements to meet their particular needs. The following are the general elements commonly found in most health and safety programs.

Establishment of Site Specific Occupational Health and Safety Policy

This policy expresses a company's committee to its employee's health and safety, and guides the company's actions. Clearly defined objectives include:

a) Employees understanding of their right to refuse unsafe work.

b) Accountability and Responsibility of Management and Employees.

c) Orientation training for new and returning employees.

d) Safe work and emergency procedure development and training.

e) Process and procedure for accident and incidents reports, audits, and investigation.

f) Process and procedure for risk assessment, hazard identification, and control.

g) Regular and active promotion of workplace Health and Safety.

h) Medical aid, including first aid facilities provision.

i) Other health and safety requirements specific to the worksite.

Establishment of Joint Occupational (Workplace) Health and Safety Committee

It is recommended that a joint health and safety committee be established. The committee must consist of members from both workers and management.

The **Canadian Labour Code PART II - Occupational Health and Safety** describes the duties and responsibilities of the Workplace Health and Safety Committees. The following is based on the Canadian Labour Code.

Workplace health and safety committees must be established in any workplace under federal jurisdiction, where there are 20 or more employees. Some of the many duties of the committee are listed below.

a) Consider and quickly resolve health and safety complaints.
b) Participate in all of the inquiries, investigations, studies, and inspections that pertain to employee health and safety.
c) Participate in implementing and monitoring a program for the provision of personal protective equipment, clothing, devices, or materials. If there is no policy committee, participate in the development of the program.
d) Participate in planning and implementing changes that may affect occupational health and safety, including work processes and procedures.
e) Inspect all or part of the workplace each month, so that every part of the workplace is inspected at least once a year.

Employees appointed to the workplace health and safety committee must receive training and compensation for participating in meetings and carrying out their duties. The safety meetings consist of equal representation of management and workers.

Emergency Response Plans

Emergency procedures need to be created to deal with potential threats from fire, hazardous spills, hazardous leaks, or hazardous actions. These following points must be included in these procedures.

a) A plan for an emergency evacuation of personnel. Provisions are to be included for those requiring special assistance.
b) A full description of the emergency procedures that are to be followed.
c) The location of emergency equipment in the plant.
d) The name and address of the owner of the building.
e) Designated evacuation routes and muster areas (gathering places).
f) Training, responsibility, and location of Wardens. Designated employees serve as Wardens during an emergency. They may be in charge of specific areas, such as a floor of a large building or a lab area. If necessary, they will assist and direct the evacuation toward the assigned muster area.
g) Emergency evacuation drills must be carried out at least once a year. Records of the drill are to be kept on file. The local fire department and emergency services should be notified prior to the drill.
h) Bi-annual safety inspections. These inspections are done to make sure fire escapes, exits, stairways, and fire equipment are all in working order. Inspection records must be kept for two years.

Site Specific Safety Training Requirements

The elements of occupational, health and safety programs discussed above apply to basic general requirements at most plant sites. In addition, specialized safety training is required to address site-specific needs. Some examples of site-specific training will be discussed in the next few objectives.

Objective 2

Describe industrial safety programs in which Power Engineers may require additional training.

General Industrial Safety Programs

The following specialized safety trainings are usually provided by external certifying organizations. However, this training is often followed up with company-based training to further reinforce the skills and competency of the employees. Listed below are some of the common specialized trainings for a plant site.

1. Confined Space Entry (CSE)

The **Canadian Occupational Health and Safety Regulations SOR 86-304** (federal regulations) define a **confined space** as an enclosed or partially enclosed space that:

a) Is not designed or intended for human occupancy except for the purpose of performing work
b) Has restricted means of access or egress
c) May become hazardous to any person entering it due to:
   i. its design, construction, location or atmosphere
   ii. the materials or substances in it
   iii. any other conditions relating to it

Power Engineers are likely to encounter confined spaces such as:

- Deaerators
- Condensate Tanks
- Boilers
- Air Receivers
- Expansion tanks
- Ducting
- Stacks
- Other vessels that are used in operations

These vessels are regularly shut down for maintenance and possibly unscheduled events that involve entry for inspection and repair. A written and documented confined space entry program is required, outlining entry requirements and procedures including the use of a CSE Permit.

2. Workplace Hazardous Materials Information System (WHMIS)

WHMIS is a Canadian hazard communication system. The key components of WHMIS are:

- Hazard classification
- Labelling requirements
- **Safety data sheets (SDS)**
- Worker training and education programs

Additional training is required for all workers dealing with potential hazardous products at a work site.

WHMIS has transitioned from WHMIS 1988 to WHMIS 2015. WHMIS 2015 incorporates the **Globally Harmonized System (GHS)**. Please consult with a qualified training provider for up-to-date training and information.

3. Transportation of Dangerous Goods (TDG)

Transport Canada first developed the **Transportation of Dangerous Goods (TDG) Act** in 1992. It also enforces these safety acts and regulations. The focus of the TDG regulations is on the safe transport of goods. It does not address how goods are used in the workplace.

Proper packaging is important in order to maintain the safety of those moving and handling the goods. The **TDG Acts and Regulations** are under Canadian (federal) jurisdiction, and are adopted by all provinces and territories.

The employer, and therefore the Power Engineer, will receive hazardous goods transported to the worksite according to TDG regulations. Part of the TDG regulations is that anyone transporting, shipping, or receiving dangerous goods covered by the regulation must have proper training.

A Power Engineer may be required to receive or ship dangerous goods in the form of fuels, chemicals, or other goods for the plant. Employers must ensure workers who ship or receive dangerous goods are trained and certified.

4. Fall Protection

If a worker is at risk of falling at a height of 3 metres or more, fall protection equipment must be worn and additional training will be required. (Please note: some companies and jurisdictions have more restrictive height requirements. If in doubt, always chose the stricter standard.)

Fall protection is usually in the form of an approved harness and securing device. In the event that the employee is required to work where this is not practical, the employer will endeavor to provide all means necessary to reduce the possibility of a fall. This could include:

- Performing job safety analysis
- Proper training
- Hazard elimination, if possible

5. Fire Safety

Canadian national, provincial and many municipal governments require building and industrial facility owners to develop a fire safety plan for each building and plant. A fire safety plan's main purpose is to enhance and maintain the safety of a facility or plant with respect to potential fire threats by assessing a site for fire risks, developing measures to address potential fire issues, and formalizing responses to fire-related incidents.

The list of required measures will vary by jurisdiction but a fire safety plan may be required to include some combination of the following list required by Ontario's **Office of the Fire Marshal for Industrial Occupancies (OFM-TG-02-2000)** which recommends a ten step process:

1. Conduct a fire safety audit.
2. Appoint and organize supervisory staff.
3. Develop site specific emergency procedures
4. Conduct fire drills and develop training procedures
5. Maintain building facilities fire protection equipment
6. Provide alternate measures for temporary shutdown of fire protection equipment or systems
7. Control fire hazards
8. Provide Fire Department access to fire fighting and fire suppression information
9. Prepare and schematic diagrams and site plans
10. Post emergency procedures and emergency phone numbers.

6. H_2S Awareness

The **Canadian Center of Occupational Health and Safety (CCOHS)** describes **hydrogen sulfide (H_2S)** as a very dangerous gas. It is prevalent in varying concentrations in:

- Oil and gas fields
- Septic tanks
- Manure pits
- Anywhere bacteria can break down organic matter in an oxygen deficient environment

Coal miners refer to the H_2S found in coal mines as "stink damp." In Western Canada, H_2S is produced and liquefied for use in the nuclear power industry for the production of heavy water. H_2S is shipped to Eastern Canada in pressurized tank cars in its liquid state.

H_2S is a byproduct of many industries. For example, it can be produced when sulfuric acid is accidentally mixed with black liquor in pulp mills.

Hydrogen sulfide is an extremely poisonous substance. It is normally encountered as a gas or vapor. Numerous deaths have occurred over the years as a result of exposure to H_2S. Some deaths were caused by falls sustained when workers were overcome by gas. Other deaths resulted from suffocation by brief exposure to the gas.

Proper training is required for employees working in areas that have the potential of H_2S exposure. Training must be either the minimum **H_2S Aware**, or the **H_2S Alive** which includes rescue procedures and the use of self-contained breathing apparatus (SCBA).

7. Ground Disturbance

There are many surprises in the ground, and they can show up when digging trenches or foundations. Provinces and territories have implemented programs regarding the importance of reducing hazards related to ground disturbance. Specialized ground disturbance training and certification is necessary.

Below are examples of what could be buried under a proposed excavation site.

- Natural gas service lines
- Oil pipelines
- Electrical wires
- Telecommunication wires
- Water lines

As well, workers in a trench face the hazard of engulfment.

There are a number of related municipal, provincial, and federal regulations. A Safe Work Permit for trenching and digging work must also include a Ground Disturbance Permit. The Ground Disturbance Permits are only issued to qualified workers with the appropriate training.

8. First Aid Program

According to the **Canadian OH&S Regulations**, every employer shall establish written instructions that provide quick first aid to an employee with an injury, occupational disease, or illness. These instructions must be kept up to date.

a) If there are six or more employees (four in some provinces) working at the same time, the employer will ensure that there is a first aid attendant. At least one of the employees must have the necessary training to provide resuscitation by mouth to mouth, cardiopulmonary, or an equivalent direct method.

b) Qualified first aid attendants will be available for employees during their work hours. These attendants are in charge of first aid cases, and cannot be overruled by others.

c) The first aid room will be stocked with supplies. The room should be comfortable and well lit.

d) Signs will be posted to direct employees to first aid stations and rooms. The information can also be available on phones for the employees to access services.

e) Eyewash facilities and showers will be provided if there is a risk of injury from hazardous substances. (There can be numerous chemicals in a plant.)

f) The employer has to ensure that transportation to a medical treatment facility is available if needed. This would include an ambulance, which is accessible in a city, or a helicopter in a remote region.

g) In most plants, all Power Engineers are trained in first aid to some level. Power Engineers usually work shifts, and there may not be a trained First Aid attendant available to help with emergencies except on day shift.

9. Asbestos Abatement

Asbestos is an excellent insulation and is found in older power plants built before asbestos regulations were implemented. Asbestos was used to cover tanks and piping, and as a part of building materials. It was applied to numerous surfaces and products regularly in the early part of the 20th century before it was discovered to be a health hazard.

The fibres of asbestos can be described as having "hooks" in them that attach to the lungs when inhaled. These fibres impair the lungs and cause scar tissue, asbestosis, and other forms of pulmonary distress. As a result, asbestos abatement programs must be in place in any plant having used asbestos.

If the asbestos in a plant is not considered a safety hazard, it does not require removal. In Canada, the use of asbestos is prohibited for new construction. However, plants that had it installed before the ban was implemented do not need to remove it, provided it has been rendered inert, and poses no threat in its present condition. Often, this is accomplished by painting or covering the piping or tank and "sealing in" the asbestos.

The presence of asbestos must be clearly identified in a recognizable manner.

- Tags affixed to the insulation
- Paint
- Painted symbols
- Labels

Any renovations, movement, or other manner of disturbing the asbestos must result in the removal of that asbestos. Any small areas damaged, or any detected wear or abrasions to asbestos insulation during regular work operations, must be addressed immediately by government certified trained insulators.

In small organizations, asbestos abatement contractors are called in. Larger plants may have some employees trained in the removal or repair of asbestos material.

Plant employees must be trained to not disturb the asbestos in any way. This training must include direction regarding regular operations around asbestos. For example, care must be taken to not cause damage by abrasions while working with tools. As well, piping covered with insulation cannot be used for the placement of ropes or slings used for hoisting, or for resting ladders.

Even the smallest amount of exposure to asbestos is considered a significant safety issue. As a result, when there is a possibility of exposure, serious safety steps must be taken.

Objective 3

Discuss safe work permits.

Safe Work Permits

Note: Specialized internal training is required for both safe work permit receivers and issuers. Please consult site-specific training requirements.

Safe work permits (SWPs) are designed to ensure potentially hazardous work can be carried out safely. A safe work permit is a written agreement between the worker performing the task and the person issuing the permit. No SWP is issued before dissipating and locking out all energy related to the scope of work. The SWP attempts to identify any risk associated with a job, and specifies the control measures needed to mitigate the hazards. These control measures may include:

a) Lockout requirements
b) Atmospheric testing
c) PPE requirements
d) Safety watch
e) Means of summoning help
f) Additional permits required
   - Confined space
   - Hot work
   - Excavation (ground disturbance)

The workers performing the job, and the company representative authorized to issue the permit, review the SWP. The authorized permit issuer is often a Shift Engineer or Assistant Shift Engineer. After reviewing the permit and agreeing to its terms, the permit issuer, the permit holder, and the workers doing the job sign and date the SWP. The signed SWP is then a legal agreement on the safety steps that will be used on the job.

The permit, or associated permits, are issued for a job of a certain scope, and for a particular duration. If the scope of the job changes, or if the work lasts longer than the duration stated on the permit, a new SWP must be issued.

The type of safe work permit required depends on the scope of the work and the potential hazards of the job. This includes hazards present while preparing to do the work. With this in mind, a single SWP does not address all possible work situations.

Often, the permits listed below are specific amendments to a more general SWP form. Following are some of the common types of safe work permits used in industry with a brief description of each of the common types.

1. **Cold Work Permit**
   a) For general maintenance work that does not produce an ignition source.
2. **Hot Work Permit**
   a) Work produces a direct ignition source such as welding, metal grinding, the use of cutting torches, and electric drills.
   b) Work produces an indirect ignition source. This could involve flashes from a camera, mobile phone, laser pointers, and other electronic devices that are not **intrinsically safe**.

3. **Confined Space Entry Permit**
   a) Work requires personnel to enter a confined area such as a vessel, tank, silo, sump, or sewer.
4. **Excavation (Ground Disturbance)**
   a) Any activity disturbing the ground. Can include digging, trenching, post pounding, tunneling, and drilling at or exceeding 30 cm in depth.

Issuing a Permit

The permit issuer's responsibilities are:

1. Inspect the work area.
2. Identify potential hazards.
3. Detail the safety precautions required.
4. Understand and apply safe work practices.
5. Set working conditions within the scope of work.
6. Review work and safety precaution requirements with the permit receiver (person or persons doing the work).
7. Detail completion expectations and requirements with permit receiver.
8. Issue the permit.
9. Stop workers if safe work procedures are not being followed.
10. Inspect area after work is completed before signing off.

Receiving a Permit

The permit receiver's responsibilities are:

1. Understand the scope of work and job requirements.
2. Understand potential hazards and safety precautions.
3. Sign and accept the permit, and keep permit on the jobsite.
4. Work safely by following site and job specific safe work procedures.
5. Complete work as per agreed job expectations and requirements.
6. Return work permit after completion of work to permit issuer/safety office.

Contents of a Safe Work Permit

Listed below is some of the information contained in a general safe work permit.

Note: This is a general guideline only. Various jurisdictions and worksites may have specific requirements not listed here.

1. Date and time the permit is issued, and when it expires.
2. Specific location of the work. (Building, level, process area, some description of the area.)
3. Description of the work (the scope).
4. Number of workers involved, including the name of any external company or internal department.
5. Communication method (e.g. two-way radio).
6. Potential hazards.
7. Personal protective equipment requirements.
8. Job site preparation check list.
9. Safety precautions.
10. Atmospheric Testing (for Hot Work Permit).
11. Authorization and signatures for Permit Completion.

Figures 1 and 2 are samples of the front and back of a General Safe Work Permit sheet.

Figure 1 – Example of a General Safe Work Permit – Front of Sheet

General Safe Work Permit

Permit Number:	Issued by (Print name):	Signature:
Date Issued:	Time Issued:	Expires On:

Note: All information to be completed by permit issuer

A. Scope of Work

Check relevant boxes to indicate type(s) of work required to complete task.

☐ Cold Work

Complete additional required permits for any of the following tasks:

☐ Hot Work ☐ Excavation (Ground Disturbance) ☐ Confined Space Entry

Work Location:		
Work Description:		
Company or Dept. doing work:		# of workers:
Two-Way Radio Assigned: ☐ Yes ☐ No	Unit #:	Channel #:

B. Potential Hazards

Check applicable potential hazards listed below. Check Other and list additional hazards identified:

☐ Flammable
☐ Explosive Atmosphere
☐ Corrosive Chemicals
☐ Potential Health Hazards
☐ High Temperature
☐ Process Hazard Overview Location
☐ Harmful to Breathe
☐ Process Hazard
☐ High Pressure
☐ Extreme Heat Working Conditions
☐ Harmful by Skin Contact
☐ Extreme Cold Working Conditions

☐ Other (please specify)______________________________

C. Personal Protective Equipment (PPE)

Check required PPE from the list below. Check Other to list additional equipment to be used:

☐ Hard Hat
☐ Chemical Resistant Suit
☐ Chemical Resistant Gloves
☐ Rubber Boots
☐ Flash Hood
☐ Life Vest
☐ Hearing Protection
☐ Goggles
☐ Full Face Shield
☐ Steel Toed Boots
☐ Supplied Air Hood
☐ SCBA
☐ Respirator
☐ Gas Monitor
☐ Safety Harness and Life Line
☐ Personal Fall Protection Equipment

☐ Other (please specify)______________________________

Figure 2 – Example of a General Safe Work Permit – Back of Sheet

D. Job site preparation check list (Check items as they are completed)

Check required PPE from the list below. Check Other to list additional equipment to be used:

☐ Joint Job Site Visit	☐ Electrical Isolation Completed	☐ Double Blocked and Bleed
☐ Equipment Depressurized/Drained	☐ Equipment Isolated and Locked Out	☐ Line Flushed
☐ Drains/Vents Opened and Cleared	☐ Blinds in Place	☐ Valves and Vents Tagged
☐ Equipment Flushed	☐ Fuel Lines Isolation Completed	☐ Line Identified
☐ Equipment Inert Gas Purged	☐ Equipment Still Live	☐ Equipment Identified
☐ Written Formal JSA Completed	☐ Atmosphere Tested	

☐ Other (please specify)________________________________

E. Safety Precautions (Check off when completed prior to commencing work

Check required PPE from the list below. Check Other to list additional equipment to be used:

☐ Scaffolding Inspection Complete	☐ Fire Watch	☐ Fire Extinguisher at Work Site
☐ Work Area Marked-Off with Ribbon	☐ Continuous Atmospheric Monitoring	☐ Fire Resistant Blanket

☐ Communication Type(s)________________________________

☐ Other (please specify)________________________________

F. Atmospheric Testing (for Hot Work Permit)

Time: ____________	Time: ____________	Time: ____________
O_2: ____________%	O_2: ____________%	O_2: ____________%
CO: ____________%	CO: ____________%	CO: ____________%
H_2S: ____________%	H_2S: ____________%	H_2S: ____________%
LEL: ____________%	LEL: ____________%	LEL: ____________%
Tested by: ____________	Tested by: ____________	Tested by: ____________

G. Permit Completion

Work is: ☐ Completed ☐ Incomplete	Work Area has been cleaned up: ☐ Yes ☐ No

Print Name and Sign:

________________________________ **Date:** ____________ **Time:** ____________
(Representative completed work)

________________________________ **Date:** ____________ **Time:** ____________
(Representative Owner/Permit Issuer)

Upon completion of this work, return this permit to the Owner's permit office.

Objective 4

Describe methods of equipment isolation and lock out.

Lockout Procedures for Power Plant Equipment

Note: Specialized internal training is required for both workers and lockout installers. Please adhere to site-specific training requirements.

Lockouts

Lockouts are an essential part of replacing, repairing, and maintaining equipment. The Power Engineer is usually responsible to put equipment in a safe state before it can be worked on.

The term "lockout" refers to the placement of a lock on an energy isolating device. This ensures that while the equipment or process is locked-out, it is impossible to energize, startup, or release stored energy during work activities. Energy isolating devices include:

- Valves
- Blinds
- Blanks
- Breakers
- Disconnect switches

Before work begins, all energy sources for the equipment must be de-energized with securing devices such as locks and chains. This is a safeguard, so that no one can operate or interfere with the equipment being worked on.

Sometimes, in addition to the installation of locks, equipment may need to be rendered inoperative by the removal of parts, placing blocks, or pinning equipment to prevent motion. Whichever method is used, it must provide a level of protection equal to, or greater than, that achieved by locking and tagging.

In a safety lockout, all energy that can harm a worker must be de energized. When it comes to safety, there are no shortcuts or relaxed procedures.

If equipment is locked out, it cannot be interfered with in any way. There can be serious consequences for doing so. It may be possible to force the valve to move while it is still locked out – but do not do it. No one can remove personal safety locks other than the owner of those locks.

Some Jurisdictions permit other "securing devices" for lockout use besides locks and chains. These may include various wire **car seals**. A car seal is a one-time seal, made of steel cable or plastic, stamped with a unique number. Be aware of local lockout jurisdictional requirements regarding the use of locks or car seals.

For learning purposes across Canada, the federal legislation is the focus. It effectively covers most generic lockout conditions that may occur in the Power Engineer's work place.

CSA Z460 Control of Hazardous Energy - Lockout and Other Methods

There are two types of lockouts:

1. Personal lockouts
2. Group or Lockbox lockouts

A **personal lockout** - is performed by an individual. The individual lock owner locks out and safely secures equipment that only he or she will be working on.

A **group lockout** (also known as a lockbox lockout) - is performed by one or two trained individuals. Using a set of lockbox locks, they lock out and safely secure equipment that others will be working on.

Personal Lockouts

a) Each worker in the plant is assigned their own personal set of locks.

b) Few assigned locks are issued. If the worker cannot do a personal lockout of equipment with these locks, then a lockbox lockout will be required.

c) All personal lockout locks look identical. Therefore, it is easy to recognize when an applied lock is a personal lock. Each personal lock is identified by a unique number, so its owner can be determined. To help identify the owner of the lock, a "Do Not Operate" tag with personal information may be attached beside the personal lock.

d) There is only one key assigned to the holder of a personal lock. No one else has a key. The key must not be given to someone else to use. There may be a copy kept securely in a supervisor's office or safety department for emergency purposes only.

e) The holder of the personal lock must carry their personal key at all times. In some plants, the worker carries a personal lock at all times.

f) The worker will isolate all harmful energy sources. Then a personal lock or other approved securing device can be applied to each isolation device.

g) Personal locks are mainly used for smaller jobs such as locking out a control valve or a pump. However, personal locks are also used with group lockouts, which will be discussed later.

h) The personal locks belong only to the one individual. No one else can borrow them or use them to work under. For example, a second person wants to work on the same equipment at the same time. That person must put a set of personal locks at the same places as the first person before beginning the work. With very few exceptions, **NOBODY SHALL REMOVE A PERSONAL LOCK THAT BELONGS TO SOMEONE ELSE!**

Figure 3 – Personal Lockouts

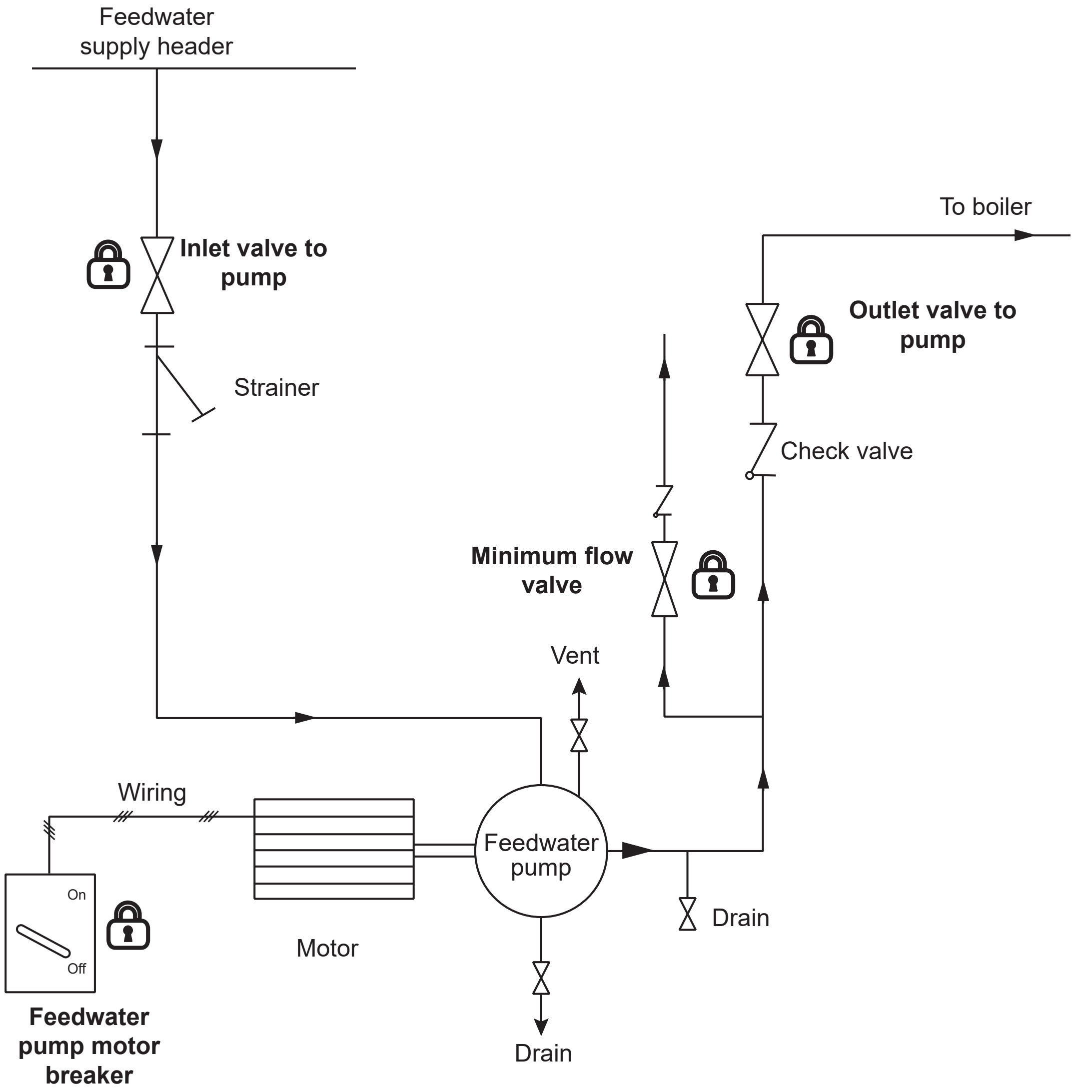


Figure 3 shows a sample lockout for a boiler feedwater pump using the personal lockout method. This pump has been turned off using the normal shutdown procedures. To lockout this pump with personal locks, the Power Engineer would follow these steps.

1. It is best practice to first isolate the power supply for the pump motor. This is done by opening the breaker and/or the disconnect switch. Place a personal lock on the disconnect switch. Try to start the pump using the normal start methods, and make sure it does not start.
2. Close the suction (inlet) valve to the pump. Wrap chains or steel cables to secure the valve handle, so it cannot be opened. Apply a personal lock to the chain or cable.
3. Close the discharge (outlet) valve to the pump. Wrap chains or steel cables to secure the valve handle, so it cannot be opened. Apply a personal lock to the chain or cable.
4. Close the minimum flow isolation valve. Wrap chains or steel cables to secure the valve handle, so it cannot be opened. Apply a personal lock to the chain or cable.
5. Open and apply a warning tag to the drain valve to relieve pressure in the piping system. If left closed, pressurized water may cause injury to workers dismantling the pump. By observing the drain valve, it can be determined whether the inlet, outlet, and minimum flow valves are tightly shut.

6. Open and apply a warning tag to the pump casing vent, so that all liquid in the pump housing and piping can properly drain.

Group (Lockbox) Lockouts

Often, many workers are assigned to repair a single piece of equipment. These workers may include electricians, power engineers, and mechanics. A group lockout is designed to protect all workers who are required to work on locked out equipment. Each worker must be satisfied that the lockout procedure is sufficient and sign or initial on the lockout sheet. As well, each worker must verify that the machinery is de-energized and isolated before beginning to work.

These tradespeople may conduct their work over a period as stated on the Safe Work Permit associated with the lockout. The group lockout allows each worker to apply a single personal lock in one centralized location, and only for the period of time he or she is working on it. This is accomplished with a lockbox.

Figure 4 – Portable Group Lock Box

Figure 4 shows a portable group lockbox that can accommodate multiple personal locks and car seals. The portable lockbox is suitable for use in remote parts of the plant that are far away from permanent lockboxes situated in the main operating areas of the plant.

Two trained operators normally perform the actual group lockout. One operator is the lock installer and the other is the verifier. A set or sets of group locks are used to do the lockout. Each of the locks in the set are keyed alike, so that one master key can open all the locks of the set. Each set of group locks has a unique identification number with a pre-determined number of locks (for example, 10 locks in a set).

The trained operators apply one group lock from a set at each isolation point, such as the breaker/ disconnect and isolation valves. The master key(s) are placed inside the lockbox along with the lockout isolation sheet and any unused locks from the lock sets that were applied. The operators and workers then apply their personal locks to the lockbox. The master key is sealed inside the box with a car seal.

As with the personal lockout, the equipment lockout must be verified before work proceeds. Verification proves that:

a) The correct breaker was opened.
b) All the isolation points were isolated effectively.
c) All forms of stored energy have been dissipated.

Other workers can now put their own personal lock on the lockbox. Their personal locks now prevent access to the group lock master key. When workers complete their tasks, they must remove their personal locks from the lockbox. The lockbox cannot be opened until all workers' personal locks have been removed – to ensure the safety of all personnel that are working on the equipment covered under the group lockout.

From time to time, especially during maintenance shutdowns (turn arounds), there can be more than one group lockout in place at the same time. For example, a boiler can typically have separate fireside and waterside lockouts. The plant may also have other lockouts on pumps or other vessels, such as a deaerator, that are inter-related to each other with unclear lockout boundary lines. These situations are called "complex group lockouts." It is advisable to consult the site-specific policy and procedures, as well as, local jurisdictional regulations addressing "complex group lockouts."

The following is a set of suggested general guidelines suitable for a single group lockout.

a) Lockboxes can be located near the work area, process building, permit issuing office, or in some other area (especially during turn around) for viewing. The lockout sheet (described below) is kept with the lockbox for quick reference.
b) A written lockout procedure must be completed for a group lockout. The following should be included on the lockout sheet.
    i. A title that identifies the unit or equipment being locked out.
    ii. The date the lockout was implemented.
    iii. Names of the trained individuals that installed and verified the locks on the lockout.
    iv. Identification of the group lock set and number of locks used for the lockout. Group lock sets should be numbered and colour coded. For example, yellow locks may be designated for operations, red for electrical trades, silver for commissioning and start-up, black for maintenance crews, blue for personal locks, and so on.

        For example, an operator may have used set #5 of the yellow group locks (designated for operations). This set may have 10 locks in total. The operator may have only used locks 1 to 7. Locks 8, 9, and 10 would be locked inside the lock box.
    v. A list of all isolation points where a lockbox lock has been applied. It should identify all equipment (such as valves, gates, actuators, dampers, motors, or fans) that could affect the safety of the operator working on the locked out equipment.

On Track

Note: The lockout sheet is often accompanied with a marked up as-built drawing, such as a P&ID (piping and instrumentation diagram). The drawing should clearly identify the isolation points.

    vi. The car seal number used on the lockbox.
    vii. A place for initials beside the lockout point entries. This can be a box beside the lockout point on the page, so the operator(s) can initial to verify that the point has been locked out.
    viii. Equipment that is not locked out, but has had its status changed (e.g. open or shut) to support the lockout. For example, an opened drain valve may be identified as open, but not locked open. This changed state should be recorded on the lockout sheet.

ix. If an electrical breaker lockout for a motor is required at a motor control centre (MCC), a bump test at the local on/off hand switch is performed. The trained operator must prove the motor will not start accidently. The local on/off hand switch is locked in the "off" position with one of the group locks. It is then recorded on the lockout sheet, along with the name and signature of the operator who performed the bump test.

x. All involved workers must be identified. Their name, personal lock number, name of employer, sign in/sign out time, and date must be on the lockout sheet.

xi. After all work is completed, personal locks will be remove from the lockbox by all involved parties. Then, the car seal is broken to retrieve the master key or keys and the lockout sheet.

xii. The trained operator(s) will open the locks, remove locks and chains or steel cables at the isolation points, and return the valves back to normal operating positions. When the lockout is fully removed, the same operator(s) will initial the lockout sheet to sign off.

xiii. A supervisor or designate will then verify all locks have been removed. All isolation points are checked to ensure that they have been restored to normal operating positions. When the verification is completed, the supervisor or designate signs off on the lockout sheet with a printed name, signature, and date of confirmation.

CAUTION

Occasionally, a lockout requires modification. In this situation, all personal locks must be removed from the lockbox. The car seal is broken off so that the master keys of the group locks can be accessed. A site specific "lockout deviation process" must be followed, in accordance with plant policy and/or jurisdictional requirements.

Figures 5 and 6 are samples of the front and back of a typical group/lockbox lockout sheet.

Figure 5 – Sample Group Lockout Sheet – Front of Sheet

Sample Group Lockout Sheet

A. Lockout Identification

Equipment #:	Equipment Name:	Lock Box #:	Car Seal #:
Description of Lockout:			

B. Lock Set(s) Information

Lock Set #	Number of Locks in Set:	Total Locks Installed:

C. Lockout Points Information

Lock Set #	Lock #	Description	Locked Position LC (Locked Closed) LO (Locked Open)	Operating Position NC (Normally Closed) NO (Normally Open)	Lock Installer (Initials	Lock Verifier (Initials)	Lock Remover (Initials)

Figure 6 – Sample Group Lockout Sheet – Back of Sheet

D. Lockout Installed by:			
Print Name:	Personal Lock #:	Signature:	Date:

E. Lockout Verified by:			
Print Name:	Personal Lock #:	Signature:	Date:

F. Motor Bump Test Confirmed by: or □ N/A			
Print Name:	Personal Lock #:	Signature:	Date:

G. Workers Sign On/Off				
Print Name:	Personal Lock #:	Company Name:	Time In / Initials:	Time Out / Initials:
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

H. Lockout Removal Sign Off		
All locks have been removed and all isolation points have been restored to normal Operating positions. Confirmed by:		
Print Name:	Signature:	Date:

Chapter Summary

Having a functioning **Occupational Health and Safety (OH&S)** program is a license-to-operate. It is a defined plan of action to prevent accidents and incidents from occurring at the workplace. Its specific focus is to keep workers safe and alive.

The elements for the (OHS) program presented in this chapter serve as general guidelines for the implementation of a site-specific program. The safety training discussed requires both external and internal qualification for a worker to be proven competent to work under these conditions and environment.

The **Safe Work Permit (SWP)** and **Control of Hazardous Energy (Log Out, Tag Out)** programs described in this chapter are similar to the ones commonly used in plant sites. However, they are for general demonstration and explanation purposes only. They are not intended to replace the site-specific programs. Please consult site specific and jurisdictional (OHS) policy and requirements for further information.

In addition, only qualified and competent operators in the applicable areas are selected to take the training. Only these successfully trained and qualified operators may issue safe work permits, and perform lockouts and tag outs.

Chapter 3

Handling of Dangerous Materials

Learning Outcome

When you complete this chapter you should be able to:

Describe the policies and procedures for safe storage and handling of dangerous materials.

Learning Objectives

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

1. *Discuss the WHMIS system.*
2. *Discuss the essential components required in the WHMIS systems.*
3. *Describe the safe handling and use of gas cylinders in an energy plant (power plant).*
4. *Discuss the safe handling of hydrocarbons.*

Chapter Introduction

The first part of this chapter will help Canadian Power Engineers to have a better understanding of the **Workplace Hazardous Materials Information System (WHMIS)** and how it applies to worksites in Canada. It will also prepare Canadian Power Engineers for the **WHMIS 1988** to **WHMIS 2015** transition.

The second part of the chapter deals with the safe handling of compressed gas cylinders and hydrocarbons in energy plants.

Objective 1

Discuss the WHMIS system.

Understanding Workplace Hazardous Materials Information System (WHMIS) and the Transition

In Canada, various types of materials are used in the workplace. The purpose of **WHMIS** is to provide a comprehensive system to communicate and inform workers on the safe use of hazardous materials.

WHMIS was developed by a group of representatives from Canadian government, employers, and workers. This program was in response to the Canadian workers' right to know about the safety and health hazards of the materials and chemicals that they deal with at the worksite. In October 31, 1988, **WHMIS** became law in Canada across all Canadian jurisdictions.

WHMIS in Transition

The world has become more connected, and with it are more opportunities for global trading. However, countries have different ways of classifying chemicals and identifying hazardous products. This situation creates confusion for the trading countries. As a result, risks and hazards to workers increase.

To address this situation, the **Global Harmonized System of Classification and Labelling of Chemicals (GHS)** was developed by an international team of hazard communication experts. **GHS** is a system that defines and classifies the hazards of chemical products. It communicates health and safety information on labels and safety data sheets. The goal is to adopt and use the same set of rules for classifying hazards, and the same format and content for labels and safety data sheets (SDS) around the world.

Effective February 11, 2015, Canada incorporated **GHS for Canadian workplaces and amended WHMIS 1988**; the modified system is now **WHMIS 2015**. To allow suppliers, employers, and workers time to adjust to the new system, a 3-stage transition plan is in place to align with the implementation process across all Canadian jurisdictions.

Following are the important timelines for the transition period between **WHMIS 1988** and **WHMIS 2015**.

Table 1 – WHMIS Transition Summary by Phase

Phase	Timeline	Suppliers		Employers
		Manufactures and Importers	Distributors	
1	From February 11, 2015 to May 31, 2017	WHMIS 1988 or WHMIS 2015	WHMIS 1988 or WHMIS 2015	Consult local jurisdictional legislative requirements WHMIS 1988 or WHMIS 2015
2	From June 1, 2017 to May 31, 2018	WHMIS 2015	WHMIS 1988 or WHMIS 2015	WHMIS 1988 or WHMIS 2015
3	From June 1, 2018 to November 30, 2018	WHMIS 2015	WHMIS 2015	WHMIS 1988 or WHMIS 2015
Completion	December 1, 2018	WHMIS 2015	WHMIS 2015	WHMIS 2015

Please consult the local jurisdictional **WHMIS** regulations or the **Canadian Centre for Occupational Health and Safety (CCOHS)** for further information and details on the **WHMIS 1988** system, and the new **WHMIS 2015** system.

Objective 2

Discuss the essential components required in the WHMIS systems.

Both **WHMIS 1988** and **2015** systems consist of essentially four main components.

1. Hazard identification and product classification
2. Labelling
3. Material Safety Data Sheets (MSDS) for **WHMIS 1988** and Safety Data Sheets (SDS) for **WHMIS 2015**
4. Worker training and education

WHMIS is enforced by the departments or agencies responsible for health and safety across all Canadian jurisdictions.

The roles and responsibilities for suppliers, employers, and workers will remain the same in **WHMIS 2015**.

Note: The first component, "Hazard Identification and Product Classification" was not specifically listed as part of the **WHMIS 1988** literature outline. However, it was a component of the WHMIS program.

Use of Hazardous Products in the Workplace

What must a "Supplier" do?

Suppliers that manufacture or import hazardous products are required to:

a) Classify products by labelling
b) Provide Safety Data Sheets (SDS) or Material Safety Data Sheets (MSDS) to their customers

What must an "Employer" do?

When utilizing hazardous products in the workplace, the employer must:

a) Ensure the products are properly labelled
b) Ensure the products have an SDS sheet (or MSDS sheet) and that they are easily accessible to workers
c) Ensure the products have workplace labels prepared as needed
d) Use proper control measures to keep the workplace and employees safe
e) Educate and train workers about these hazardous materials and how to use them safely

In addition, if the employer makes or manufactures hazardous materials on the premises, they must prepare an SDS for each product.

What must a Worker do?

Workers must:

a) Participate in their training and education
b) Protect themselves and their co-workers
c) Participate in identifying and controlling hazards
d) Ensure that labels are in good condition. Replace as required.

Labelling

The two types of labels required are supplier labels and workplace labels.

Supplier labels contain extensive information about the hazardous product, written in a specific manner, and have specific content. Supplier labels must be on every hazardous product that comes into the worksite. If not, the product cannot be used until one is supplied. Supplier labels are the first source of information any employee is likely to see about the product. It will provide all the information required in order to use it safely. The following table provides a list of required information on a supplier label.

Table 2 – WHMIS Supplier Label Information

Required Information	Description
1. Product Identifier	The exact product name appears on the container and on the SDS.
2. Hazard Pictograms	Determined by the hazard classification of the product. In some cases, no pictogram is required.
3. Signal Word (New)	“Danger” or “Warning” is used to emphasize and indicate the severity of the hazards
4. Hazard Statement	Brief standard statements of all hazards based on the hazard classification of the product.
5. Precautionary Statements	Gives the recommended measures to minimize or prevent negative effects from exposure to the product, including utilizing protective equipment and emergency actions.
6. Supplier Identifier	Contact information of the company responsible for this product.

Workplace labels also have specific content, but are much simpler and contain only basic information. They are intended to be written by the worker or the employer, and are to be used only in the workplace. Workplace labels are required if a supplier label is damaged, or if hazardous material is poured into a different container for use within the same workplace.

Safety Data Sheet (SDS) and Material Safety Data Sheet (MSDS)

Prepared by the manufacturer of the product, an **SDS/MSDS** provides a detailed description of the hazardous material. The employer is responsible for preparing the data sheet if the product is manufactured on the worksite.

Of the three documents – workplace label, supplier label, and **SDS** – the **SDS** is the most comprehensive. It will be used by workers and employers, but may also be referenced by safety attendants and medical professionals.

The **SDS** and **MSDS** are similar documents. Both provide comprehensive identification information for the hazardous material in question. There are minor differences between the **SDS** and the **MSDS**. The **SDS**, however, conforms to an international method of identification in reference to the **GHS**.

Table 3 is a comparison of the **WHMIS 2015 Safety Data Sheet (SDS)** (16 sections) and the **1988 Material Safety Data Sheets (MSDS)** (9 sections). **SDS** contains additional sections to give more information regarding the material.

Table 3 – 2015 SDS and 1988 MSDS

Section	2015 - SDS	1988 - MSDS
1	Identification	Product Identification and Use
2	Hazard Identification	
3	Composition/Information on Ingredients	Hazardous Ingredients
4	First Aid Measures	First Aid Measures
5	Fire-Fighting Measures	Fire and Explosion Data
6	Accidental Release Measures	
7	Handling and Storage	
8	Exposure Controls/Personal Protection	Preventive Measures
9	Physical and Chemical Properties	Physical Data of Product
10	Stability and Reactivity	Reactivity Data
11	Toxicological Information	Toxicological Properties
12	Ecological Information	
13	Disposal Considerations	
14	Transport Information	
15	Regulatory Information	MSDS Preparation and Update Information
16	Other Information	

WHMIS Training for the Worksite

The employer must provide **WHMIS** training to the workers. Employee training should cover all aspects of **WHMIS**. Instruction should also include:

a) Proper use of supplier labels, workplace labels, and other forms of labelling in the plant.
b) Safe use of hazardous materials on site, and the safety features and other conditions in the plant that the use of these materials requires
c) Proper use of Personal Protective Equipment.
d) Location of safety equipment such as eyewash fountains, emergency showers, and first aid room.
e) Location of the **SDS** and other safety literature.

The employer must be able to verify that the worker has completed the training, and has competent knowledge of the **WHMIS** program. This is usually a test approved by a safety officer or other Jurisdictional representative.

After a test is completed, the worker will undergo hands on training. The worker must become familiar with the practices of working with hazardous materials in the workplace.

Note: Additional training will be required, beyond this course material. The Employer is responsible to provide appropriate training in each employment assignment.

Objective 3

Describe the safe handling and use of gas cylinders in an energy plant (power plant).

Gas cylinders are regulated by Transport Canada. In many installations requiring gases for fuel or operations, many or all of the gases are delivered to the workplace in containers called cylinders. These cylinders are small, easy to transport pressure vessels. In the interest of safety, it is important that workers be properly trained in the safe practices for handling and storing these cylinders.

This objective covers the standards and rules for handling and storing gases contained in portable cylinders. Compliance with these standards will help to reduce the number of accidents in the workplace.

It is advisable that employees working with gas cylinders be aware at all times of the type and density of gases contained in the cylinders. For example, the worker should know whether the contents are liquid or vapour state, the vapour pressure, and other related details.

Safe Handling of Cylinders

The following are suggested general guidelines only. Please be sure to follow site specific policies, procedures, and training requirements. Consult local jurisdictional regulatory requirements regarding the safe handling, storage, care, and use of gas cylinders.

Below are some rules for the safe handling of compress gas cylinders (Figure 1).

a) **Do not drop a cylinder.** The cylinders are not fragile; however, a fall from a height could easily damage the valve, and could turn the cylinder into a rocket-like projectile. A cylinder containing flammable gas or liquid could also blow up, especially if it ignites.

b) **Do not "roll" a cylinder on its bottom edge**. This is a risky practice, due to the weight of the cylinder. The cylinder could slip and fall. Always use a dolly, a hand truck, or other wheeled carrier. A delivery vehicle for cylinders usually has some kind of hoist or hydraulic gate to lower cylinders to the ground.

c) **Keep the metal cap on** (if it has one) when moving or storing the cylinder – this protects the valve. Note that some cylinders have a guard ring around the valve instead of a metal cap.

d) **Keep the cylinder upright**. There is a safety valve at the top of the cylinder designed to relieve excess vapour pressure. The safety valve is designed to relieve vapour, not liquid. If the tank was stored on its side, the safety valve would be flooded with liquid, and incapable of relieving pressure.

Figure 1 – Handling of Gas Cylinder

Care and Maintenance

a) Routinely inspect tanks and cylinders for damage such as nicks, scrapes, or dents, especially when receiving them.

b) If the operator suspects a cylinder or tank is damaged, it must be taken out of service, and returned to the supplier. It may need to be disposed of.

c) Store the tanks properly in an outside storage area. Ensure that empty tanks and full tanks are stored in separate areas.

Storage Procedures

Locating and storing gas cylinders is as important as handling and moving them.

Cylinders should be located outside of the building when connected to gas consuming equipment, or for storage. However, where outside location is impractical, cylinders may be located for use (but not for storage) inside a building. In this type of installation, the gas is only to be used for industrial processing or repair work, and the building has to be of an industrial nature.

When stored, gas cylinders must be in an upright position and firmly secured to prevent rolling over.

Acetylene and oxygen cylinders must be stored in separate areas. They must be stored at least 6 metres apart to prevent explosive mixtures forming in the event of leakage. For safety reasons, these cylinders are usually colour coded: acetylene is stored in maroon cylinders and oxygen is usually stored in black cylinders."

Before storing cylinders, make sure all hoses, piping, pressure regulators, gauges, manifold connections, and fittings are disconnected from the cylinders. Verify that the valves are closed and not leaking.

Objective 4

Discuss the safe handling of hydrocarbons.

It is necessary to know the properties of **hydrocarbons** to handle them safely. The properties that are important for operators to safely use and store hydrocarbon fluids will be discussed here.

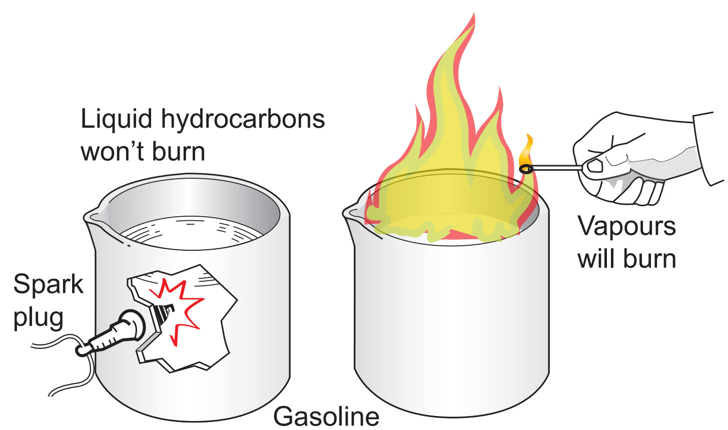
Significant Properties of Hydrocarbon Fluids

The significant properties of the most common hydrocarbons include:

1. Flammable or explosive Limits
2. Flash Point
3. Ignition Temperature

It is important to note that the hydrocarbons in their liquid state do not burn. The evaporated hydrocarbon gas, when mixed with air, will burn. If the vapours ignite, the un-vapourized liquid will become warmer, which will cause more liquid to evaporate and produce large amounts of flammable gases. If the liquid is volatile enough, and mixes with a lot of air, it can ignite very rapidly and explode.

Figure 2 – Vapours Burn



Flammable or Explosive Limits

Hydrocarbons need air to burn. The minimum concentration of hydrocarbon gas in air which will ignite is the **Lower Explosive Limit (LEL)**. If the concentration of gas is too low, it will not ignite, because there is not enough flammable gas (or too much air). This condition is known as "lean."

The **Upper Explosive Limit (UEL)** is the maximum concentration of vapour that can be in a given volume and still ignite. In other words, if there is too high of a concentration of flammable gas mixed with air, it will not burn because there is not enough air. This condition is known as "rich."

Flash Point

The **flash point** of a liquid is the lowest temperature at which the liquid produces sufficient vapour to form a flammable mixture of vapour and air, immediately above the liquid surface. Lighter hydrocarbons, such as methane, ethane, butane, and propane, are gases at room temperatures, and as such are above their flash point at room temperature.

However, even if a hydrocarbon is colder than its saturation temperature, it may give off sufficient vapour to momentarily support combustion. Therefore, a liquid's flash point may be far lower than the liquid's saturation temperature.

Butane, for example, has a saturation temperature of approximately 0°C. Despite this, butane will produce flammable vapour at temperatures as low as –60°C (the flash point of butane). This low temperature atmosphere around a container of liquid butane, while still quite cold, has enough heat in it to evaporate liquid butane at atmospheric pressure, and produce a flammable mixture.

Gasoline will vapourize at –43°C. This also means that when it is colder than –43°C it will not vapourize. As a result, cars in northern Canadian winters may not start when the outdoor temperature is –60°C unless there is a way to keep the gasoline warm.

Sources of Ignition

The ignition temperature is the lowest temperature at which a fuel/air mixture will burn.

Most ignition temperatures are relatively low when one considers that a match can burn at a temperature of 870°C, and an electric arc can be over 5000°C. If the gas is at a proper air/fuel mixture it will ignite when exposed to their relative ignition temperature. For example, propane ignites at 490°C and gasoline at 480°C.

The following are suggested general guidelines only. Please be sure to follow site specific policies, procedures, and training requirements. Consult local jurisdictional regulatory requirements for the safe storage of hydrocarbons.

Storage of Hydrocarbons

Hydrocarbons in liquid or gaseous form are delivered to plants in pipelines, barrels, pails, or pressurized containers. Generally a Power Engineer is not required to load or unload hydrocarbons, but is required to be familiar with their storage and use in small quantities.

Typical storage facilities for hydrocarbons in gaseous state can take the form of pressurized tanks or containers that are on site. The operator is responsible for the monitoring of pressures, temperatures, and flows from these units.

Almost all plants have oil tanks: from diesel tanks that supply fuel for emergency generators, to large oil processing plants that store oil. A trained operator monitors these tanks by:

a) Checking levels periodically
b) Ensuring that there is a vapour space so that if the oil gets warm it will not expand and overflow the tank
c) Removing water that accumulates in the bottom of the tanks.

Some large oil tanks may have a "blanket" of inert slightly pressurized gas, to ensure that air does not get into the tank. Tank farms in the oil industry may use blankets of natural gas, under pressure, to prevent infiltration of air into the tanks.

Operators may be required to pump and circulate the oil. They must ensure that the fuel oil is recirculated back to the same tank from which it was originally drawn.

Oils, greases, and solvents used for lubrication or cleaning will be stored in a designated area outside, or in a flammable material storage cabinet. The Power Engineer may be required to occasionally use or move this oil, either in barrels or in small containers.

The operator may use a small barrel pump to transfer from a barrel or tank to a smaller container such as a jerry can. When pouring or transferring these fluids, it is expected that the operator will have proper training, is wearing PPE, and adheres to hazards instruction given in the plant. Workplace labels for controlled products must be used, when necessary.

Figure 3 – Flammable Material Storage Locker

Chapter Summary

The **WHMIS 2015** program is coming into effect under the **Global Harmonization System (GHS)**. The **GHS** is designed to "harmonize" how hazardous products in the workplace are identified and classified. In many ways, **WHMIS 2015** is similar to the **WHMIS 1988** system. The exception is that it presents the **WHMIS** hazardous products information in a format that conforms to other global organizations that participate in the **GHS**.

Both systems (**WHMIS 1988** and **WHMIS 2015**) are in effect simultaneously, until **WHMIS 1988** is phased out completely at the end of 2018.

The intent of both **WHMIS** systems is to identify and classify hazardous products. This gives the worker the information necessary to make informed decisions about how to safely work with these products. This involves labelling the products with the appropriate labels – such as the supplier and workplace labels, having access to the **MSDS** (old) or the **SDS** (new), and training the employees on all components of **WHMIS**.

Power Engineers must receive **WHMIS** training in their workplace. The general information discussed here will assist in understanding the specific **WHMIS** training material provided at the worksite.

Gas cylinders are often used in plants where Power Engineers work. It is necessary to be familiar with the components of a cylinder. The operator of the cylinder should be able to identify and operate the cylinder and associated equipment. This includes connecting and disconnecting cylinders – to a header if necessary – to supply a pressurized service to their plant.

Hydrocarbons – gas, fluid or solid – should be handled carefully. The properties and characteristics of these hydrocarbons should be understood. A method of determining these characteristics are important. Significant properties such as flammability, explosive limits, flash point, and ignition temperature should be recognized and considered when using hydrocarbons, when either used as fuel or stored for later.

CHAPTER 4

Plant Fire Safety

LEARNING OUTCOME

When you complete this chapter you should be able to:

Explain fire safety in an industrial plant.

LEARNING OBJECTIVES

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

1. *Discuss the theory, terminology, and the life safety issues associated with fires.*
2. *Explain the five classes of fires, and describe the types of fire extinguishing media and how they act on these fires.*
3. *Explain fire prevention.*
4. *Discuss fire prevention methods for the five types of fires.*

Chapter Introduction

This chapter will discuss what fires are, how they occur, types of fires, and methods to prevent them.

This information explores and determines how to keep a premises safe when dealing with a fire, especially when it relates to Power Engineering. What is a fire? What different conditions have to exist before a fire can occur? How does a fire start? What supports combustion? How is a fire extinguished? Common terminology will be used to increase the understanding of fire and fire safety.

There are a number of different classifications of combustible materials. Each material may require a different extinguishing method. Classes of fires and their extinguishing methods will be presented.

Power Engineers will be required to respond to a wide variety of fires. It might be a small fire in a wastebasket filled with paper which is ignited by a lit cigarette. Maybe it is a fire started by cooking oil in a restaurant kitchen.

The Power Engineer may be part of a group that is included in first response to fire. In larger or more remote establishments, they might be part of an emergency response team that attends to a large blaze in a building.

It is important to be familiar with the types of fires that might be encountered, including preventative measures and fire-fighting procedures. Further training at the worksite should be provided, however basic knowledge of what fires are and how to put them out is essential.

Objective 1

Discuss the theory, terminology, and the life safety issues associated with fires.

Fire Theory

Combustion is defined as an exothermic reaction (gives off heat). This self-sustaining reaction involves a solid, liquid, and/or gaseous fuel. The reaction is usually associated with the oxidation (combining with oxygen) of a fuel, generation of heat, and the emission of light.

There are many types of fuel and many sources of oxygen besides what is found in the air. Some fuels contain enough oxygen in the fuel material itself that combustion is possible even in an inert atmosphere. For combustion to occur, the following four criteria must be met.

1. There has to be a fuel to burn.
2. There has to be oxygen to "oxidize" it.
3. There has to be an ignition source.
4. The fire must be able to continue burning.

When a wood log is completely burned, only ashes are left. The combustible parts of wood will burn with the oxygen in the air and generate heat. Fuel is technically identified as a **reducing agent**. The air that supplies the oxygen for burning is an **oxidizing agent.**

There are many different types of **reducing agents** that will burn in the presence of an **oxidizing agent**, so that when **intense heat** (ignition source) is added, then a fire starts. While burning, the temperature stays high enough to increase the molecular activity of the reducing agent – which enables the fire to continue.

Reducing Agent = Fuel

Oxidizing Agent = Anything that supplies oxygen

Intense Heat = A spark, a match, or anything else hot enough to raise the temperature and ignite the fuel

Therefore, to be a self-sustaining, **uninhibited chain reaction**, the fuel must:

a) Continue to burn
b) Generate heat
c) Maintain a high enough temperature to sustain ignition

Experience shows that wet wood is very difficult to burn. The water in the wood converts to steam and draws heat away from the fire. The remaining heat may be insufficient to keep the temperature of the combustion reaction above its ignition temperature. The wetter the wood, the lower the temperature. Wood that is too wet will not generate enough heat to sustain the chain reaction, and the fire will go out.

Oxidizing Agent

Oxidizing agent refers to any chemical element or compound that can provide oxygen and combine with a fuel in the combustion process.

Oxygen is the simplest and most common oxidizing agent. However, many other chemicals that are found in power plants can also be oxidizing agents. The following are examples:

a) Oxygen and ozone– ozone is highly reactive with fuel - and has extra oxygen readily available for combustion
b) Hydrogen peroxide
c) Members of the halogen group such as fluorine, chlorine, bromine, and iodine
d) Concentrated nitric and sulfuric acids
e) Oxides of heavy metals such as manganese dioxide and lead oxide
f) Nitrates, chlorates, percholates, and peroxides
g) Chromates, dichromates, permanganates, hypochlorites, and hypobromites

Most accidental fires involve a reaction primarily with air. Atmospheric air is about 21% oxygen by volume. The balance is mainly nitrogen, which plays no part in the combustion process.

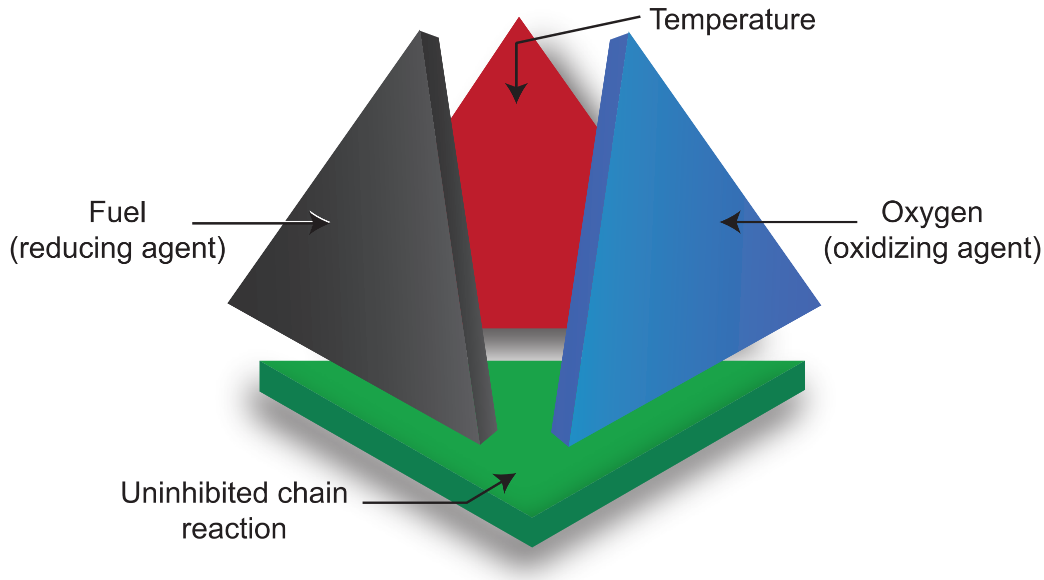
Reducing Agent

As mentioned above, a reducing agent is any combustible material. This fuel combines with oxygen provided by an oxidizing agent and burns. The following are the most common materials involved as fuels (reducing agents) in fires.

a) **Nonmetals** such as carbon, sulfur, and phosphorous.
b) **Hydrogen.**
c) **Carbon monoxide.** Carbon monoxide can result from incomplete combustion. It will combine with oxygen to generate heat as it forms carbon dioxide.
d) **Compounds rich in carbon and hydrogen.** Materials high in both carbon and hydrogen content include common fuels, and are highly flammable. Examples of hydrocarbons that burn readily are:
   - Methane
   - Ethane
   - Propane
   - Butane
   - Natural gas
   - Acetylene
   - Gasoline
   - Fuel oils
   - Wood
   - Coal
   - Cellulose
e) **Metals** such as aluminum, magnesium, titanium, zirconium.
f) **Alkali metals** such as sodium and potassium.

A fire requires four components to burn, and is represented by the fire tetrahedron illustrated in Figure 1:

Figure 1 – Fire Tetrahedron



All four components of the fire tetrahedron are required for there to be a fire.

1. Fuel
2. Oxygen
3. Ignition (heat)
4. Uninhibited (self-sustaining) chain reaction

Therefore, in order to **extinguish or prevent a fire**, remove any one of four components.

a) Remove the fuel so there is nothing to burn.

b) Remove the oxygen by smothering the fire (such as with an inert gas).

c) Keep the fuel or air below the ignition temperature. No matter how combustible a material is, and how much oxygen is present, it must be hot enough to ignite or there will be no fire.

d) Stop the chemical chain reaction.

A Power Engineer may notice a buildup of soot on an oil-fired burner in a boiler where there is insufficient combustion air or turbulence. This incomplete combustion will result in unburned particles of soot coating the boiler furnace surfaces.

Rapid combustion is when a fire quickly releases large amounts of heat and light energy, which results in a rapidly expanding flame. This form of fire occurs in internal combustion engines. **Detonation** is the term used to describe the rapid ignition that occurs in an internal combustion engine.

Many solid fuels, such as coal and wood, contain both **volatile combustible material (VCM)** and carbon. The VCMs are organic hydrocarbons that become gaseous when the fuel is heated. These vapours ignite and burn with a visible flame. The carbon in the solid fuel burns without a flame.

Liquid fuels do not burn directly. They must first be heated to a high enough temperature to produce sufficient flammable vapour to support combustion. Then, the vapours ignite, producing visible flames. Some liquids, such as methanol, produce faint flames that may not be visible, depending on the lighting conditions.

Gaseous fuels do not require preheating to produce combustible vapours. They only require sufficient mixing with air or oxygen and an ignition source. Gaseous fuels burn with visible flames. Hydrogen gas burns with such a faint visible flame that it may not be noticeable, depending on the lighting conditions.

The first stage of a solid fuel fire is the **preheating phase**, where the fuel is heated up hot enough to burn. The next stage is the **distillation phase or gaseous phase**, where the mixture of air and flammable gases have been ignited. In the gaseous phase, flames are visible and the fire is self-sustaining. The third stage, known as the **charcoal phase or solid phase**, is when a solid fuel such as wood or coal is reduced to embers. In this stage, combustion of the remaining glowing carbon takes place with nearly invisible flames. This form of combustion may be called **flameless** or **glowing combustion**. The embers burn, giving off light and heat, but the self-sustaining reaction is much slower. Fires can burn in this slow, self-sustaining way for prolonged periods of time, such as in subsurface peat bogs or coal mine fires, and can be very difficult to extinguish.

Fire Safety

The threat to life from a fire comes from:

- High temperatures
- The gaseous products of combustion
- The depletion of oxygen in the vicinity of the fire

The **gaseous products** of combustion are toxic and can have immediate and long-term health effects, including death. Also, these gaseous combustion products displace air, which leads to oxygen deficiency.

Note:

a) At **oxygen concentrations** of about 17%, a person will suffer impaired thinking and reduced muscular coordination.

b) In the range of 10 to 14%, the individual may still be conscious, but will show abnormal fatigue on exertion and impaired judgement.

c) Below a concentration of 10%, an individual will lose consciousness and will quickly need fresh air or oxygen to be revived.

The levels of impairment will be greater if the person requires increased oxygen due to exertion.

In a fire, **smoke** fills the environment, causing it to be difficult to see and breath. The toxicity of the smoke causes irritations to the eyes and lungs. Disorientation can result. People can get lost even in a familiar layout. Therefore, when in a fire, stay as close to the floor as possible where heavier oxygenated air is concentrated. If possible, breathe through a wet filter, such as clothing or a towel.

Additional precautions must be taken when entering an enclosed fire area. The **oxygen in the room may become depleted** and the fire may be diminished. However, the fire can resume rapidly if air (oxygen) is reintroduced when a door or a window is opened. This allows more air to flow into the room. When the fresh oxygen feeds the hot combustible gases, it can result in an explosion.

Early detection is a major way to effectively control a fire condition. Power Engineers working in commercial buildings, hospitals, or schools are often trained as first responders to a fire situation. They will recognize the importance of a quick response in order to catch a situation early before it can develop into something bigger. Minutes, even seconds can count. Responding to a situation in the very early stages can be the difference between fighting a small paper fire or a large, tougher to extinguish fire.

Fire and other emergency situations can cause major physical and psychological stress. People will often behave erratically, which will have negative impacts in emergency situations. Panic, confusion, and disorientation can rapidly set in.

For example, people may head in the wrong direction or simply freeze-up, unable to perform routine tasks in familiar surroundings. Mistakes can be made, if the person attempting to respond to the fire is panicking. It is often difficult to determine why one person will be calm and another person will be in a state of panic. When people panic, it can significantly interfere with the ability of others to respond to a fire or other emergencies.

An effective training method for people to deal with emergency situations is to have repeated exposure by practicing. Simulated emergencies teach people how to respond calmly in real situations. Most companies will have regular "fire drills", where an alarm is sounded and the building is evacuated. This gives everyone in the company an opportunity to calmly "walk through" what would need to happen in the case of a real emergency.

Fire Drills

One of the most effective ways to prepare for a fire emergency is by having regular fire drills. Steps are established and practiced repeatedly until everyone is familiar with the procedures. Fire drills are often initiated by sounding a fire alarm. This notifies the occupants that they need to exit the building calmly, quickly, and in an orderly manner.

For fires local to a small area, some staff may be trained as first responders to take action. For example, a method called "REACT" can be used for this purpose. REACT is an acronym outlining a set of steps that can be initiated as follows:

- **R**emove people from immediate danger
- **E**nsure the doors are closed
- **A**ctivate the alarm
- **C**all the fire department
- **T**ry to extinguish the fire, BUT ONLY IF IT IS SAFE TO DO SO!

The above steps are intended to be followed in order. Note that the last step is to "try to extinguish the fire." Taking care of people is the first priority. After ensuring the occupants are safe, isolate the fire behind barriers such as doors. Then, sound the alarm to warn others and to notify the local fire department of the emergency. Finally, attempt to extinguish and contain the fire while waiting help.

Posters containing these steps are often available from jurisdictional safety services. These posters should be located in areas with high visibility throughout the workplace as a reminder to employees in case of a fire emergency. As part of the safety orientation, employees are informed of the locations of the fire alarm pull stations and trained how to activate them.

Power Engineers often receive firefighting training specific to the type of industry where they are employed, and are designated as first responders. For example, in a hospital or school they may be expected to be familiar with the building equipment and services (such as gas lines and electrical power), so when a fire occurs they know where to shut off the services. They may also participate in a number of tasks such as:

a) How to reset pull stations.

b) How to shut off sprinkler lines that have been activated when they are no longer required.

c) How to attend to the fire alarm panels in the building and reset them, if necessary.

d) How to determine from fire panels where fires are located or when a system is experiencing "trouble."

e) How to activate and deactivate fire alarm zones during construction or maintenance.

f) How to service fire dampers.

g) How to reset fire doors and smoke hatches.

h) How to use fire hoses.

i) How to drain and roll up fire hoses that may have been used.

j) How to use the various fire extinguishers available to fight fires.

All jurisdictions across North America require regular fire drills, depending on the building occupancy, for the following reasons:

a) To allow employees to practice and memorize fire response procedures.

b) To assess and improve fire response procedures.

c) To provide an opportunity to test the fire alarm system.

Power Engineers must consult site-specific requirements. This also includes evacuation procedures.

OBJECTIVE 2

Explain the five classes of fires, and describe the types of fire extinguishing media and how they act on these fires.

CLASSES OF FIRES

There are five classes of fire.

1. Class A
2. Class B
3. Class C
4. Class D
5. Class K

Class A

Class A fires consist of ordinary combustible materials such as:

- Wood
- Cloth
- Paper
- Rubber
- Many plastics

Usually a Class A fire is anything that leaves behind ash, though some plastics may burn completely.

These fires are extinguished by:

a) **Cooling the fire with water and water solutions.** This is the primary method associated with extinguishing a Class A fire. Each litre of water placed on a fire removes about 2257 kJ of heat as it evaporates. The evaporating water removes heat from the fire so rapidly that the fire can no longer remain hot enough to continue burning.

b) **Coating the fuel with dry chemicals which retard combustion by excluding oxygen.** The dry chemical from this type of extinguisher coats the fuel, separating it from the oxygen in the air. Unlike water, the dry chemical does not penetrate and soak the fuel. Also, dry chemical does not lower the temperature of the fuel like water does.

c) **Interruption of the combustion chain with dry chemicals.** The dry chemicals from this type of extinguisher interfere with the self-sustaining chain reaction of the fire, causing it to go out. Dry chemicals do not reduce the temperature of the fuel like water does.

d) **Interruption of the combustion chain by halogenated agents.** Halotron is a gas that interferes with the self-sustaining chain reaction of the fire. In this way, the fire is extinguished. Like dry chemicals, halotron does not soak or reduce the temperature of the fuel.

Note: Halotron is an environmentally acceptable replacement for halon gases, which have been banned in Canada due to their harmful effect on the ozone layer.

e) **Removing oxygen from the area.** Fire needs oxygen to burn. Class A fires can be smothered with fire blankets. Carbon dioxide (CO_2) gas can also smother fires. However, it is not recommended for use on a Class A fire because CO_2 does not cool the fuel. Once discharged, the CO_2 dissipates quickly and allows oxygen to access the hot fuel, which can then re-ignite the fire.

Class B

Class B fires involve flammable or combustible liquids such as:

- Oil
- Gasoline
- Greases
- Or similar material such as solvents

Class B fires do not include cooking oils or grease.

These fires are extinguished by:

a) **Smothering the fire** by covering the liquid fuel with an inert gas, to remove and separate the oxygen from the fuel.

b) **Interruption of the combustion chain reaction with dry chemicals.**

c) **Coating the fuel with dry chemicals which retard combustion by excluding oxygen**

d) **Inhibiting the release of combustion vapours.**

Note: Water must not be used to put out a Class B fire. Burning oil floats on water. Applying water will cause the oil fire to spread. Water rapidly boils when applied to fires. The boiling action will cause burning oil to be sprayed on the surrounding surfaces. However, in some cases water can be used as a fine mist (fogging) from a special nozzle used by trained and experienced individuals.

Class C

A Class C fire is an electrical fire, which means that there is electricity present in the burning area. An electrical fire is usually caused by electrical connections that overheat or by an electrical arc which ignites combustible material.

To put out this type of fire, non-conducting extinguishing elements must be used. Otherwise, the fire fighter runs the risk of electrocution. For example, water conducts electricity. This allows the electrical current to flow through the water and shock the person fighting the fire. If the power is shut off, what remains is a Class A or Class B fire which can be extinguished by the methods described above.

CO_2 is a commonly used medium for extinguishing Class C fires, because it is non-conductive and leaves no residue behind. However, if the power is not shut off, this type of fire may re-ignite after the CO_2 dissipates.

Class D

Class D fires involve combustible metals including:

- Magnesium
- Potassium
- Sodium
- Zirconium
- Titanium
- Calcium
- Lithium
- Uranium

Although Class D fires are not very common, understanding the potential risks is important. Most people do not expect metals to catch on fire. These fires can spread rapidly from a small fire into a dangerous situation if appropriate actions are not taken quickly.

As well, extinguishing media used for Class A, B, and C fires are ineffective for Class D fires, and can actually further spread or intensify the fire. Metals that are burning require a heat absorbing extinguishing media to put out the fire, such as graphite in powder form and sodium chloride in granular from.

Class K

Class "K" can be taken to mean "Kitchen." A Class K fire occurs with oils and greases common to kitchens such as:

a) Animal or vegetable fats

b) Oil or grease on a grill or in a deep fryer

To extinguish a Class K fire, these methods can be used:

a) Class K fires are successfully extinguished in the same way as Class B fires. A Class B extinguishing product that smothers and removes the oxygen from the area is recommended.

b) A practical method used in kitchen fires is an extinguishing medium called a **wet chemical,** which can be used on a deep fryer fire, for example. The wet chemical extinguishing agent has a cooling effect, and creates a barrier between the hot grease/oil and the air (oxygen).

Extinguishing Media

The means of extinguishing a fire can be summarized into four categories:

1. Cooling
2. Reduction in oxygen content
3. Removal of fuel
4. Chemical flame inhibition

Fuel removal refers not only to the physical removal of the fuel, but also to the cutting off of fuel vapours from combustion (while in flaming mode). It may also consist of the covering of the glowing surface to isolate the fuel from the oxidizing agent.

The various broad classes of extinguishing media available use one of the following materials to extinguish a fire:

- Water
- Carbon Dioxide
- Dry Chemicals
- Wet Chemicals
- Aqueous Film-forming Foam (AFFF)
- Dry Powder
- Halogenated Agents

Water

Water is an efficient and readily available extinguishing agent used for Class A fires. It does so by cooling the combustible material, and by lowering its temperature to a point where combustion is no longer sustained. The water may also produce steam which will reduce the ambient oxygen supply.

It is a common misconception that water "smothers" a fire. Certainly if a deluge of water completely covering the fire occurs, then smothering does separate the air from the fire. However, water primarily reduces the fuel temperature by quickly drawing away the heat as it evaporates. This lowers the temperature to below that at which the fuel will burn, thus putting out the fire.

Carbon Dioxide (CO_2)

Carbon dioxide is noncombustible and therefore does not react with most substances. It primarily extinguishes by reducing the oxygen content of the atmosphere to a point where combustion can no longer be supported. It is used for Class B (flammable liquids) fires and for Class C (electrical) fires as it does not conduct electricity.

The CO_2 gas displaces the oxygen required for combustion. CO_2 has a minor cooling effect as well. Under some conditions of application, the available cooling effect can be helpful, especially where the CO_2 is applied directly to the burning material.

The principal advantage of CO_2 is that it does not leave a residue. This consideration is important in laboratories, areas where food is prepared and where there is electronic equipment.

Dry Chemicals

Dry chemical extinguishing agents are either regular or multipurpose. The regular dry chemicals are used for Class B or Class C fires. The multipurpose dry chemicals can also be used on Class A fires. Note that the dry chemical extinguishing agents do not penetrate some Class A materials that are on fire as well as water does (such as burning mattresses).

Wet Chemicals

Wet chemical extinguishing agents are a newer form of fire-fighting media. They are designed primarily for fighting Class K (kitchen) types of grease fires, such as the oil in deep fryers. Wet chemicals can also be used for Class A fires.

Aqueous Film-Forming Foam (AFFF)

This extinguishing agent is an "aqueous" (liquid water) film-forming "surfactant." Essentially, this is a soapy water foam that not only provides water to put out a Class A fire, but also spreads out as a film and covers the burning material to separate the fuel from the air. Therefore, AFFF both cools and smothers the fire.

Due to its filming and foaming qualities it will adhere to the burning material rather than run off as water would. This results in the foam not only cooling the fire, it smothers it also and provides a seal so that the air cannot return and reignite the fire.

When used properly, AFFF can be effective on Class B fires. It can be directed to spread foam over the oil or grease fire. Water on the other hand, would splash and cause a bigger fire. AFFF is conductive, so it cannot be used on electrical fires.

Dry Powder

Dry power extinguishing agents are used on Class D (combustible metals) fires.

Metals will burn, particularly if they are in a finely divided form. Some metals burn when exposed to external heat. Other metals burn from contact with moisture or reaction with other materials.

Dry powders are often a combination of chemicals that are determined by the type of combustible metal that is on fire. For example, Graphite in dry powder form is an effective extinguishing media for a Class D fire. The dry powder covers the metal and smothers it so that oxygen is separated from the burning surface. Use the appropriate extinguisher according to the manufacturer instructions.

It is expected that additional training for these types of fires and their appropriate extinguishing agents will be provided at the worksite. This training should also include the warning that dry **powder** extinguishers are not be confused with dry **chemical.**

Halogenated Agents and Halotron

Halon extinguishers were commonly used from the 1970's onward in control rooms and computer rooms to rapidly extinguish fires without leaving damaging residue. Halons were much more effective than CO_2. However, halon is quite damaging to the environment and harmful to people when breathing the halon fumes. Therefore, the use of halon has been abandoned.

It is unlikely that Power Engineers will use or even encounter halon fire extinguishers. Most, if not all, jurisdictions have completely phased out halon use.

Halotron is a replacement medium that operates in the same way as halon but with fewer negative environmental effects. Like halon, it interferes with the uninhibited chain reaction that occurs in the flaming mode of the combustion process. It is effective on Class A, B and C fires, does not conduct electricity, and is not corrosive.

The extinguishing medium is a pressurized halocarbon. It discharges as a rapidly evaporating liquid that boils at a higher temperature than many other fire-fighting liquids (27°C in the atmosphere). This allows the medium to reach farther into a fire before evaporating, making it an effective extinguishing agent.

Objective 3

Explain fire prevention.

The safest fire is one which is never given a chance to start!

The best method of dealing with a fire is to prevent the fire from occurring in the first place. Various methods of fire prevention will be described in this objective. Some examples of ways to prevent fires are:

a) Keep areas free and clear of debris.
b) Remove flammable material from the location.
c) Store flammables in the proper areas and building structures, or in equipment built from non-flammable or fire resistant material.

Fire Risk Assessment

An effective method of fire prevention is to **assess the possibility of a fire occurring** in any location of a working environment. Reviewing an area for risks can result in the implementation of simple procedures. For example, storing flammable materials in self-contained areas that are located a safe distance away from any ignition source. A fire risk assessment can identify potential fire hazards and reduces the threat of a fire occurring.

The Canadian Centre for Occupational Health and Safety provides rules for risk assessments, which can be applied to **Fire Risk Assessment:**

a) Identify fire hazards
b) Evaluate the risk associated with that fire hazard
c) Determine appropriate ways to eliminate or control the fire hazard

Competent or qualified individuals, such as Power Engineers, should assess all areas of the plant for fire hazards. These individuals should be familiar with both fire and safety practices, and with the plant itself. The intent is to:

a) Identify any hazards.
b) Evaluate the possibility of a fire starting and the severity of the impact.
c) Develop steps to take to ensure the fire does not happen.

Identifying fire hazards may involve the inspection of the workplace by a designated party, for example, the fire and safety committee or representative. The inspector may use tools such as:

a) Checklists.
b) Documents identifying the types of material in the area for their flammability potential.
c) On the job experience to determine where and how a fire hazard may exist.

It is not unusual to discover flammable material that has "always been stored there" and was previously overlooked in the past.

Evaluating the risk associated with that fire hazard. This involves looking at everything from a fresh perspective of what could cause a fire. Consider the possibility of:

a) Debris build up over time.
b) The nature of the material in the location.
c) Whether it is possible to move the material to a safer location.
d) Occasional or temporary placement of hazardous materials in an area where they may not normally be present.
e) The removal of barriers or protective methods that had previously been in place.

Controlling the hazards may require solutions such as:

a) Relocating the identified hazard to a safer area.
b) Providing protection so that flammable material in the area can no longer come in contact with a heat or ignition source.

Flammable debris must be regularly cleaned up. Replacement of guards and barriers may be necessary. Non-flammable materials can be substituted for flammable materials, where possible.

Regular fire hazard inspections may be implemented. Individuals that work in the area may require training so that they can recognize fire hazards and prevent fires from happening. As well, they should be able to respond should a fire break out.

General Provisions Preventing a Fire from Occurring

There are numerous ways to prevent fires in a plant or industrial setting. These methods will be explained in the following paragraphs.

Fire prevention practices include:

a) **Prohibiting smoking**
b) **Allowing cooking only in prescribed areas**
c) **Prohibiting fires and heat of any kind around combustible material**

It is also effective to have equipment in place that will automatically extinguish a fire, and having fire prevention equipment readily at hand to manually fight a fire if required.

Housekeeping is very important for fire prevention. Keep all areas clean and free of a buildup of combustible materials. There are various conditions in which these materials can build up and become fire hazards.

A **schedule of regular inspections and cleaning**, if necessary, should be implemented and monitored. Power Engineers may be required to do the sweeping and washing in a power house as it may not be safe for untrained personnel to come into the plant to do so. Work is to be considered incomplete until the debris created from the work has been cleaned up, especially if an area can become a fire hazard.

Specific Power Plant Fire Prevention Methods

A Power Engineer will likely encounter fire hazards that those in other professions do not. Power Engineers burn fossil fuels as part of their normal operating duties. Power Engineers, then, must have special knowledge about safe storage, handling, and precautions when working with fuels. It requires extra diligence to make sure the only fire in the plant stays in the boiler furnace instead of spreading out to any surroundings – a particular concern for some solid fuel boilers.

The following points cover fire prevention from the aspect of eliminating parts of the fire tetrahedron. Specifically discussed are removing:

1. Oxygen (air)
2. Fuel
3. Heat or ignition source

Heat or Ignition

Preventing possible heat sources from igniting combustibles can prevent fires.

Process equipment, while operating, can create heat. Examples of sources of ignition are:

a) Electric motors
b) Steam lines
c) Hot water or hot oil lines
d) Tanks containing hot process material

For example, in a sawmill it is not uncommon for dust to accumulate on motor surfaces. Regular cleaning of the fins of a motor removes the insulating properties of the dust, and reduces the possibility of the motor overheating.

In contrast, applying proper insulation to boilers, steam lines, and hot process tanks keeps the heat inside these tanks and lines, and protects employees from burns. Some sawmill boilers operate at steam temperatures hotter than the ignition point of paper. In this situation, insulation not only protects the workforce, but also prevents hot surfaces from contacting combustible material.

Another example of an ignition source involves pulp mill boiler operation. A balanced draft boiler, such as a recovery or a hog fired boiler, can have blow-backs due to furnace pressure excursions. A blow-back will shoot burning fuel from ports in the boiler. Areas surrounding these ports should be constructed of fireproof material such as steel or cement, with no storage of flammable materials permitted.

Control Ignition Sources

There are two ways to control sources of ignition from heat:

a) Keep the process equipment clean so that heat does not transfer to any combustible material that may be present.
b) Contain the heat by insulating it from the rest of the equipment.

If something can burn, then protect it with a protective non-flammable cover, where possible. Otherwise, separate the combustible material from any source of ignition, and store it in an area safely away from sources of ignition. Other ignition source prevention methods are outlined below.

a) **Clean chimneys and stacks.** Inspect the chimneys, exhaust stacks, and ducting. Make sure that there is no buildup of combustible products, and clean the passages if necessary to prevent a fire from occurring. Ensure combustible materials are stored away from boiler chimneys and vent connectors.

b) **Storage around heat sources.** If possible, remove all combustible material and place it at a safe distance from the heat source. However, this may not always be possible. Consider a boiler fuel line; it must not have any leaking gaskets, packing glands, and pipe joints. Oil drips can be caught in trays temporarily until the leak is identified and repaired. In some situations, temperature sensors, extinguishers, sprinklers, or fire insulating media may be installed.

c) **Identify hazardous areas with warning signs**. Areas where workers may encounter flammable materials should be identified with warning signs that establish an area as having a possible fire risk. Often, these signs specify minimum safe distances for potential ignition sources (such as cigarette or cell phone use).

d) **Keep equipment clear of debris or other material.** Do not permit material to pile up around heat sources, as it can cause overheating and potential ignition.

e) **Keep equipment that may overheat well ventilated.** Equipment ventilation allows for air to cool off equipment that can overheat. In some locations, an HVAC system can be installed to maintain a lower temperature where equipment is prone to overheating.

Other sources of ignition include:

a) Static electricity that is discharged from material handling systems (such as plant vacuum hoses and fuel transfer stations).

b) The use of electronic devices such as cell phones and two-way radios.

When using hoses to transfer process materials in hazardous areas, or when transferring combustible products, hoses, pails and drip pans must be grounded to dissipate the static charge that may build up and cause a spark.

Two-way radios and other electronic devices must be intrinsically safe when used in plants such as oil refineries and natural gas processing plants. Most cameras and cell phones are NOT intrinsically safe, and may create ignition sources. Therefore, these devices are usually prohibited at the worksite unless used under a hot-work permit.

Hot Work

Hot work is categorized as work done that creates hot conditions or sources of ignition. Hot work may include:

a) Welding or brazing

b) Flame cutting

c) Use of a torch to heat frozen process lines

d) Grinding

e) Use of electric corded or cordless tools, such as drills or circular saws

Hot work requires special procedures, and the assignment of specific responsibilities.

A checklist should be created as part of the Field Hazard Assessment of the Safe Work Permit process to identify and remove possible fire conditions before starting any hot work.

a) Check the area prior to start for possible hazardous conditions that can contribute to a fire.

b) Remove any combustible material or debris away from the hot work area to a safe or safer area if possible.

c) Provide barriers or non-flammable covers to protect materials and equipment that could potentially ignite.

d) Wet down the area if possible to reduce the chance of ignition from sparks or welding spatter.

e) Have a water hose and/or fire extinguisher present. Ensure that there is an individual present (this could be the worker doing the hot work) that is trained in fire extinguishing methods.

f) Control or direct sparks or other potential heat sources that could cause ignition.
g) Assign a Fire Watch to monitor the work for any potential fire creating conditions and respond if necessary.
h) After the hot work is complete, the worker or assistant should review the work to ensure all ignition sources are eliminated. For example, any hot metal scraps left in the work zone can be cooled down and removed.
i) Check the work area later in the shift after work is completed. In some plants, the Fire Watch must stand by for an hour or more after the work is complete, watching the area for signs of smoldering or of a potential fire.

Electrical Equipment

To prevent electrical equipment from becoming heat or ignition sources:

a) Use only approved equipment rated for the work.
b) Electric cords must be in good condition and rated for the conditions (moisture, oil, or abrasion resistant as needed). Use heavy-duty industrial cords that are built to withstand rough industrial use.
c) Inspection of electrical cords should be done before and during use to ensure they are safe to use.
d) In areas where pests can potentially damage equipment, pest control should be initiated to limit "wear" on electrical equipment.
e) Avoid using extension cords if possible.
f) Have defective equipment repaired or replaced promptly.

Oxygen or Air

Increased oxygen concentrations increase the possibility of a fire, or will accelerate a fire. An oxygen-enriched environment is described as having a percentage of oxygen in the atmosphere at or above 22 percent. Oxygen tanks and cylinders used in plants for flame cutting or medical purposes can create oxygen-enriched environments. Even compressed air from tanks or air lines may accelerate combustion. Therefore:

a) Use caution with oxygen tanks – ensure fittings and connections are not leaking.
b) Watch for oxygen enrichment activities such as chemical reactions that could generate excess oxygen.
c) Increase ventilation to prevent buildup of oxygen enriched areas. Ensure forced air or induced air fans are operating, and other related equipment such as dampers and registers are operating or positioned properly.
d) Never smoke in areas where oxygen is used or stored.
e) Never use oil or grease on oxygen equipment, as oil and grease are more likely to ignite in contact with the high oxygen concentrations.
f) Tanks containing combustible or pressurized media should be stored away from other buildings, and away from ignition sources. Oxygen tanks should not be stored near acetylene tanks or other flammable sources.
g) Areas where oxygen concentrations may increase can be monitored with sensors and alarms.

Fuel

Keep fuel – gases, liquids or solids – from burning anywhere except where intended. In order to do so, the following points will be discussed.

a) Identify all combustibles.

b) Store all combustibles properly.

   i. Do not store combustibles with heat emitting units nearby.

   ii. Store dry combustibles separately from flammable liquids, gases, and solids.

   iii. Store flammable liquids and gases in proper cabinets.

c) Ensure that **combustible materials** used in the plant are **properly stored.** Gas cylinders not in use should be stored outdoors in an enclosure separate from the main building. Those in use in the plant should have two sets of chains holding the cylinder in place. Oil and grease should be stored away from other buildings in an enclosure properly equipped with fire prevention equipment rather than kept inside the power plant. Any grease or oil that is being used in the plant should be kept clear of all combustible conditions, and stored even temporarily in approved areas. Rags, papers, garbage, and other potentially combustible materials should be stored properly in approved areas.

d) Transport all fuels properly.

e) Areas that store waste wood material, grains, flour, or any other material that can create dust must be in a location that is physically isolated from any heat source, and insulated from any possibility of electrical sparks. These dusty areas can have dust suppression systems similar to those used handling coal. These are essentially large and powerful vacuum cleaning systems that collect and filter dust from where it may accumulate. Anything that can create piles of wood waste that build up over time, such as a buildup of debris under a conveyor, need to be swept or hosed away on a regular basis – especially any that can build up and rub against the belt and cause friction, or cover a bearing or motor and cause overheating. The cooling fins of motors should be cleaned of any dust that can build up over time.

f) Sawdust and waste wood material from sawmills are a valuable fuel commodity, and are burned in "hog" boilers (wood that has been ground up or "hogged" and is suitable for burning). Hog fuel spills from conveyors and accumulates under the conveyor belts. Static discharge from the conveyor belts or overheated motors and bearings can ignite the fuel and cause disastrous conveyor belt fires. Regular use of a shovel or pitchfork or hose for cleanup and removal of these build-ups is necessary.

g) Fuel line and equipment oil line leaks must be cleaned up and repaired as quickly as possible.

h) Coal dust must be removed from surfaces as it accumulates. Coal dust suppression systems must be in use whenever bunkering is active. Firing floors must be cleaned several times a day.

i) Blowback from a solid fuel boiler can introduce combustible material to the areas surrounding the furnace ports. This material must be removed by hosing down the area and/or sweeping.

j) Plants must be constantly monitored with both automatic fire detection equipment and with operators performing physical rounds.

k) A schedule of regular inspections and cleaning should be implemented and monitored.

Spontaneous Combustion

Spontaneous combustion refers to combustion that occurs without any apparent external ignition source. Anything flammable will ignite, when its temperature is raised high enough. Slowly oxidizing material will give off heat. If the heat cannot dissipate, the temperature of the material will increase until the ignition temperature is reached. This can happen in piles of hay or straw, in coal piles, and even in piles of rags. Spontaneous combustion can occur even in areas that are at room temperature.

This process is different from raising the temperature of the surrounding environment to ignition temperature with an outside source of heat. Anyone familiar with composting will recognize that the composting organic material (grass, garden clippings, etc.) develops its own heat. Oil rags in a pile are particularly vulnerable to spontaneous ignition, because the rags have an insulating effect, and trap heat inside the pile.

To prevent the occurrence of spontaneous combustion:

a) Flammable material such as oily rags should be stored in proper receptacles.
b) Conduct regular rounds to detect any possible signs of combustion, such as hot spots or smoke.
c) Monitor the potentially flammable material with temperature sensors and alarms. This is often done at power plants with bulk coal storage.

Fire Protection Standards, Laws and Regulations

Preventing fires is about preserving life as well as property. Buildings need to be constructed according to federal rules and regulations. In Canada, the **National Fire Code** and the **National Building Code** specify how buildings are to be constructed. They state the requirements for fire detection and suppression systems, based upon materials of construction and type of occupancy. Depending on the facility layout, its occupancy (industrial, commercial, residential, institutional, etc.), and its materials of construction, a facility will require various devices working together in order to promote fire safety. These devices may include:

a) Fire zones and fire separation between zones, including fire doors and dampers.
b) Smoke and fire detectors at specific locations.
c) Sprinklers of specific types, at specific locations.
d) Standpipes and fire pumps.
e) Fire hose cabinets and extinguishers at specific locations.
f) Smoke hatches.
g) HVAC fan/fire alarm interlocks.
h) Stairwell pressurization fans.
i) Pull-stations.
j) Alarm annunciation panels, horns, and lights.

Please note the above list is not comprehensive.

Provinces, territories, and often cities have similar regulations that are mostly consistent with federal regulations. They often reference the same supporting documents as federal regulations (or simply adopt the federal regulations as part of their regulations). These regulations take into account unique regional situations that may not be accounted for in the federal codes.

Other codes such as the **US National Fire Prevention Association (NFPA)** codes are an excellent resource and are frequently referenced by Canadian laws or even adopted directly as law.

Objective 4

Discuss fire prevention methods for the five classes of fires.

Methods of Preventing the Five Different Types of Fires

Class A Fire Prevention

To prevent a Class A fire from starting, there are a number of additional measures, as well as, the general methods mentioned above that can be applied:

a) **Regular cleaning** is an effective method of removing accumulations of Class A type material so that it does not build up to a combustible volume. Class A material is of particular importance to the Power Engineer in plants such as pulp mills, sawmills, and coal-fired plants, where the fuel is a Class A material. Fuel can accumulate in various locations of the plant (such as alongside conveyors, at tripper floors, and atop bunkers). Regular sweeping, vacuuming, mopping, hosing and washing are key to preventing Class A fires.

b) **Hose any vulnerable areas down regularly.** Even if regular cleaning occurs, areas that are inaccessible to sweeping and cleaning can exist. A useful method of removing the buildup of Class A material is to hose down the area. Water not only washes away Class A material, but it also wets down any remaining material, thus reducing the likelihood of ignition. One should first ensure that equipment in the area is protected from water with barriers or covers before the hose is turned on. Some areas cannot be hosed down, such as any opening into a black liquor recovery boiler. A devastating explosion could occur if water gets into the furnace of a black liquor recovery boiler. A hose accidentally aimed at an open port into a furnace can be a life threatening condition.

c) When there is possible exposure to an ignition source, **clothing should be fire-rated.** This applies particularly to those working around boilers or other sources of heat, such as welders.

d) **Install sprinklers** in areas that have Class A material. Water is extremely effective in putting out Class A fires. Sprinklers react automatically to extinguish fires, and to prevent fires from getting larger.

Class B Fire Prevention

Oils and greases are most effectively prevented from igniting by separating the fuel from the ignition source and by keeping the fuel from coming into contact with air (oxygen). Some methods are:

a) **Maintain fuel-containing pipelines.** Leaking valve packing, screwed fittings and gaskets permit Class B materials to contact air. Leaks must be identified and immediately repaired. Puddles must be absorbed and the absorbent properly disposed of.

b) **If clothes have come in contact with oil or grease, be aware that they can be flammable. Also, clothes – coveralls, for example – for laundry should be stored properly.** Coveralls may no longer be flame retardant if they have become covered with grease, oil, or even insect repellent. Spontaneous combustion with oily clothes – or rags – can occur if they are left in a pile and exposed to the air. Laundry services have been known to have piles of clothes burn, and ignite in dryers even after they have been washed. Piles of rags used in work with oil and being discarded can also spontaneously combust. Store oily clothes and rags in proper storage or disposal areas.

c) **Oil storage tanks and lines must be constructed according to code.** Fuel storage tanks are vented to the air to permit changes in the tank volume as fuel is withdrawn, added, or changes in volume with temperature. The tank must not be exposed to any ignition source, especially near the vent. Note that safety codes require that any temporary sources of ignition such as welding near the vent is not permitted. Welding or cutting a tank that has contained fuel is a dangerous and usually prohibited practice, as the tanks can absorb fuel and explode. Fuel tanks are also required to have a berm or spill container that will hold the entire contents of the tank in the case of a leak. Fuel tanks can also be constructed with double walls with detection devices between the two walls to detect any leaks from the inside container. Oil containers should be stored away from ignition on a platform that has a large enough reservoir to hold a leak or spills.

d) **Oil or grease spills or leaks should be cleaned up**. A buildup of grease for example around grease nipple can be ignited by an overheated bearing or welding spatter. Grease or oil dripping down to a lower area can also be susceptible to ignition.

e) **Grease, oil, and tools such as grease guns and pumps should be stored in proper areas.** Flammable materials such as greases, oil barrels, and other related equipment should be stored in vented buildings at a safe distance from other buildings and areas.

f) Of particular importance to a Power Engineer is that **the boiler fuel oil systems near the burner be kept free from oil**. Oil guns are inserted and removed from boilers regularly, and drips and spills are common. It is not unusual to have trays containing absorbent material located under the burner guns. This also includes areas where the guns will be cleaned and serviced.

Class C Fire Prevention

Class C fires become Class A and Class B fires once the electrical power is turned off. Class C electrical fires start when the ignition source – the heat due to over-current or electrical arc – ignites the flammable material it is in contact with. To prevent these conditions from occurring:

a) All electrical installations must follow **electrical code** so that overheating and arcing do not occur. Power Engineers should ensure that electrical tradespeople have installation permits, and that the equipment is inspected before being placed in service.

b) **Ensure all electrical equipment purchased, installed, or used on site is approved by CSA, ULC or some other accepted approval agency**. Power Engineers can look for approval stamps or labels on the equipment nameplate of portable electric power tools, extension cords, appliances, and lighting.

c) **Do not put flammable material on or near electrical equipment.** For example, do not store small lubricating oil cans or paper towels in a breaker panel or in the electrical room.

d) **Regular inspections** should occur to ensure there is no damage to electrical equipment. Electrical cords should be checked for wear and are either repaired or replaced. Motors should be cleaned of dust accumulations.

e) If necessary **covers and protection barriers** should be installed over electrical equipment. Breakers and motor control centres should be protected from leaking water or other fluids. If water may be present outside of an electrical room then there should be a lip at the bottom of the door to act as a dam to prevent water from leaking under the door. Water services should not be installed near electrical equipment.

f) **Operators should be trained to safely operate the main breaker and electrical isolation switches.** During an emergency, a Power Engineer may be required to electrically isolate certain areas of the plant.

Preventing Fires in Areas having Electrical Classifications

Class I electrical equipment must be designed to be fire safe in any area where there may be the presence of flammable gases or vapours.

> *To prevent fires from occurring within a Class 1 designated area, electrical equipment* (even portable equipment) such as lights, switches, breakers and controllers must be of an acceptable explosion proof design and be hermetically sealed or immersed in oil, so that the electricity cannot ignite an explosive atmosphere.

Class II locations are concerned with the presence of **combustible dusts** that can exist in explosive concentrations.

> *To prevent fires from burning in these dusty areas the electrical equipment should be contained in dust tight enclosures.* Lights or lamps should be designed to accumulate minimal amounts of dust, be protected from damage by an acceptable guard or by location, and clearly marked to indicate wattage.

Class III locations involve the presence of airborne material fibers that are easily ignited.

To prevent a Class III location fire, the motors, lamps, switches, circuit breakers, controllers and other electrical equipment must be enclosed with tight covers. Lights and lamps must have their wattage clearly marked.

Class D Fire Prevention

It is unlikely that the average Power Engineer will encounter a Class D fire. However, if combustible metals exist in the plant, operators need specialized training to fight Class D fires. Training must address the specific metals that are on-site, because particular combustible metals require particular extinguishing materials.

The Power Engineer should be familiar with how to prevent Class D fires from occurring. Some measures include:

a) Store combustible metals away from potential ignition sources. Ignition sources could be traditional heat sources, or materials that may react with and ignite a combustible metal. Such a reaction would arise from contact between a specific metal and a specific reactant (such as sodium and water). Therefore, it is necessary to understand the reactivity of a particular metal with a particular substance, and to keep the two substances far from each other. The material would have to be identified by an individual familiar with the metal in question, who can determine which specific material is to be kept from the metal.

b) Signage should be in place that states what combustible metal is being stored and what materials cannot be stored near the metal.

Class K Fire Prevention

A Class K fire involves kitchen greases and oils that burn at high temperature. While essentially a Class B fire, the type of oil and grease used in kitchens and the dangerous conditions under which they are used (large open containers of heated oil) increase the likelihood of a large and destructive fire. To prevent Class K fires:

a) Turn off electric power to the oil and grease heating elements when not in use.

b) Do not leave heated oil workstations unattended, even when first warming the oil.

c) Continually monitor the temperature of the oil while the cooking station is in use.

d) Fill the oil and grease reservoirs when they are cool. This will protect the individual from being splashed, and it will reduce the possibility of ignition.

e) Cover the oil and grease containers with metal covers to prevent any ignition sources from falling into the oil.

Chapter Summary

It is important to understand the types of fires and how they burn in order to be able to prevent them. Different classes of fuels require different preventative measures to reduce the possibility of fire.

The Power Engineer or other workers on site should:

a) Be able to determine which one of the five classes of fire they are dealing with.

b) Know what fire preventative methods are available.

c) Be able to apply preventative measures effectively.

Recall that fires have both a reducing agent and an oxidizing agent that interact to create a fire. The fire tetrahedron explains how a fire continues to burn. The four elements are fuel, oxygen, ignition and a self sustaining uninhibited chain reaction. If any one of these elements is removed, a fire cannot start, and an existing fire cannot continue to burn.

Once the student understands the basics of how a fire can occur, methods of preventing these different classes of fires can be implemented. There are standard preventative measures such as restricting areas as no smoking, cleaning the area, or removing flammable materials to a safe area. Power Engineers should also recognize that they handle combustible material as a regular part of their job – not just the fuel for the boiler, but also other combustible materials on the worksite. As a result, Power Engineers must pay greater attention to possible fire conditions.

Power Engineers must understand how electricity can ignite combustibles in various hazardous locations. Recognizing the consequences of what can happen when there is a blow back from a balanced draft boiler, or storing oil and grease in an outside enclosure away from ignition sources are extra situations that the Power Engineer should be trained in. These and others mentioned in this chapter are effective methods of preventing fires from happening.

CHAPTER 5

Fire Extinguishing Methods and Equipment

Learning Outcome

When you complete this chapter you should be able to:

Describe typical fire extinguishing equipment and its operation in plant environments.

Learning Objectives

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

1. Describe the construction and operation of various types of portable fire extinguishers.
2. Discuss the inspection and maintenance requirements of portable fire extinguishers.
3. Describe the types, layout, and operation of standpipe and sprinkler systems.
4. Discuss the maintenance requirements of standpipe and sprinkler system components.
5. Describe the purpose, operation, and maintenance of fire pumps.

Chapter Introduction

Fire extinguishers and fire hoses connected to internal or external fire water supply systems are the first line of defense to put out fires. Federal and provincial Fire Regulations require extinguishers to be readily available at most industrial sites in the event that someone is available to respond. Sprinklers operate automatically. Fire hoses are effective when used on larger fires.

Fire extinguishers are commonly used to put out small fires, either in their beginning stages, or if they are contained in a small area or location. The challenge is knowing which type of fire extinguisher to use on a particular fire. When attending to fires, first responders must be familiar with the different types of fires, and the effect different types of extinguishers have on these fires. Using the wrong extinguisher on fires can make them worse.

Previous material has discussed the manner in which fires progress, the various materials that may be burning, and how to identify them. This material will focus on the use of fire extinguishers – the types, how they are constructed, how they operate, and which extinguisher is most effective for each type of fire. Class K is a new class of wet chemical type extinguisher. It will be introduced as another method for responding to kitchen grease fires. Maintenance of extinguishers will be discussed.

This chapter will discuss automatic sprinkler systems: how they are triggered, how they suppress fires, and the basic requirements for their maintenance and operation. Standpipes are large pipes that are installed vertically on buildings taller than three stories. These pipes help firefighters with pressure loss in their hoses, for fighting fires in taller buildings. Combination systems for standpipes and sprinkler systems will also be covered, along with the codes that govern them.

The last topic is about stationary fire pump operation and inspection. This content is about ensuring fire pumps are ready when needed.

Objective 1

Describe the construction and operation of various types of portable fire extinguishers.

Fire Extinguisher Operation

CAUTION

Additional hands-on training in fire extinguisher use is usually required at each place of employment.

The most common instructions for using fire extinguishers involves the acronym **PASS**:

P – Pull the pin

A – Aim the nozzle

S – Squeeze the handle

S – Sweep the extinguisher spray at the fire

Fire extinguishers are equipped with ring pins that lock the operating lever, to prevent accidental discharge.

To operate an extinguisher:

1. Set it on the ground, hold the handle loosely in one hand (so as not to squeeze the handle and have the extinguishing agent blow out unintended), and pull out the ring pin with the other hand.
2. Move the unit to the best position.
3. Hold the hose in one hand, and squeeze the discharge lever with the other.
4. Aim the extinguisher at the base of the fire, and sweep the nozzle back and forth. Do not sweep too fast. Fire extinguishers are most effective when their spray lingers briefly when sweeping.

Figure 1 shows the general instructions found on a fire extinguisher, as well as, the class of fires that the extinguisher is suitable for.

Figure 1 – Fire Extinguisher Instructions

Construction and Operation of Portable Fire Extinguishers

Approved fire extinguishers are grouped by their mechanical action of operation:

1. Stored-Pressure
2. Pump Tank
3. Self-Expelling
4. Cartridge or Cylinder Operated

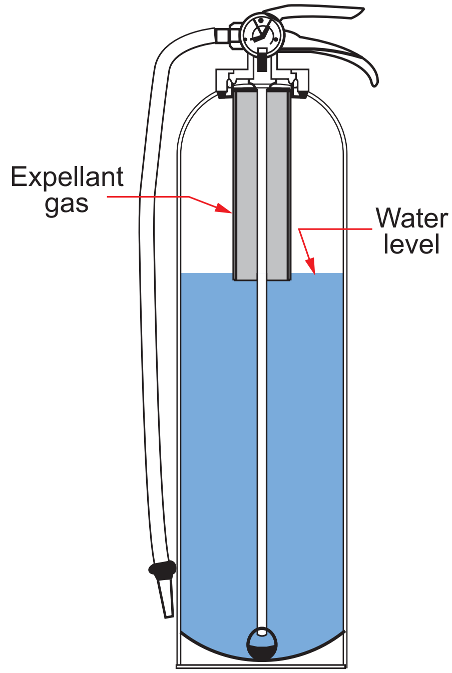
Stored-Pressure Type

A common type of stored-pressure extinguisher contains 10 litres of water, and has a mass of about 14 kg. It can be operated intermittently, and is easily recharged.

A stored-pressure extinguisher has a single chamber, which contains both the agent and the expellant gas. The cap, or head assembly, consists of a siphon tube, combination carrying handle/operating lever, discharge valve, air pressure valve, pressure gauge, discharge hose, and nozzle.

The stored-pressure water extinguisher is shown below.

Figure 2 – Stored-Pressure Water Extinguisher



The extinguisher is pressurized with compressed air or an inert gas. The pressure is in the range of 600 to 900 kPa. The air or gas is charged through a **Schrader valve** on the head.

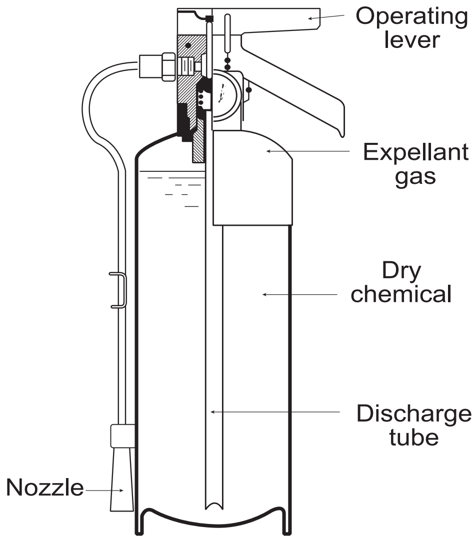
Another stored-pressure extinguisher is the Type K for kitchen fires.

Figure 3 – Class K Fire Extinguisher

Some dry chemical extinguishers are also of the stored-pressure type, with either a rechargeable or disposable shell. The disposable shell type has the agent and the expellant gas factory sealed. The shell is then screwed onto a valve and nozzle assembly. Some smaller extinguishers are of a throwaway type, where the entire device is disposed of after use, or after expiry.

Figure 4 shows a dry chemical stored-pressure extinguisher.

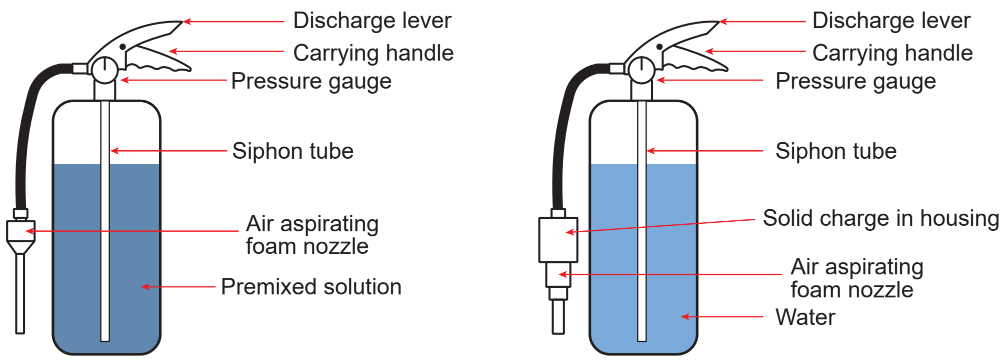
Figure 4 – Dry Chemical Extinguisher



Stored-pressure type

The **Aqueous Film Forming Foam (AFFF)** type of extinguisher is suitable for water-soluble flammable liquids such as alcohols, acetone, esters, or ketones. The hand-held extinguisher is a stored-pressure type. One type has a liquid solution of AFFF in the tank. Another type has plain water in the tank, and a replaceable charge of solid AFFF in part of the nozzle. Both types have an air-aspirating nozzle. The two types are shown in the figure below.

Figure 5 – AFFF Extinguishers



Pump Tanks

Two types of pump tanks are available:

1. Floor-Standing model
2. Backpack model

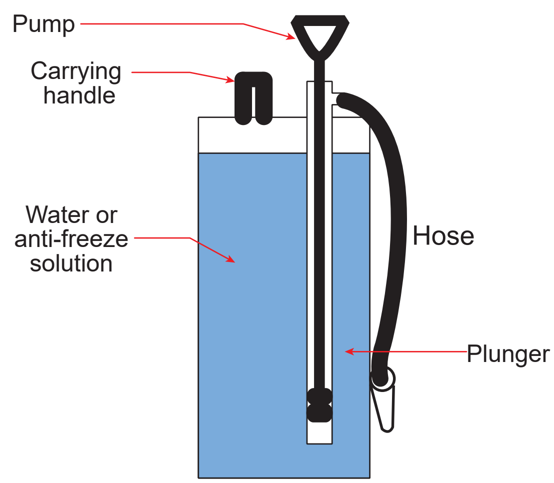
The **floor-standing** model shown in Figure 6 is a cylindrical tank, with carrying handles on the container or built into the pump handle. Lighter tanks have a hinged footrest so the tank does not move around as it empties. The tank capacity ranges from about 7 to 25 litres. The pump is a vertical piston type, mounted inside the cylinder. A short length of hose with a discharge nozzle is attached to the external part of the pump.

To operate the pump:

1. Set the unit on the ground, and lower the foot rest.
2. To force water through the hose, pump the handle up and down with one hand, while holding the hose in the other hand.

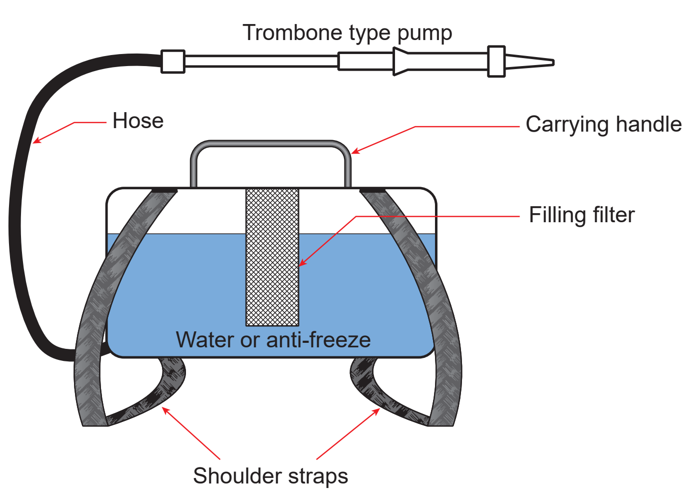
The disadvantage of this type of unit is that to move the unit, pumping must stop. Also, the force, range, and duration of water flow depends to some extent on the operator. The duration of operation ranges from 45 seconds to 180 seconds, depending on capacity. The range of the stream is 9 m to 12 m.

Figure 6 – Floor-Standing Water Pump Tank Extinguisher



The figure below shows the **backpack pump type**. The principle of operation is similar to the floor model, except that the pump is of the "trombone" type, and the discharge nozzle is mounted on the pump. The capacity is usually 10 litres, so that it can be easily carried. The performance and rating are the same as a floor-standing type of the same capacity. The trombone handle has a pump action to pressurize the line and force the water out onto the fire.

Figure 7 – Backpack Water Pump Extinguisher



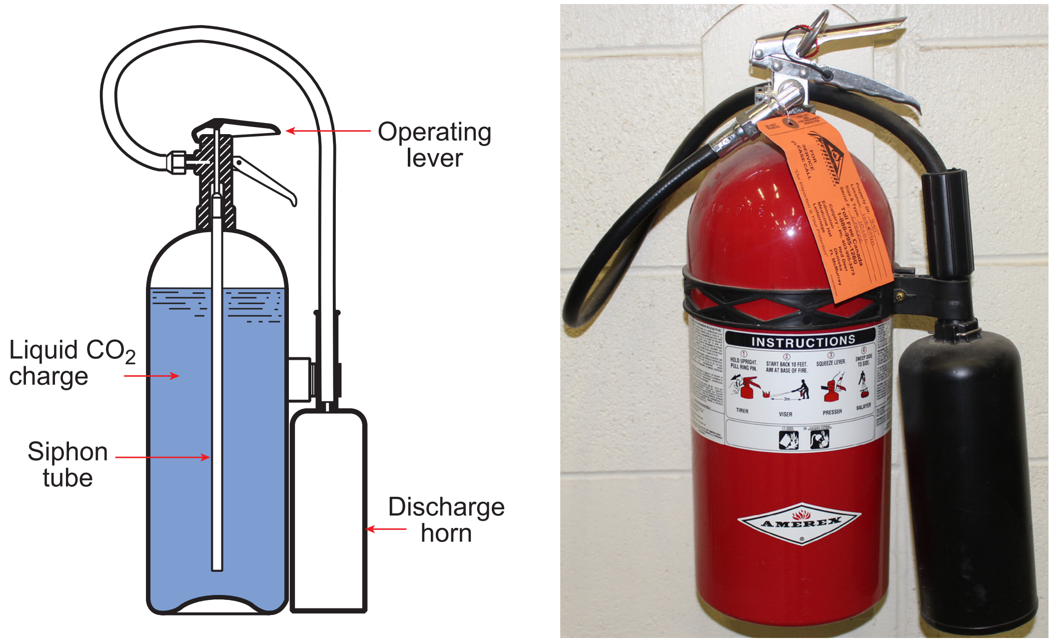
Self-Expelling

CO_2 fire extinguishers are self-expelling. The extinguishing agent, confined in liquid and gaseous form, is also the pressurizing agent. When released from the extinguisher, CO_2 displaces oxygen in the vicinity of discharge to the point where combustion cannot be supported. The rapid expansion from a liquid to a gas, when the CO_2 discharges, converts about 30% of the liquid into dry ice, which then sublimes (evaporates directly) into a gas. Carbon dioxide extinguishers have a short range, because the agent is expelled in the form of a cloud, which is a mixture of gaseous and solid CO_2.

The extinguisher consists of a pressure cylinder (or shell), a siphon tube, and a valve to release the agent. Connected to the valve is a discharge "horn," or a horn and hose combination. The siphon tube extends from the valve to almost the bottom of the cylinder. Normally only liquid CO_2 reaches the discharge horn. After about 80% of the cylinder contents have been discharged, the remainder enters the siphon tube as a gas.

A typical carbon dioxide extinguisher is shown in Figure 8.

Figure 8 – CO_2 Extinguisher



(a) (b)

The smaller hand-held models often have the horn directly connected to the valve assembly with a metal tube swing joint connector. Larger models have the discharge horn connected to the valve by a short length of hose. The extinguisher is discharged by squeezing the operating lever. Touching the discharge horn during operation should be avoided, as it is likely to be very cold.

To extinguish flammable liquid fires, start at the nearest edge of the fire, and sweep from side-to-side, towards the back of the fire.

Another method that can be used is called overhead application. In this method, point the discharge horn down, at an angle of about 45°, towards the centre of the burning area. Usually the horn is not moved. If the surface on fire is a large pool of oil on a floor space, be careful when progressing into the room. Flames from burning liquids can spread and reignite surfaces that have already been extinguished. This will block the means of egress.

The side-to-side sweeping method is likely to give better results on spill fires. The overhead method may be better on confined fires.

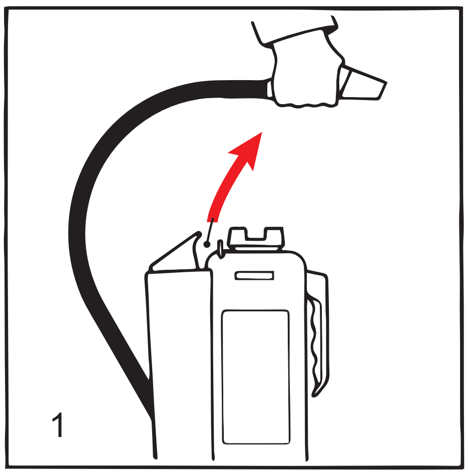
For electrical equipment fires, direct the discharge at the source of the flames. The equipment should be de-energized as soon as possible to prevent possible re-ignition.

The Halotron I Clean Agent extinguishing medium is effective on Class A, B, and C fires. It does not conduct electricity, and it is not corrosive. As well, this pressurized halocarbon agent is environmentally acceptable. Despite its name, it does not contain **halon**. It discharges as a rapidly evaporating liquid, with a higher boiling temperature than other fire-fighting liquids under pressure (at 27°C in the atmosphere). Because Halotron I retains its liquid state longer, it permits for a greater distance of travel (1.8 – 13.7 metres), before turning into a gas.

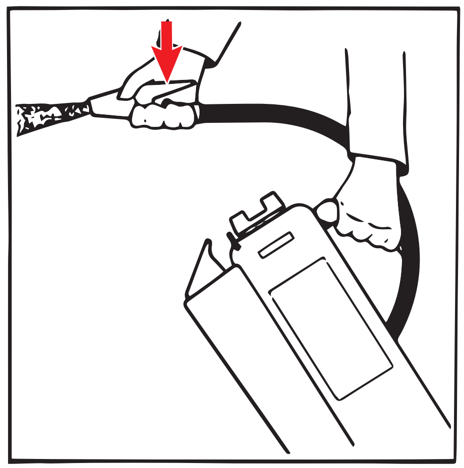
Cartridge or Cylinder Operated

Dry chemical extinguishers can also be cartridge type. One design uses a cartridge of carbon dioxide or nitrogen to expel the agent. In this type of extinguisher, the cartridge can be either internal or external. The expellant gas is released to the bottom of the shell when the puncture lever is depressed, forcing the dry chemical out the nozzle. The rate of flow of dry chemical agent can be controlled by squeezing the operating lever at the nozzle on the end of the hose.

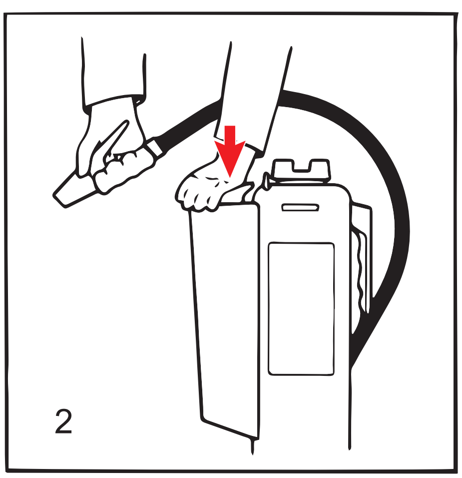
Figure 9 – How to use the Cartridge Type Dry Chemical Extinguisher



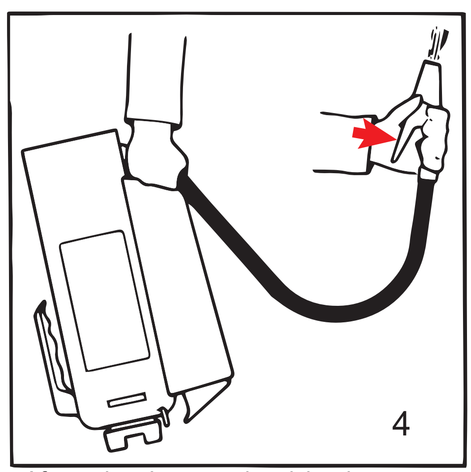
If so equipped, remove ring pin.
Remove hose.



Squeeze nozzle operating lever. Direct stream at base of flames using a side to side motion.



Push down on puncture lever.



After using: Invert extinguisher by grasping elbow, and squeeze nozzle to release all pressure.

Larger capacity AFFF extinguishers are of the wheeled type. They have a separate cylinder of nitrogen to pressurize the agent container. The discharge is controlled by a special type of aspirating nozzle at the end of the hose assembly. The aspirating nozzle induces air into the water/agent solution. The mixing of the air and solution causes the solution to form a foam.

On a flammable liquid fire of a depth that is more than 6 mm, such as in a large tank, the best results are obtained when the discharge is directed against the back wall of the tank. Aim the flow of foam to just above the burning surface, to permit the natural spread of the foam back over the burning liquid. If this is not possible, stand far enough away from the fire to allow the foam to fall lightly on the burning surface. Do not allow the foam to splash into the burning liquid. If possible, move around the fire while directing the foam stream. This will give maximum coverage while the extinguisher is discharging.

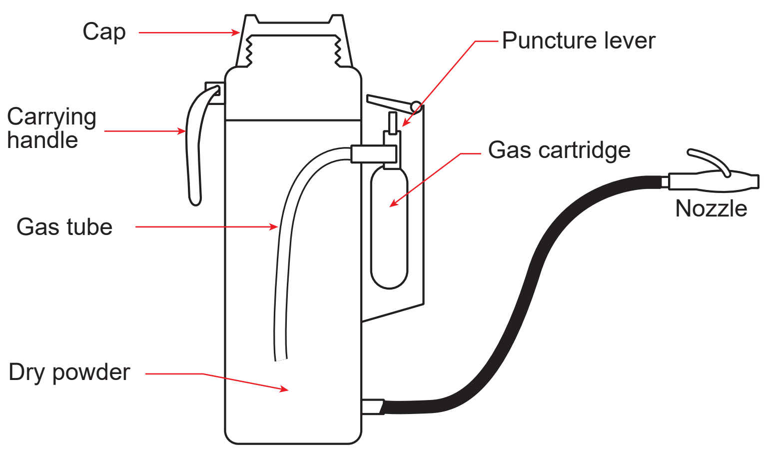
For flammable liquid fires, direct the foam over the burning surface by bouncing it off the floor just in front of the burning area.

Dry powder agent can be deployed on a fire in many ways. The agent, extinguisher, and method of application should be selected in accordance with the manufacturer's recommendations.

The powder may be applied to the fire by means of an extinguisher, using a CO_2 cartridge as the expellant, or from cardboard tubes or metal pails by means of a scoop or shovel. The agent should be applied so that it covers the fire and provides a smothering blanket. Additional agent may be required for hot spots. Care should be taken not to scatter the fire. The fire should be left undisturbed until it has cooled.

A dry powder extinguisher is shown in Figure 10.

Figure 10 – Dry Powder Extinguisher



Extinguishing combustible metal fires involves hazards such as high temperatures, steam explosions, hydrogen explosions, and toxic products of combustion. If common extinguishing agents are used, explosive reactions may occur.

Objective 2

Discuss the inspection and maintenance requirements of portable fire extinguishers.

Inspection and Maintenance of Extinguishers

It is the responsibility of the purchaser, or their designated agent, to maintain fire extinguishers. Extinguishers should be periodically inspected, recharged, and hydrostatically tested, as needed or legally required.

Inspection

Inspections are performed by the owner or the owner's agent. This quick visual check determines whether a fire extinguisher is in the correct location and ready for operation. This simple inspection gives reasonable assurance that extinguishers are fully charged and will function effectively when needed.

An inspection should determine that the extinguisher:

a) Is easily accessible
b) Is in its designated place
c) Is noticeable
d) Is not blocked in any way by furniture or other equipment
e) Has not been activated and is not partially or fully discharged
f) Has not been tampered with – the pin is in place and secured with an intact seal
g) Has not been damaged by, or subjected to, a hazardous environment
h) Has gauges accurately indicating satisfactory operating pressure
i) Is full – confirmed by weight
j) Hose, nozzle, and the extinguisher itself are all in good condition

Figure 11 – Pressure Gauge and Seal on Extinguisher

Note the gauge indicates proper pressure (in the green zone), and the pin is secured in place with an easily broken plastic car seal.

Dry chemical extinguishers should be held upside down monthly for a few seconds and shaken slightly. This prevents the products inside from settling on the bottom.

Power Engineers, or other employees, may be required to do monthly checks, documented on an attached card that shows the extinguisher has passed a visual check. Records of the checks should be logged appropriately.

Maintenance

Fire extinguisher certification can expire, due to the age and settling of the extinguishing agent; or deterioration of the extinguisher vessel and its attachments. The seal on the neck of the bottle can become brittle, and the expellant or the pressurized contents can leak out. This renders the extinguisher ineffective when needed. If an ABC extinguisher is filled with ammonium phosphate, it is possible for the chemical to form a solid block in the bottom of the extinguisher.

Annual fire extinguisher maintenance is required by building and fire codes, and must only be performed by certified agencies. Maintenance should also be done after each use, and when an inspection shows the need. If an inspection indicates tampering, leakage, or physical damage, then a complete maintenance check should be conducted.

Maintenance, as opposed to inspection, means a complete and thorough examination of each extinguisher. Maintenance involves:

a) Disassembling the extinguisher
b) Cleaning and replacing any defective parts
c) Reassembly
d) Recharging
e) Re-pressuring where appropriate

Maintenance checks may reveal the need for special testing of the extinguisher shell or other components. It may, for example, show the need for hydrostatic testing of the shell (cylinder) or even replacement. A hydrostatic test is required every five years on most fire extinguishers, except for dry chemical, dry powder and halogenated agents which, are every 12 years. Every six years, stored-pressure extinguishers that require a 12-year hydrostatic test must be emptied, and subjected to the applicable maintenance procedures described above.

Maintenance work is usually contracted out to certified service companies. It is advisable to discharge portable extinguishers prior to sending them for maintenance for two reasons:

1. Personnel have the opportunity to practice using the extinguishers.
2. It ensures that the extinguishers are filled with a new extinguishing agent after servicing.

Obviously, it is not advisable to send all the extinguishers for maintenance at the same time. The maintenance schedule should be staggered and, if possible, replacements taken from storage so that no area is left without an extinguisher. Service companies may provide loaners.

Side Track

Facilities that have many employees (like hospitals) may find it valuable to have annual fire practices. This gives the employees hands-on training with various types of fire extinguishers, on different types of fires.

Mattresses and ignited oil trays are extinguished with CO_2 or ABC extinguishers in special open areas set aside for practicing. This is of special interest to those who have never used extinguishers or fire hoses.

Fire hoses may be rolled out for all employees to have an opportunity to open the nozzles, control the spray pattern, direct the spray, and experience the force of the water leaving the hose.

This practice is an effective way to empty extinguishers, and test hoses that are due for replacement or maintenance.

Objective 3

Describe the types, layout, and operation of standpipe and sprinkler systems.

Standpipe Systems

Standpipe systems are used in buildings over 3 stories (14 metres) in height. This is the practical limit for firefighters to couple hoses together from a pumper truck at street level, and up the stairways to the floor where the fire is located.

Standpipes allow firefighters, and in some cases, building occupants, the ability to fight fire using a fire hose connected to a standpipe. The standpipe may also be used to supply water to the sprinkler system. If the standpipe only has hose connections, it must be at least DN 100 (4" NPS). If the standpipe also supplies sprinkler systems, it must be at least DN 150 (6" NPS).

The standpipe rises to all floors, usually through a stairwell or a pipe chase. At each floor, there is a provision for fire hose connection. The firefighters can connect the hoses to one of the valve outlets on the standpipe to access the firefighting water supply. It is best practice to use the standpipe connections on the floor below the fire, and approach the fire from below.

Fighting a fire from above is like approaching a fire through a chimney: heat and smoke rise. This is not a recommended way to fight a fire. Newer buildings have stairwell pressurization fans to keep the stairwell exits clear of smoke for people leaving the building. This also minimizes the chimney effect.

There are three classes of standpipe systems:

Class I: These standpipe systems have 65 mm (2.5 inches) hoses and hose connections, to accommodate the larger hoses used by firefighters. When pressurized, these larger hoses can be difficult to control. Only those who have been trained in their use should handle them. Class I systems are usually installed in stairwells.

Class II: These systems have 40 mm (1.5 inch) hoses and hose connections. These are smaller and easier for building occupants to handle. Subject to local authority, 25 mm (1 inch) hoses and hose connections may be used in Class II service for light hazard occupations. Class II systems are usually found in rooms with wall-mounted firehose cabinets, located to be readily available to the personnel in the area. Note that training is required for these types of hoses.

Class III: Class III standpipes combine Class I and Class II hose fittings. In other words, Class III standpipes have both 40 mm (1.5 inch) and 65 mm (2.5 inch) hose connections.

Figure 12 – Class III Standpipe and Hose

Provincial and local authorities govern the fire acts, codes, and regulations for the installation and use of fire systems.

The number and location of standpipes and equipment depends on the use, occupancy, and construction of the facility. The standpipe risers are usually located in non-combustible, fire-rated stairwells. If it is not possible to locate all standpipes in stairwells, additional standpipes may be located in pipe shafts at the building interior column locations.

There should be at least one 65 mm hose connection on the roof for each standpipe.

Power Engineers should know the location of the standpipes and their fire department connections, to provide valuable information to responding firefighters.

Fire Zones for Standpipes

New plants and buildings are built to current building and fire codes. Included in the codes are requirements for fire separations, or zones, within the building or plant. These zones must have suitable walls, floors, and ceilings to prevent fire from spreading for a specified period of time. This allows occupants time to get out, and fire fighters time to contain a fire before it moves to other areas of the building or plant.

The usual zone separations are by floor - each floor being its own zone - with fire doors protecting the stairwells. If the floor area is large, there may be fire walls on each floor, to further separate the zones. Each zone will have access to firefighting equipment and a standpipe system. These zones will also have sprinkler systems.

Hose stations must be installed so that all places in each building zone are within 9 metres of a nozzle. The nozzle must not have more than 30 metres of hose. If the smaller NPS 25 mm hose is installed, then all portions of each zone of a building must be within 6 metres of a hose, as the smaller hoses do not have the high flow capacity of the larger size hoses.

Types of Standpipe Systems

There are seven basic standpipe systems, as defined by **NFPA 14 – Standard for the Installation of Standpipe and Hose Systems**.

1. **Automatic Dry Standpipe**: A standpipe system permanently attached to a water supply (municipal or otherwise) capable of supplying the standpipe system water demand at all times. This system is charged with compressed air or nitrogen. Upon release of the compressed gas, a **dry pipe valve** opens, allowing water to flow into the piping system and out of the opened hose valve. The release of compressed gas is caused by the opening of a standpipe hose valve.

   If a fire requires fire department participation, a pumper engine will connect to a nearby street hydrant, and supply water into the standpipe system through the fire department connection, which features a "Y" piece so that two sources can feed the standpipe system from the exterior of the building. See Figure 13.

2. **Automatic Wet Standpipe**: A standpipe system containing water at all times that is attached to a water supply (municipal or otherwise) capable of supplying the standpipe system water demand at all times. An automatic wet standpipe provides immediate water flow upon opening a valve at a hose connection. A "Y" connection can also be provided on a wet standpipe system, so the fire department can hook up and supply the system.

3. **Combined Standpipe System**: A standpipe system that supplies water to both the hose connections and an automatic sprinkler system.

4. **Manual Dry Standpipe**: A standpipe system with no permanently connected water supply. It relies exclusively on external fire department connections to supply the water. The installed piping is completely dry, and terminates outside the building with a fire department connection.

5. **Manual Wet Standpipe**: A standpipe system that contains a water charge, but is not hooked up to a permanent water supply. This system relies solely on the connection outside the building by the Fire Department.

6. **Semi-Automatic Dry Standpipe**: A standpipe system that is permanently attached to a water supply (municipal or otherwise) capable of supplying the standpipe system water demand at all times, through a control device such as a **deluge valve**, that must be activated by another device before the valve opens and allows water into the system.

7. **Wet Standpipe System**: A standpipe system that contains water at all times and does not depend on any other controls to allow water to flow to the system.

Figure 13 – Fire Department Connection

Sprinkler Systems

The **NFPA 13 – Standard for the Installation of Sprinkler Systems** is adopted by the **National Fire Code of Canada**. This standard provides the necessary requirements and specific guidance with respect to the design, layout, and installation of sprinkler systems.

There are four basic types of sprinkler systems:

1. Wet pipe
2. Dry pipe
3. Preaction
4. Deluge

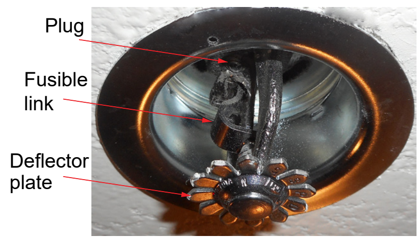
Wet Pipe Sprinkler Systems

Wet pipe sprinkler systems are the most common. They are the easiest to design, and the simplest to maintain. Wet pipe sprinkler systems contain water under pressure, and are piped to headers that have rows of sprinkler heads. When a sprinkler head is exposed to heat and rises to a predetermined temperature (presumably due to fire), a small liquid filled bulb or metal fusible link in the sprinkler head breaks and water flows to extinguish the fire.

Wet pipe systems are used when the temperature of the protected area is maintained at or above 4°C, to prevent freezing of the system. Wet pipe systems are typically found in office buildings, stores, hotels, schools, and health facilities. They are intended to provide coverage for general use facilities.

Figure 14 – Sprinkler Head

(a)



(b)

The sprinkler head shown in Figure 14(a) has a thermally activated glass bulb that contains a blue-coloured liquid. (The colour of the liquid indicates that this sprinkler activates at between 120°C and 150°C.) The bulb holds a valve mechanism shut. At a predetermined temperature, the bulb pops open, due to the volumetric expansion of the liquid in the bulb. This allows water to flow out and extinguish the fire.

Sprinkler head liquid bulbs have different colours that correspond to their activation temperatures. These temperatures range from 38°C to 329°C. Figure 14(b) is a ceiling mounted fusible link sprinkler head. When the temperature increases, the soldered link melts, and the plug opens. Water then flows out and the deflector plate spreads it over the fire.

Dry Pipe Sprinkler Systems

When the temperature in an environment is subject to freezing temperatures or maintained below 4°C, **dry pipe sprinkler systems** are installed. The water in this type of system has a supply valve (called a "dry pipe valve") held closed with air pressure. The sprinkler piping is pressurized with compressed air to at least 275 kPa, in order to hold the dry pipe valve closed. A small air compressor keeps the sprinkler system piping pressurized in the event of a small air leak. The compressor does not have the capacity to maintain the system air pressure if a sprinkler head is activated.

Like wet sprinkler systems, dry pipe systems have sprinkler heads that pop open at a predetermined temperature. When a sprinkler head opens, it first releases air. When the piping system air pressure drops, the dry pipe valve opens wide, and quickly fills the entire sprinkler system with water. The water flows from the activated head as soon as it reaches that point in the piping system.

Dry pipe installations are found in outside areas, cold storage warehouses, or anywhere freezing could occur.

Preaction Systems

Preaction sprinkler systems are categorized three ways:

1. Single-Interlock Systems
2. Non-Interlock Systems
3. Double-Interlock Systems

Single-Interlock Systems

The piping for single-interlock systems is similar to a dry pipe system. Typically, the system has compressed air or nitrogen in the lines, and an electrically operated **preaction valve** that must open before water flows into the sprinkler line. The preaction system is equipped with a supplemental detection system such as a smoke detector, heat detector or other sensing device. This supplemental detection system electrically opens the preaction valve. This charges the sprinkler line with water, making it essentially a wet pipe system.

If a sprinkler head is activated, water will immediately flow to suppress the fire. This is known as a single-interlock system. The sprinkler lines can be filled with water due to the detection system opening the preaction valve, even if the sprinkler head has not activated.

The small amount of compressed air or nitrogen in the pipe is used to monitor system integrity. If the pipe develops a leak, air pressure will drop, and a low system pressure alarm will sound. However, the preaction valve stays closed until the detection system is activated.

Non-Interlock Systems

Non-interlock systems allow water into the sprinkler piping with either operation of the detection device or the activation of an automatic sprinkler head.

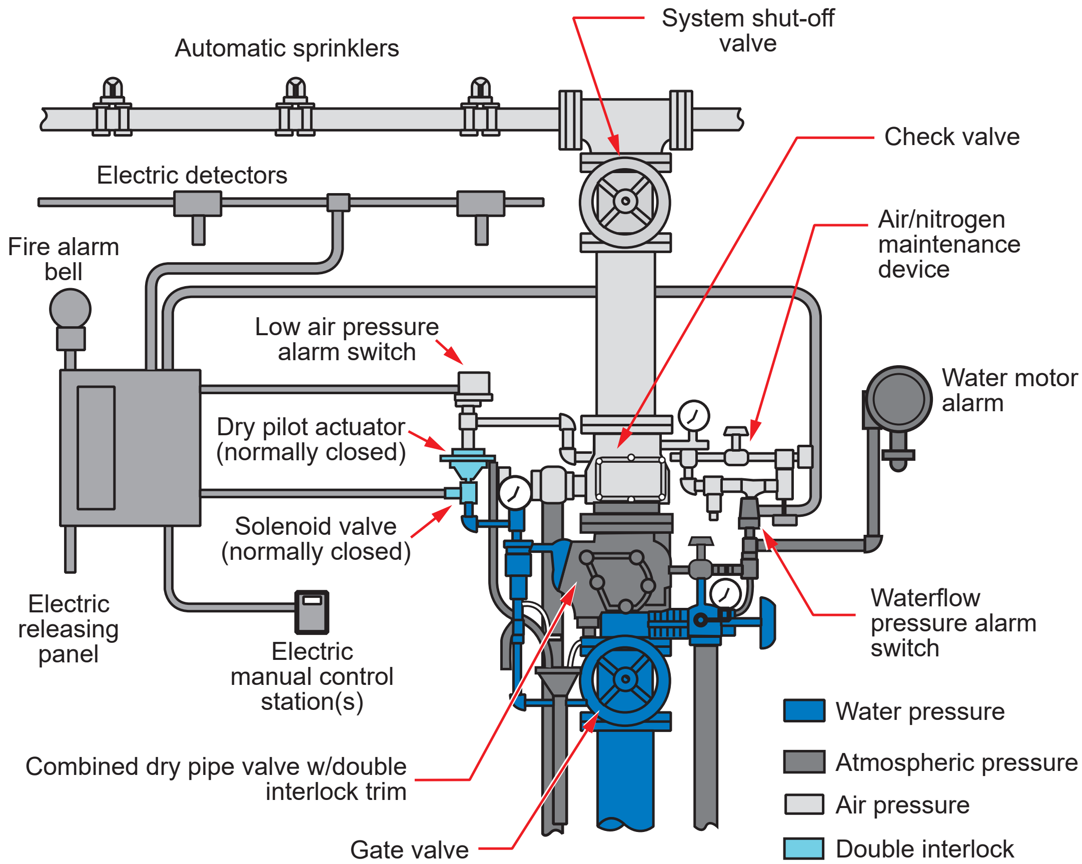
Double-Interlock Systems

In double-interlock systems, water is not admitted to the sprinkler piping until both the detection device and an automatic sprinkler head are activated. These systems are mostly found in low-temperature applications, where water may cause sprinkler system pipes to freeze.

Preaction systems are typically found in environments like museums, or facilities where water discharge is of major concern. They are also found in computer rooms or telecommunications facilities where an unintended discharge of water can do significant damage.

A double-interlock preaction system is shown in Figure 15. The Dry Pilot Actuator and the Solenoid Valve must both activate for the preaction valve to open.

Figure 15 – Double Interlock Preaction System



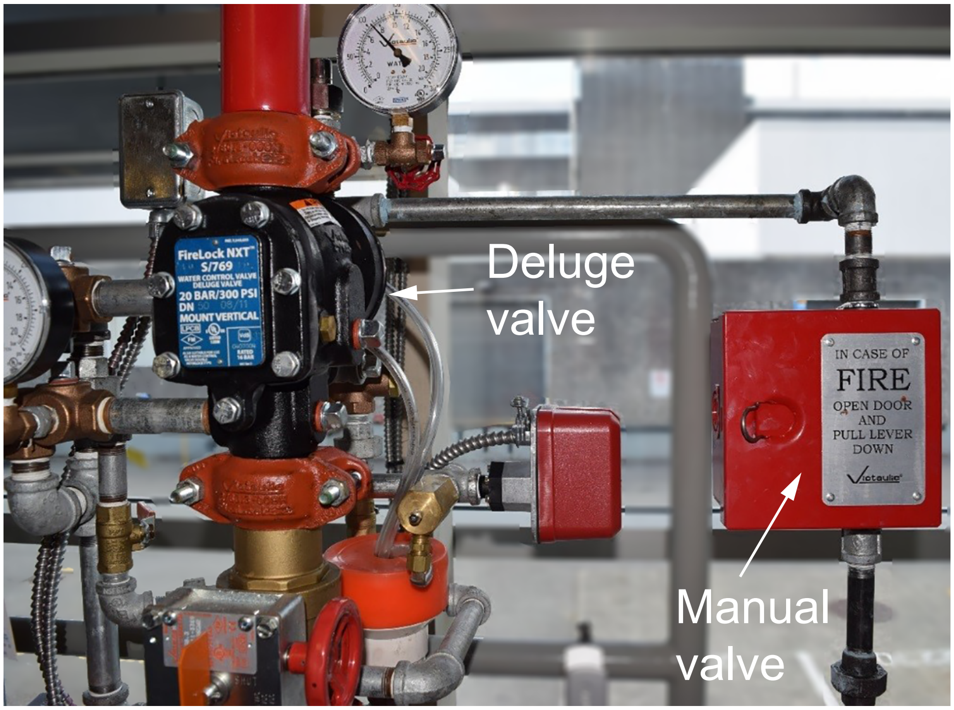
Deluge Systems

Deluge sprinkler systems deliver large amounts of water using non-automatic sprinkler heads. These sprinkler heads are not heat activated; they are always fully open. When water flows through the sprinkler line, all of the sprinklers on the piping system flow without delay.

A deluge valve is used to control the system water supply. The sprinkler system pipe is at atmospheric pressure, since only open sprinklers are attached to it. Supply water is delivered upstream of the deluge valve. As in preaction systems, a supplemental detection system is located in the same area as the sprinklers. Upon activation of the supplemental detection system, the deluge valve is electrically opened, admitting water into the sprinkler system piping. As the water reaches the sprinklers, the water immediately discharges, and soaks the entire area.

Figure 16 shows a deluge valve for a power plant sprinkler system. Note the manual activation lever in the box on the right.

Figure 16 – Deluge Valve Installed in a Deluge System



This system is appropriate for facilities that contain combustible or flammable liquids, warehouses full of paper, or other situations in which extensive fire damage is likely to occur over a short period of time. This system may also be used to provide fire separation between parts of a building or plant. Another use is to keep windows that separate building sections cool so they do not break during a fire.

Some building have specialized automatic fire suppression systems that operate similar to sprinkler systems. These include:

a) Kitchen fire suppression systems that spray Class K extinguishing agent on cooking equipment.

b) CO_2 extinguishing systems that flood an area such as a gas turbine enclosure, smothering the fire, see Figure 17.

c) Other systems using extinguishing agents to extinguish electrical fires.

While these are not usually identified as standpipe or sprinkler systems, they do utilize devices to direct and distribute the extinguishing agent over a specific area.

Figure 17 – CO_2 Fire Suppression System for an Engine Room

Objective 4

Discuss the maintenance requirements of standpipe and sprinkler system components.

The **NFPA 25 – Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems** is recognized by the **National Fire Code of Canada**. It has also been adopted by the various provincial and territorial jurisdictions. This standard requires regular testing of standpipe and sprinkler system components, to ensure their reliable operation. While various jurisdictions may modify these rules, generally the requirements are similar. A typical description of maintenance for standpipe and sprinkler systems is described below.

Fire Sprinkler System Inspections and Testing

Fire systems should be tested annually to ensure that they work properly when needed. There are checks to be performed on a regular basis on all parts of the fire system, such as those described below.

a) Fire pump tests, which include checking the operation of the driver (usually an electric motor or internal combustion engine). For most plants, this test should be conducted weekly or monthly.

b) Testing water flows to ensure they are adequate to supply all the sprinklers if they are activated in a large fire. Depending on the jurisdiction, these tests may be conducted quarterly or yearly.

c) Alarm tests.

d) Activating the wet, dry, preaction, and deluge valves, and checking operation of the flow switches and other attached devices.

e) Ensuring a signal is sent to alarm panels if the sprinklers or standpipes are activated.

f) Keeping written records of all the tests.

Daily and Weekly Checks could include:

a) Visual inspections of equipment for cleanliness and rusting.

b) Removal of stored equipment or debris that could restrict access to the fire equipment.

c) Inspection of lighting systems to verify that the lighting is adequate for operation of fire equipment, even in emergency conditions.

d) Cold weather enclosures are adequately heated and sealed.

e) Fire hoses are properly coiled and ready to use.

f) Equipment is not stored in any manner that would affect the operation of sprinklers.

g) Visual monitoring of alarm panels connected to the sprinklers and standpipes and other fire detection systems to ensure that they are operating properly.

Monthly Checks could include:

a) All of the daily and weekly checks.

b) Verify that water supply valves for the fire suppression systems are open (and locked open if required).

c) No damage has occurred to any of the equipment due to accidental contact to equipment such as panels, wiring or valves. Breakers should be checked to ensure they are supplying equipment with power at all times.

d) The proper air pressure is maintained on systems such as a dry standpipe, and the small air compressors are functioning properly. If the air compressor is running repeatedly or starting and stopping in short cycles, this would indicate a leak that should be located and repaired.

e) Visual checks of all pressure gauges on the system including standpipe and sprinkler supply water pressure, and pressure in wet and dry sprinkler systems.

f) Visual inspection of piping to check for leaking air or water.

g) Operation of fire pumps to verify that they are able to start automatically and supply required pressure.

h) Check to ensure sprinkler heads have not been painted or otherwise compromised.

Annual Checks could include:

a) All daily, weekly, and monthly inspections.

b) Calling in an authorized company to do an inspection and testing of all devices connected to the fire alarm system, including activation alarms from sprinklers and standpipes.

c) Full flow testing on sprinklers and standpipes. The fire inspector will use flow-measuring equipment to do this. This is particularly important when commissioning sprinkler systems.

d) Draining the low points of a dry system, particularly before cold season.

e) Testing and replacing fire hoses if necessary.

Every three and five years:

a) A dry testing trip in which the whole system is activated, with the control valve open and the water flow tested.

b) A wet system flow test under the same conditions.

c) A hydrostatic test of sprinklers and standpipes, depending on location.

Objective 5

Describe the purpose, operation, and maintenance of fire pumps.

Fire Pumps Installations

A reliable flow of water for fire hoses and sprinklers is necessary for first responders and fire fighters, in order to extinguish fires.

There are times when the water supply to a facility's fire protection system may not be able to meet water volume requirements due to insufficient pressure. Larger facilities and tall buildings are particularly vulnerable. In order to meet these needs, fire pumps may be installed near the point of water supply to the facility. These pumps are designed to start automatically if the system pressure drops to a pre-determined value.

Typically, centrifugal pumps (either horizontal or vertical) are used as fire pumps, though positive displacement types are permitted. Capacities of fire pumps may range from 1.6 L/s to over 300 L/s. Discharge pressures range from 280 kPa to 2000 kPa, depending on the height of the building, and the amount of water to be supplied. Fire pumps are required to meet the certification requirements outlined in applicable **NFPA** and **Underwriters Laboratories Canada (ULC)** standards. Installation of fire pumps must meet **NFPA 20** – **Standard for the Installation of Stationary Pumps for Fire Protection**.

Fire pumps must have check valves in the discharge piping so that water does not push back into the pump when it is off, especially if two pumps feed a common discharge line, and only one is running.

Fire pumps usually start automatically, from a drop in pressure in the standpipe system. The drop in pressure may be due to water supplying fire hoses or activated sprinkler systems. The flow of water caused by one or two sprinklers in use would not cause a significant pressure drop to actuate the fire pump. However, multiple sprinkler head actuation may start the pump. A flow switch like that shown in Figure 18 activates an alarm when there is a high fire water flow.

Figure 18 – Flow Switch in a Fire Line (Fire Main)

Fire Pump Checks

Checks When Running

Operators should check fire pumps shortly after start-up. Checks should include:

- suction and discharge pressures
- packing gland leakage, and
- abnormal sounds and leaks.

If the pump is driven by a gasoline or diesel engine, also check:

- engine RPM
- oil pressure
- engine and coolant temperature, and
- fuel supply pressure (if diesel engine powered).

Preferably, fire pumps should be shut down manually, to ensure they keep running for a certain length of time. In some installations, a timer ensures a minimum operating time. This is usually 1 minute for each 750 watts of motor rating, with a maximum time of about 7 minutes. The use of a timer prevents frequent starts and stops.

Checks When Not Running

When the pump is not running, certain checks should be made as part of regular operator rounds. Below is a general checklist.

1. Verify the fire pump inlet water pressure.
2. Verify that all required inlet and outlet valves are locked open to prevent accidental closure.
3. Verify that the breaker for an electrically driven fire pump (and other auxiliary equipment) is energized and in auto.
4. Verify that the fuel supply for an internal combustion engine (usually diesel oil) is ready to be delivered to the engine when required.
   a) Ensure the day tank is full of fuel oil.
   b) Verify that supply line valves in the oil line are open.
   c) Ensure the fuel supply lines to the engine are primed.
   d) Verify that the day tank fuel pump (for supplying fuel oil to the engine) is valved correctly and functioning properly.
   e) Verify the day tank fuel pump power supply. The day tank pump may be battery operated, so that fuel and power can be supplied to the fire pump engine in the event of a power outage.
5. If the fire pump engine has a block heater, ensure the heater is operating and the engine is warm.
6. Check the charge and the water levels of the engine starting batteries. Make sure the battery charger is in service.
7. Verify the level of coolant and the freeze point of the engine cooling system.
8. Check the engine oil level and add if necessary. Change the lubrication oil as required.
9. Keep a regular log of the hours a diesel driver has been running. Also log the times and dates when the pump is tested.

Fire Pump Testing

Regular weekly, monthly, quarterly, and annual fire pump testing is mandated by **NFPA 25 – Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems**. It is common for Power Engineers to test start fire pumps and monitor their operation.

Pump testing typically involves the following:

a) Fire pump operation may set off alarms to monitoring companies or fire departments. It is necessary to notify these agencies of the dates and times when testing is to be done. If the monitoring agency is temporarily disconnected from the alarm, procedures must be in place to notify these agencies manually if a real fire occurs during the test.

b) Complete the pre-start checklist, according to installer and manufacturer's instructions and site-specific procedures.

c) Start the pump, according to site-specific procedures. This is usually done by simulating water use by opening a drain valve in the sprinkler system. Record the sprinkler system pressure when the pump starts, and the time it takes for the pump to come up to operating speed.

d) Monitor the operation of the pump. Check and record inlet and discharge pressures of the pump. Check the pump packing glands for leakage and excessive temperature. Adjust the packing nuts, if necessary. Listen for unusual sounds and vibration.

e) If driven by an internal combustion engine, observe and record the engine oil pressure, the engine RPM, the water and oil temperatures, and the fuel oil pressure whenever the engine is running. Run the test for the prescribed time (usually an hour).

f) Annually, run the pump under no-flow and 150% rated capacity and compare to manufacturer's specifications. This must be conducted by a certified agency and documented. Flow tests usually involve connecting fire hoses and flowmeters to a standpipe connection, and throttling the flow as appropriate.

g) Record the results in a log book.

Note that fire pumps start on loss of standpipe or sprinkler system pressure instigated by the activation of a sprinkler head, fire hose, or other standpipe connection. The resulting system pressure drop operates a pressure-sensitive switch that starts the fire pump. The fire pump continues to operate to maintain system pressure.

Jockey Pumps

Wet systems may have small, insignificant leaks that gradually result in a drop in system pressure. If the system pressure drops below a set value, the fire pump will start unnecessarily, and the system will go into alarm. To prevent this from occurring, the system must be kept pressurized above the starting pressure of the fire pump. This is accomplished with a **jockey pump**.

Jockey pumps are small centrifugal pumps that have only enough capacity to pressurize the standpipe in the event of small leaks. If a sprinkler head or a firehose is activated, the jockey pump cannot maintain the system pressure, and the fire pump starts.

Engineers should check jockey pumps regularly to ensure they do not cycle too frequently. This would indicate a significant leak in the fire system.

Electric motors and diesel engines are the most common drivers for fire pumps, although gasoline engines and steam turbines have been used.

All pump drivers, auxiliary equipment, fuel storage systems, and associated electrical equipment must meet federal, provincial, and territorial regulations, which commonly reference the following codes and standards:

- **CSA C22.1 – Canadian Electrical Code**
- **National Building Code of Canada**
- **NFPA 37 – Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines**
- **NFPA – 54 National Fuel Gas Code**
- **NFPA – 58 Liquefied Petroleum Gas Code**
- **NFPA 31 – Standard for the Installation of Oil-Burning Equipment**

In addition to federal and provincial legislation, there may be requirements to meet local codes, and those of insurance underwriters.

Chapter Summary

Power Engineer may be trained as first responders. This means they must be familiar with how to identify and use the correct fire extinguisher for the type of fire. Fire extinguishers are portable containers that contain agents designed to fight particular types of fires. Because they are small, fire extinguishers are only intended for use on smaller fires contained to small areas.

Class A fires (normal combustibles) are most effectively put out with water. Class B fires (flammable liquids) are best smothered or separated from the air. Class C (electrical) fires should be extinguished with non-conductive agents, as soon as the power supply to the burning equipment is shut off. Class ABC fire extinguishers are suitable for all these types of fires.

Kitchen fires of vegetable or animal fats are most effectively extinguished with a special foam type fire extinguisher. Metal fires are put out with Class D extinguishing agents, each designed for a specific type of metal (there is no general-purpose Class D extinguisher for all metals).

Use "**PASS**" – **p**ull, **a**im, **s**queeze, **s**weep – as a method of putting out a fire with an extinguisher.

Sprinklers and standpipes are intended to supply water to fight larger fires. Standpipes for fire hoses can be charged with water (wet) or be filled with air (dry). Dry standpipes are charged with water quickly when needed. Fire department connections for standpipes and sprinklers are available through outside "Y" connections. These systems may also be supplied from municipal water sources.

Sprinkler systems are considered to be automatic because they are readily available, and operate without human intervention. Some special systems such as preaction and deluge sprinklers have valves that are manually activated, or activated by fire detection equipment (such as smoke and heat detectors). Preaction sprinkler systems are for special locations such as museums, or other places that want to be sure of an actual fire before the system activates. Deluge sprinkler systems are intended to supply large amounts of water with extra coverage to prevent fast-spreading fires, such as in a paper storage area.

Sprinkler systems must be tested regularly to ensure their proper operation. Weekly and monthly visual checks verify that the equipment is operational. Annual maintenance, such as flushing and flow checking, is done according to regulations. This is usually part of the overall fire systems maintenance, testing fire alarms and other fire detection equipment.

Fire pumps are kept on standby, ready for use. This ensures that adequate water pressure is available for standpipes and sprinkler systems. Regardless of whether the driver is a diesel engine or an electric motor, regular checks and testing are required to assure reliable water delivery. These tests and checks are often performed by Power Engineers.

Unit Summary

Safety considerations are inherent in every phase of a plant's life, including:

- Conscientious planning during the design phase,
- Exact implementation of the plans for erection,
- The use of appropriately sourced, and approved materials during construction,
- The validation and operation of all in-plant processes using qualified individuals and supervisors, and
- The planning and implementation of the plant's decommissioning and dismantling.

This unit focused on typical safety requirements over the life cycle of a plant, including process operations. Site specific safety programs require Power Engineers to develop both personal and system-level knowledge, as well as appropriate responses. This unit helped direct novice Power Engineers appropriately to engage in, and contribute to, site-specific and regulatory safety requirements.

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.

Notes

UNIT A-4

Knowledge Exercises and Unit Glossary

Knowledge Exercises – Chapter 1

Name: ______________________ Date: ______________________

Instructor: ______________________ Course: ______________________

Objective 1

1. Describe the possible personal impacts on an injured worker.

Objective 2

2. List five types of personal protective equipment the Canadian Standard Association publishes standards for.

3. An employee is working in an environment dealing with lack of oxygen, toxic air, and possible immediate danger to life or health due to vapours or fumes. What are the requirements for SCBAs and SABAs that the employer must provide to the employee?

Chapter 1 (Cont.)

Objective 3

4. For each hazard category, list two common origins and their consequences.

Hazard	Origin	Consequence
Mechanical hazards		
Electrical hazards		
Thermal hazards		
Noise hazards		

Objective 4

5. List the legal duties of a joint health and safety committee.

Objective 5

6. Provide a description for each of the three methods of hazard control.

Knowledge Exercises – Chapter 2

Name: ______________________ Date: ______________________

Instructor: ______________________ Course: ______________________

Objective 1

1. List the duties of a Joint Workplace Health and Safety Committee.

Objective 2

2. Give the names of some of the specialized safety training Power Engineers may need to perform their duties.

Chapter 2 (Cont.)

Objective 3

3. List the common types of safe work permits used in industry. Briefly describe each one.

4. List the general information contained in a safe work permit.

Chapter 2 (Cont.)

Objective 4

5. List the items in the lockout identification box of a typical group/lockbox lockout sheet.

Knowledge Exercises – Chapter 3

Name: ______________________ Date: ______________________

Instructor: ______________________ Course: ______________________

Objective 1

1. What is the purpose of WHMIS?

2. What are two major elements of the Global Harmonization system?

Objective 2

3. What are the four main components of both the WHMIS 1988 and WHIMIS 2015 systems?

4. What are the two labels that are seen at a worksite that has hazardous products? Briefly describe each type of label.

Chapter 3 (Cont.)

Objective 3

5. State four conditions for safely handling gas cylinders.

Objective 4

6. What are the significant properties of hydrocarbon fluids?

Knowledge Exercises – Chapter 4

Name: ______________________ Date: ______________________

Instructor: ______________________ Course: ______________________

Objective 1

1. What are the four components of a fire tetrahedron?

2. What is a reducing agent, and what are the most common materials that they are made of?

3. There are three "stages" to a solid fuel fire. What are they?

Objective 2

4. For what type of fire is carbon dioxide most effectively used?

Chapter 4 (Cont.)

5. What is a Class K fire, and what are the recommended methods of preventing it?

6. What is a Class C fire? When the electrical power supply to a Class C fire is turned off, what kind of fire remains?

Objective 3

7. What are some of the general fire prevention provisions made at a workplace?

Objective 4

8. A work environment can potentially have explosive gases and vapours. What is the electrical class of this environment? What precautions are necessary to prevent electrical equipment from creating an explosion?

Knowledge Exercises – Chapter 5

Name: ______________________ Date: ______________________

Instructor: ______________________ Course: ______________________

Objective 1

1. Describe an effective method for using any class of portable fire extinguisher.

2. What is the difference between a stored-pressure and a cartridge-operated fire extinguisher?

Objective 2

3. The only way to tell if a ____________ fire extinguisher is full is by weighing it.

Chapter 5 (Cont.)

4. When inspecting a fire extinguisher for proper operation, what visual checks could be performed?

5. Why is it advisable to discharge portable extinguishers prior to sending them for maintenance?

Objective 3

6. What is a Class III standpipe? How is it different from Class I and Class II standpipes?

7. Name four basic types of sprinkler systems.

   a)

   b)

   c)

   d)

Chapter 5 (Cont.)

8. What is the difference between a preaction and a deluge sprinkler system?

Objective 4

9. What is the name of the NFPA Standard that covers the testing of sprinkler systems?

10. List the daily and weekly checks performed on sprinkler and standpipe systems.

Chapter 5 (Cont.)

Objective 5

11. What conditions cause a fire pump to start?

12. List the items checked regularly on a fire pump when it is not operating.

13. Lists the steps required for testing a diesel fire pump.

Unit A-4 Glossary

Term	Definition
AFFF	See *aqueous film forming foam (AFFF)*.
Air purifying respirator	A breathing apparatus equipped with a filter, cartridge, or canister that removes specific air contaminants.
Aqueous film forming foam (AFFF)	A fire suppressing agent used to extinguish flammable liquid (Class B) fires.
Arc flash	A type of electrical explosion that occurs when electrical energy passes from a high-voltage source, through the air, to a low voltage conductor.
Asbestosis	A fatal lung disease caused by long-term inhalation of asbestos fibres.
Automatic dry standpipe	A piping system with a permanently attached water supply, but normally kept dry and pressurized with air or nitrogen, used to supply fire hoses. Upon release of the compressed gas, a dry pipe valve opens, allowing water to flow into the piping system, and out of a hose valve.
Automatic wet standpipe	A piping system with a permanently attached water supply, normally kept full of pressurized water, and used to supply fire hoses.
Canadian centre for occupational health and safety (CCOHS)	A Canadian federal department corporation established to promote workplace health and safety through training and education.
Canadian standards association (CSA)	An accredited, not-for-profit organization that develops international codes and standards for voluntary jurisdictional adoption.
Car seal	A single-use device used to prevent unauthorized operation or tampering of equipment or controls (including valves and breakers), by sealing access to the equipment actuating mechanism.
CCOHS	See *Canadian Centre for Occupational Health and Safety* (CCOHS).
Cold work	A task that does not produce a source of ignition.
Combined standpipe system	A piping system that has a permanently attached water supply, used to supply water to fire hoses and to fire suppression sprinkler systems.
Confined space	A workspace that is not designed for continuous human occupation, and poses significant hazard due to the potential existence of any combination of hazardous materials, mechanical hazards, dangerous atmospheres, extremes of temperature, and limited access and egress.
CSA	See *Canadian Standards Association* (CSA).
Deluge sprinkler system	A fire-suppression system that uses open sprinkler heads attached to a dry piping system. A supplemental fire or smoke detection system, or a manual device, activates a deluge valve to permit water flow to all connected sprinkler heads simultaneously.
Deluge valve	A control valve that is activated by a fire or smoke detection system, that permits water to flow through a deluge sprinkler system.
Dry pipe sprinkler system	A fire-suppression system suitable for low-temperature applications that uses automatic sprinkler heads attached to piping that is kept dry and pressurized with nitrogen or air. Loss of air pressure causes a dry pipe valve to open, permitting water to flow through the system to the activated sprinkler heads.
Dry pipe valve	A control valve in a dry pipe sprinkler system that, when activated by a loss of system compressed air pressure, automatically opens to permit water flow to activated sprinkler heads.
Dry powder	A category of fire-extinguishing agent used on Class D (burning metal) fires.

Term	Definition
Flash point	The temperature at which a flammable liquid gives off sufficient vapour to momentarily support combustion.
GHS	See Globally Harmonized System (GHS).
Globally harmonized system (GHS)	The Globally Harmonized System of Classification and Labelling of Chemicals. The GHS defines and classifies the hazards of chemical products, and communicates health and safety information on labels and safety data sheets.
Halon	An ozone-depleting substance once commonly used as a fire suppression agent.
Hot work	A task that may produce an ignition source, such as welding, flame cutting, and grinding.
Hydrocarbon	Any chemical compound of carbon and hydrogen.
Hydrogen sulfide	A highly toxic, invisible, and flammable gas, having the odour of rotten eggs.
IDLH	See *immediately dangerous to life or health* (IDLH).
Immediately dangerous to life or health (IDLH)	Airborne contaminants that are likely to cause death or permanent adverse health effects, or that can prevent the escape from a lethal environment.
Intrinsically safe	Electrical equipment and wiring with energy limiting protection against sparking or ignition. Can be used safely in areas with potential explosive hazards.
Job safety analysis (JSA)	A step used when developing Safe Work Procedures that identifies potential job hazards and recommends the safest task performance methods.
Jockey pump	A small-capacity centrifugal pump used to keep standpipe systems pressurized.
JSA	See *job safety analysis* (JSA).
Lanyard	A piece of rope or line used to fasten or secure objects.
Legionnaire's disease	A severe form of pneumonia caused by legionella bacteria. It is usually spread by water droplets entrained in HVAC systems.
LEL	See *lower explosive limit* (LEL).
Lower explosive limit (LEL)	The lowest concentration of a gas or vapour in air, expressed as a percentage, that is capable of producing a flash fire in the presence of an ignition source.
Manual dry standpipe	A piping system used to supply fire hoses, but having no permanently connected water supply. It relies exclusively on water supplied by external fire department connections. The piping is completely dry until placed in service. The piping terminates outside the building with a fire department connection.
Manual wet standpipe	A piping system kept full of water, having no permanently connected water supply, and used to supply fire hoses. This system relies on water supplied through an outside fire department connection.
Material safety data sheet (MSDS)	Under WHMIS, an information sheet, prepared by a supplier, that provides basic technical information about a product's physical characteristics and its hazardous properties.
MSDS	See *material safety data sheet* (MSDS).
Nuisance dust	Airborne particulate (solid or liquid) that, when exposure is reasonably controlled, does not produce significant disease or harmful effects.
OH&S	Occupational Health and Safety (OH&S).

Term	Definition
Oxidizing agent	A substance that causes oxidation in other substances.
Personal protective equipment (PPE)	Protective clothing, helmets, goggles, and other garments or equipment designed to protect a worker's body from injury or infection.
PPE	See *personal protective equipment*.
Preaction sprinkler system	A fire-suppression system that uses automatic sprinkler heads attached to piping that is kept dry and pressurized with nitrogen or air. A supplemental fire or smoke detection system activates a preaction valve to charge the piping system with water, regardless of whether a sprinkler head is activated.
Preaction valve	A control valve that is activated by a fire or smoke detection system, that allows water to charge a preaction sprinkler system.
Reducing agent	In a chemical reaction, an element or compound that donates an electron to another chemical.
SABA	See *supplied air breathing apparatus* (SABA).
Safe work permit (SWP)	A legal document that identifies the scope of work to be performed, the related hazards, and the precautions to be taken to mitigate the hazards.
Safety data sheet (SDS)	Under WHMIS, an information sheet, prepared by a supplier that provides basic technical information about a product's physical characteristics and its hazardous properties.
SAR	See *supplied air respirator* (SAR).
SCBA	See *self-contained breathing apparatus* (SCBA).
Schrader valve	A small spring-loaded check valve, used in combination with an air chuck, commonly used for adding compressed air to containers such as pneumatic tires and expansion tanks.
SDS	See *safety data sheet* (SDS).
Self-contained breathing apparatus (SCBA)	A respiratory protective device whereby the wearer carries compressed breathing air in a cylinder, and breathes through a pressure demand regulator mounted on a full-face respirator. The supply air permits work for short periods of time in toxic or oxygen-deficient atmospheres.
Semi-automatic dry standpipe	A piping system with a permanently attached water supply that, with activation of a control valve by a supplemental fire or smoke detection system, supplies water to fire hoses.
Silicosis	A lung disease caused by the long-term inhalation of silica particles.
SOP	See *standard operating procedure* (SOP).
Standard operating procedure (SOP)	An approved set of written instructions for safely performing routine job tasks.
Supplied air breathing apparatus (SABA)	A device that combines the features of a self-contained breathing apparatus and a supply air respirator. It provides breathing air through an air-supply hose, a positive pressure facepiece, and a pressure demand air regulator, and it has a small escape air cylinder in case the main air supply fails.
Supplied air respirator (SAR)	A respiratory protective device consisting of an air line connected to a remote breathing air supply, and a pressure demand regulator mounted on a full-face respirator.
SWP	See *safe work permit procedure* (SWP).
UEL	See *upper explosive limit* (UEL).
Ultraviolet (UV)	Electromagnetic radiation that has wavelengths between that of violet light and x-rays.

Term	Definition
Upper explosive limit (UEL)	Expressed as a percentage, it is the highest concentration of a gas or vapour in air that is capable of producing a flash fire in the presence of an ignition source.
UV	See *ultraviolet* (UV).
VCM	See *volatile combustible material* (VCM).
Volatile combustible material (VCM)	In a solid fuel, such as wood or coal, the substances that vapourize and burn during combustion.
WCB	See *workers' compensation board* (WCB).
Wet pipe sprinkler system	A fire-suppression system that uses automatic sprinkler heads attached to piping that is maintained full of pressurized water.
Wet standpipe system	A piping system that contains water at all times, used to supply fire hoses, and capable of permitting water flow without the activation of supplemental controls.
WHMIS	See *workplace hazardous materials information system* (WHMIS).
Workers' compensation board (WCB)	A government agency that provides disability insurance for workers injured or disabled in the course of employment.
Workplace hazardous materials information system (WHMIS)	A comprehensive plan that provides workers information on the safe use of hazardous materials found in Canadian workplaces.

Additional Workspace

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