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Working on the power system

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Training and development

Participant guide

BC Hydro
Power smart

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Table of contents

Course introduction 1

Safety on the power system 3
- Safety protection at BC Hydro 4
- Hazardous energy 5
- Avoiding hazardous energy 11

Elements of safety protection 17
- Introduction 18
- Isolation of equipment 19
- Worker protection grounding/bonding 20
- Blocking 22
- Securing protection: locks and tags 23
- Equipment to be treated as energized 25

Safety protection roles and responsibilities 27
- Responsibility for operating the system 28
- Division of authority for work on the system 29
- The Person in Charge 30
- System operation and safety aids 31
- PSSP roles and responsibilities 36
- WPP roles and responsibilities 37
- Job planning and communications 38
- Personal safety responsibilities 40

Your notes

Course introduction

Welcome to the **Working on the Power System** course. This course was developed by BC Hydro to train all power system workers in safe work policies and procedures.

Approximate time required to complete: **2½ to 3 hours**.

Audience

- BC Hydro employees, and contractor's workers who wish to qualify for authorization to PSSP category 3 or higher.
- BC Hydro Generation and Non-Integrated Area (NIA) employees and contractor's workers who wish to qualify for authorization to WPP category B or higher.

Prerequisites

- Basic Safety in BC Hydro Facilities

Course goal

The goal of this course is for you to fully understand the basic procedures for Safety Protection and the processes for applying Safety Protection at BC Hydro.

Purpose of this course

The purpose of this course is to prepare you for working safely on the power system.

This course is **Part 1** of the System Component training required for authorization to either:

- Power System Safety Protection (PSSP) Category 3
- Worker Protection Practices (WPP) Category B

The following table lists the authorizations and the system component courses required for these categories:

	Authorization	System Component Courses
PSSP Category 3	Work on the power system Receive Protection Extensions	Working on the Power System Working under PSSP Tagout
WPP Cat B	Place a personal lock and work under WPP	Working on the Power System Working under WPP Lockout

Course objectives

The desired outcome of this course is that you will fully understand the basic procedures for safety protection and the processes for applying safety protection at BC Hydro.

At the end of this course, you will be able to:

- Identify the types of hazardous energy you will encounter in your work.
- List the methods used to control and eliminate hazardous energy associated with electrical and mechanical equipment.
- Describe the roles and responsibilities for establishing safe working conditions on the BC Hydro power system.

Course topics

- Safety on the power system
- Elements of safety protection
- Safety protection roles and responsibilities

Completion requirements

There is no assessment for this course module. You will be assessed at the end of Part 2 of the training for your category of authorization.

Safety on the power system

Purpose: The purpose of this lesson is to provide an overview of the types of hazardous energy you will encounter when working on the BC Hydro power system and the methods of protecting yourself and others from those hazards.

Objectives: On completion of this lesson, you will be able to:

- Classify the various types of hazardous energy on the power system.
- Explain the Limits of Approach table.
- Describe how barriers and signs can protect workers.
- Summarize the use of protective equipment to control electrical energy.

Topics: This lesson covers the following topics:

- Safety protection at BC Hydro
- Hazardous energy
- Avoiding hazardous energy

Safety protection at BC Hydro

All work on BC Hydro's power system is governed by the rules and requirements defined in the *Safety Practice Regulations*. To ensure that these requirements are applied consistently and systematically, BC Hydro has defined two comprehensive, integrated **Safety Protection** processes:

- Power System Safety Protection (PSSP) is used for work on the Transmission and Distribution systems.
- Work Protection Practices (WPP) is used for work on equipment in Integrated and Non-Integrated Generating Stations and Non-Integrated Substations.

Both PSSP and WPP are designed to ensure that safe working conditions are established before anyone goes to work on power system equipment. Each process defines:

- Procedures for establishing safe work conditions.
- Roles and responsibilities for participation in those procedures.
- Systems for training and authorizing workers to assume specific roles and responsibilities.

Working on the Power System provides basic training for all workers who require authorization to work on the power system under either PSSP or WPP. It is a prerequisite for authorization to PSSP Category 3 or WPP Category B.

Note: In this course, the term power system includes generating stations, high-voltage circuits, substations, transformers, reactive equipment, and distribution circuits and other equipment used in the production, transmission and distribution of electrical energy. The power system can include equipment under construction.

Hazardous energy

In *Basic Safety in BC Hydro Facilities*, you learned about some of the general hazards that are present at BC Hydro worksites and the safety precautions you must take when you work in BC Hydro facilities. You learned that:

- Safety consists of eliminating or controlling hazards to remove or reduce the risk of injury or death.

When working with or on power system equipment, the greatest danger is in coming into contact with **hazardous energy**, which the *Safety Practice Regulations* define as:

- Any electrical, mechanical, hydraulic, pneumatic, chemical, or thermal energy or force such as gravity that could potentially harm workers.

The most common hazardous energy on the power system is electricity. However, in your work, you will also encounter many other types of hazardous energy.

Let's take a closer look at the main types of hazardous energy and some examples of where you might encounter them.

Mechanical energy

Mechanical (or "kinetic") energy is the energy that an object has because of its linear or rotational motion. It is the kinetic energy in a moving vehicle that injures a pedestrian when it hits them. On the power system, sources of hazardous mechanical energy include:

- Internal combustion engines
- Hydraulic, gas and steam turbines
- Fans
- Cranes
- Generators
- Generating unit governors
- Circuit breakers

Operating machinery can be very hazardous, since it can snag your clothing, tools or body parts. According to SPR 309:

- The moving parts of all machinery must be protected with appropriate guards.
- These guards must never be removed while the equipment is in operation.

When you are maintaining or repairing mechanical equipment, you must ensure that it cannot start up or move in a way that could cause injury or death.

Hydraulic energy

Hydraulic energy is the energy stored in a liquid under pressure. Many kinds of equipment use oil under high pressure to move large parts or objects. These include:

- Cranes and aerial lifts
- Circuit breakers
- Hydraulic actuators used to operate turbine intake gates

In hydroelectric generating stations, water under pressure can also pose potential hazards. Water passages, such as tunnels, surge tanks, penstocks and scroll cases, are fed by high-pressure, high-volume sources of hydraulic energy. Work inside such passages exposes a worker to a potentially uncontrolled release of water into the work area, with no easy means of escape. Protective measures must be taken to ensure that the water cannot be released into the passages.

Pneumatic energy

Pneumatic energy is the energy stored in compressed air or other gasses. High-pressure air or gas is used in equipment such as:

- Circuit breakers
- Pneumatic tools
- Generator braking system
- Governor hydraulic accumulators
- Compressed steam, in thermal generating stations

Before starting work on any equipment or machinery that has stored energy in the form of compressed air or other gases, you must follow proper procedures to safely release and isolate the pneumatic energy. An example is with generator braking systems. Before working on the generator brakes, the compressed air needs to be isolated and drained/vented to ensure the brakes cannot operate. It should be noted that additional isolation is required to perform this task.

Chemical energy

Chemical energy is the energy released from chemical reactions. Dangerous chemicals are present in equipment such as:

- Gas insulated systems and switchgear using sulphur hexafluoride (SF_6) gas
- CO^2 or deluge systems
- Batteries and battery rooms
- Treated wood poles
- Water treatment plants

When working on equipment that contains chemical energy, extreme caution must be taken in following proper procedures to control and/or eliminate the possibility of a release of, or exposure to, the chemicals or its by-products. An example is when working on or around SF_6 gas filled equipment. The SF_6 gas inside the equipment may be released in an uncontrolled manner and so precautions need to be taken. This may include but is not limited to the gas needing to be removed from the equipment and special PPE worn to protect against the harmful by-products that may be present in the equipment.

Energy in springs

Compressed and extended springs contain potential energy that can be dangerous if released in an uncontrolled fashion. Springs are used in many types of mechanical devices, including:

- Circuit breakers
- Hydraulic valves
- Overhead doors

Before starting work on any device that contains a spring, you must take care to release the spring's energy in a safe and controlled manner according to safe work procedures and/or equipment manufacturer recommendations.

Energy in elevated objects

Elevated objects also contain potential energy that could pose a risk. Because of the force of gravity, such objects could fall if they are not properly secured. Examples of dangerous elevated objects include:

- Any equipment or material raised by a hoist, crane or jack.
- Raised spillway or intake gates at a generating station.

While the force of gravity cannot be eliminated, measures must be taken to ensure elevated objects cannot fall on workers. If this is not possible, workers must be kept clear of the area under the elevated object.

Thermal energy

Thermal energy is contained in very hot and very cold objects. It is the result of mechanical work, radiation, chemical reaction or electrical resistance. Thermal energy can cause severe burning or freezing. It is found in:

- Steam and gas turbines
- Boilers
- Internal combustion engines

When working around such equipment, you must ensure that you maintain a safe distance as outlined in site-specific training. Before repairing or maintaining such equipment, you must shut it down and allow it to cool down or warm up.

Electrical energy

The most common hazardous energy on the power system is electricity. You have already learned some of the dangers of electrical energy in *Basic Safety in BC Hydro Facilities*:

- Electrical shock can produce severe burns, blindness and death.
- Contact with even low voltages can be fatal.
- You don’t have to touch high-voltage conductors to get a shock.

The primary protection against electrical hazards is to maintain the Limits of Approach: keep all parts of your body, as well as your tools and equipment, far enough away from the electrical source that there is no risk of injury.

However, when you are working on the power system, this is not always possible. In many cases, you need to work on—or very close to—electrical equipment and conductors. Such work requires special precautions to eliminate or control the electrical hazard.

Note: When you are working in a high-voltage electric field, an electrostatic charge is induced in your body, similar to the static charge you get when you shuffle your feet on a carpet. When you then touch a conductor, this energy can be discharged, giving you a small shock, commonly called a “bite.” Although this type of shock will not hurt you, it can cause you to jump, which could cause you to fall or to touch an energized conductor.

Working safely around hazardous energy

Whether you are working on power system equipment, or simply working close to it, it is critical to ensure that you are protected from all hazardous energy. Protection can be attained through:

- **Avoiding** the energy, by observing the Limits of Approach, or erecting barriers or other protective equipment.
- **Eliminating** the energy, by isolating the equipment from the energy sources and securing the isolating devices (using tags or locks).
- **Controlling** the energy, by providing means of dissipating it (grounding or draining, for example) or rendering it ineffective (blocking, for example).

Note: In practice, a combination of these approaches is used on most jobs, but it is important that you understand the differences so you can use them appropriately. See OSH 110 for more detail.

Your notes

Avoiding hazardous energy

In this section, we discuss the methods of avoiding hazardous energy. In the next lesson, we will discuss the methods of eliminating and controlling hazardous energy.

Observing the Limits of Approach

Observing the Limits of Approach (LOA) when you are around high-voltage electrical equipment is the primary way to protect yourself against the hazards of electrical energy.

In *Basic Safety in BC Hydro Facilities*, you learned the following:

- The Limits of Approach are a means of avoiding the risk of shock through **arcing**, by staying beyond the maximum distance that a particular voltage can arc through the air.
- Unqualified Workers are required to work at the distances specified in the *Unqualified Worker* column. If supervised by a Qualified Electrical Worker, you may work at the distances specified in the *Uninsulated equipment or Unqualified Worker and their equipment when continuously directed by a Qualified Electrial Worker* column.
- You must consider your reasonably likely movement—including the movement of any tools and equipment you are using or operating—when planning your worker positioning, so that you can always maintain your limits of approach (see SPR 402).

Figure 1. Maintain your Limits of Approach

Note: While there are no formal Limits of Approach for mechanical equipment, the same principle applies. The best protection against mechanical hazards is to maintain a safe distance.

Who is qualified?

Your manager is responsible for determining whether you qualify for Limits of Approach authorization and will authorize you as Qualified LOA or Unqualified LOA based on specific criteria.

OSH Standard 201 section 4 specifies clear criteria for determining worker qualifications:

- **Qualified Electrical Workers** must:
    1. Meet the requirements of 4.1.1 (*Only experienced electrical utility trades or technical workers who have achieved and maintained their qualifications may be designated as Qualified Electrical Workers*).
    2. Successfully complete SAFE-401 or equivalent training received through a BC Hydro Apprenticeship.

3. Be authorized to at least PSSP Category 5 or WPP Category C**.**
4. Receive BC Hydro Manager Authorization.

- **Qualified Electrical Workers in Training** must be from one of the recognized trades or technical worker classifications in OSH 201 section 4.1.1. They shall be authorized to Unqualified Worker limits of approach and to at least PSSP Category 3 or WPP Category B. These workers may work up to Qualified LOA distances specified in SPR Table 401 if all of the following are met:

    1. They are working under the direct and continuous supervision of a Qualified Electrical Worker authorized to Qualified LOA.
    2. They are working in accordance with the Level Requirements, established by the A&TTC or the Engineering GTT Subcommittee.

- **Unqualified Workers** are those who do not meet the requirements for Qualified Workers or Qualifed Electrical Workers in Training.

    1. Workers that do not meet the requirements stated in sections 4.1 to 4.3 of OSH 201 are considered unqualified. These workers must maintain Unqualified Worker LOA distances.
    2. Note: Unqualified Workers and their equipment may work up to the Uninsulated equipment distance specified in SPR Table 401 when continuously directed by a Qualified Electrical Worker.

Table 401
Limits of Approach (LOA)

Nominal Voltage (kV)	Actual Voltage Range Phase to Phase	Qualified Electrical Worker		Uninsulated equipment or Unqualified Worker and their equipment when continuously directed by Qualified Electrical Worker		Unqualified Worker	
		m	ft	m	ft	m	ft
.751 to 35	751V to 40kV	0.75	2.5	1.20	4	3.00	10
60	40kV to 75kV	0.90	3	1.50	5	3.00	10
138	75kV to 150kV	1.50	5	2.40	8	4.50	15
230	150kV to 250kV	2.10	7	3.00	10	4.50	15
287	250kV to 325kV	2.60	8.5	3.70	12	6.00	20
345	325kV to 425kV	3.00	10	4.30	14	6.00	20
500	425kV to 550kV	3.70	12	4.90	16	6.00	20

Figure 2. Limits of Approach (LOA) Table 401

Using protective equipment

In many cases, it is not possible to maintain enough distance between workers and hazardous equipment. In these cases, the next best protection is to use protective equipment to prevent workers (and the public) from being injured by the equipment.

Work area barriers and warning signs

The simplest method of controlling hazardous energy is to erect barriers and warning signs to prevent workers from being exposed to harmful energy. Work area barriers and signs may be used to define both safe work areas and hazardous areas. Refer to OSH Standard 603 for information on Barrier Standards.

For a **safe work area**, barriers are placed around the border of the work zone to prevent workers from approaching hazards. For example, work area barriers may be placed to prevent workers from approaching too close to an open access hole or to equipment undergoing maintenance.

Hazardous areas are areas where work activities (such as testing of equipment) could result in the transmission or release of energy that could be dangerous to other workers. In these cases, it is necessary to use barriers and signs to limit access to authorized personnel through appropriately posted points of entry/exit.

Hazardous area zones need to be large enough to prevent unauthorized personnel from accidentally coming into contact with any hazardous energy sources in the zone. Warning signs indicating “Authorized Personnel Only” must be posted within sight lines around the perimeter of the hazardous area.

Each defined hazardous area zone must have one or more entry/exit points displaying:

- Information about the potential hazards in the area.
- The name of the worker responsible for the work inside the zone.

Hazardous area zones may require flashing warning lights at points of entry and exit.

Approved electrical protective equipment

The electrical industry has developed various kinds of insulating equipment that eliminates the danger of arcing and thus enables workers to work very close to live electrical equipment. Examples are Lexan barriers and high-voltage rubber hoses, hoods and blankets.

Under special circumstances, if a worker needs to work closer than the distance specified for their level of qualification, a qualified electrical worker must apply approved protective equipment to protect the worker from contact or arcing injuries.

Caution: OSH Standard 602 must be consulted before using insulated tools and equipment.

Figure 3. Work area barriers defining safe work area

Figure 4. Work area barriers defining a hazard zone

Using live-line methods and tools

For some types of electrical work, particularly on the transmission and distribution systems, it is necessary to work on equipment while it is still energized.

Only Qualified Electrical Workers who have received training in the use of live-line methods, live-line tools and approved protective equipment, can work on energized equipment. To perform live-line work, the workers must receive a Live Line Permit for the work in question.

The rules for live-line work are specified in SPR section 400, while the procedures and techniques are taught in specialized trades training courses.

We will **not** be addressing live-line work any further in this course.

Note: When using live-line tools, workers must observe the Limits of Approach.

Figure 5. Use of live-line tools

Your notes

Elements of safety protection

Purpose: The purpose of this lesson is to explain the basic elements of safety protection.

Objectives: On completion of this lesson, you will be able to:

- Identify methods of isolating equipment from sources of hazardous energy.
- Describe what an equipotential zone is and how it is established.
- Explain the purpose of mechanical blocking.
- Explain how locks and tags contribute to worker protection.

Topics: This lesson covers the following topics:

- Introduction
- Isolation of equipment
- Worker protection grounding/bonding
- Blocking
- Securing protection: locks and tags
- Equipment to be treated as energized

Introduction

BC Hydro's Safety Protection systems, PSSP and WPP, specify procedures for eliminating and controlling hazardous energy to ensure equipment is safe to work on. These procedures include the following elements:

- Isolating (disconnecting) the equipment from all primary sources of hazardous energy.
- Applying worker protection grounding/bonding and/or mechanical blocking to protect against accidental re-energization or movement.
- Locking or tagging the isolation points and the grounding/bonding and blocking devices to ensure they are not restored or removed while work is in progress.

Three sections of the *Safety Practice Regulations* are dedicated to the rules and requirements for isolating equipment and securing the protection:

- SPR section 500 specifies general rules about isolation, worker protection grounding/bonding and mechanical blocking.
- SPR section 600 specifies the requirements for work on the Transmission and Distribution systems. These form the basis of Power System Safety Protection (PSSP).
- SPR section 700 specifies the requirements for work in the Integrated and Non-Integrated Generating Stations and associated facilities. These form the basis of Work Protection Practices (WPP).

Isolation of equipment

The primary means of controlling hazardous energy in a piece of equipment is to **isolate** the equipment from its primary energy sources. Isolation is slightly different for electrical and mechanical equipment, but the principle is the same.

Electrical isolation

For electrical equipment, isolation is relatively straightforward. The SPR states that electrical equipment is isolated when "the normal sources of hazardous energy have been disconnected by opening and securing all associated switches or by making a line or bus cut."

When you open a switch or cut a feeder line, normal sources of electrical energy are effectively eliminated from the equipment.

However, opening a switch on a high-voltage circuit is itself quite hazardous, because of the possibility of arcing. Only specially trained and authorized workers can perform switching or make line or bus cuts.

For detailed information on making line or bus cuts, see the *Temporary Line Cuts* work procedure.

Mechanical isolation

For mechanical equipment, isolation is more complex. The SPR states that mechanical equipment is isolated when it "has been rendered and secured non-operative by installing a blank in a pipe line, closing a valve, depressurizing, draining, venting, or other effective means."

Isolating mechanical equipment includes both disconnecting the primary sources of hazardous energy and dissipating any residual energy in the system. Here are a few examples:

- To isolate a device that is operated hydraulically, you must shut down the hydraulic pump and close a valve to remove the primary source of energy and open another valve to remove the hydraulic pressure.
- To isolate a gasoline or diesel engine, you must disconnect the starter battery either physically or by means of a disconnect switch. You may also be required to close a valve in the fuel line. Without energy to the starter, the engine cannot be turned over inadvertently, and without fuel, it cannot be started. It should be noted that neither of these measures by itself ensures complete immobilization of the engine, and certain maintenance tasks will require further isolation.

Worker protection grounding/bonding

When electrical equipment or conductors have been isolated from the sources of electrical energy, it is not yet safe to work on them. As stated in SPR 513.2, isolated equipment can be accidentally re-energized in various ways, including the following:

- Electromagnetic or electrostatic induction (from wind dust storms, adjacent conductors, power cables, static capacitors, etc.)
- A power source
- Contact with crossed or fallen conductors
- Lightning (direct or indirect)

Worker protection grounding/bonding is a method of ensuring electrical energy is controlled in the event of accidental re-energization or induction. It consists of two components:

- All conductors in the work area are “bonded” together with flexible copper leads.
- The bonded conductors are connected to ground.

Note: Induction is often unavoidable and constant in some isolated lines. Worker protection grounding/bonding continually bleeds this electrical energy to keep the lines safe for work.

Equipotential zones

Properly applied bonding forms an **equipotential zone**, a work area in which all conductive materials are always at the same voltage. In such a zone, workers are safe because there is no difference in voltage between conductors.

Connecting the bonded conductors to ground ensures that:

- All conductors remain near ground voltage.
- Any electrical charge is quickly dissipated.
- Any energization from an electrical fault results in immediate tripping of protection devices (circuit breakers or fuses) to stop the current flow.

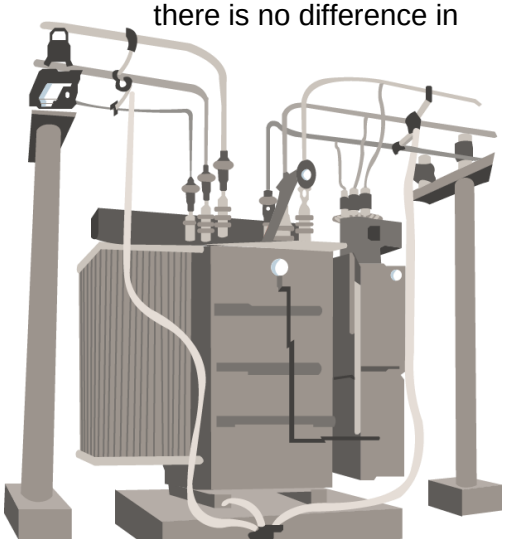


Figure 6. Equipment connected to the station ground grid

The illustrations that follow show examples of worker protection grounding/bonding used to establish equipotential zones. Note that the **pole band** in the second illustration eliminates any voltage difference between hands and feet that would result from the resistance of the wood pole.

Note: The ground grid in stations (which you learned about in *Basic Safety in BC Hydro Facilities*) functions as a built-in equipotential zone. When any conductor is accidentally energized, the entire facility rises to near the same voltage, thus minimizing step and touch hazards. Of course, when you isolate equipment in the station, you must connect it to the ground grid as well, to ensure it is part of the equipotential zone.

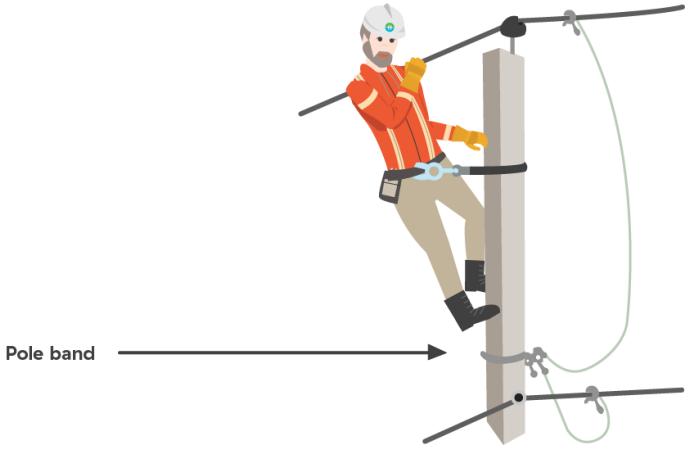


Figure 7. Use of Pole Band to eliminate voltage difference between hands and feet

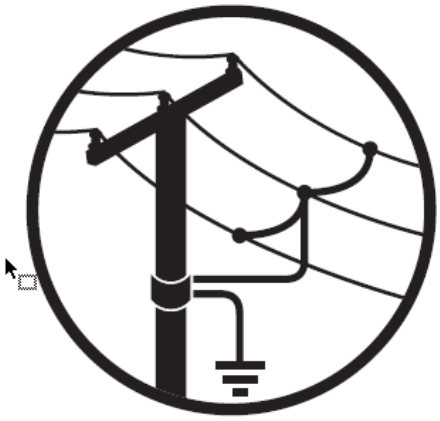


Figure 8. Ensure that worker protection grounding/bonding is applied

Blocking

Like worker protection grounding/bonding, blocking controls accidental energization of isolated equipment. Mechanical blocking prevents unintended movement (such as sliding, falling or rolling) that might be harmful to workers. Such unintended movement may be introduced by:

- Accidental de-isolation
- Forces introduced by the work being done
- External forces (such as gravity)

A good example of mechanical blocking is the use of wheel chocks on vehicles to prevent them from rolling, either when you are using them to perform work or when you are working on them (changing a tire, for example).

Other examples of mechanical blocking:

- An axle stand placed under a jacked-up vehicle to prevent it from falling in the event the jack fails.
- Metal “horseshoes” placed on the hydraulic cylinders that operate the wicket gates on a generating unit to prevent the wicket gates from moving even if hydraulic pressure is accidentally applied.
- “Dogging beams” or steel pedestals placed under raised intake gates to prevent them from falling during maintenance.

Figure 9. Worker applying mechanical blocking (horseshoe) to a hydraulic cylinder

Securing protection: locks and tags

Isolating equipment and applying worker protection grounding/bonding or blocking devices together provide a safe environment in which to work—but they do not ensure it.

If someone else comes along and closes the switch, opens the valve or removes the blocking device, a very dangerous situation is created.

To fully ensure safety, it is necessary to **secure** the isolating, grounding/bonding and blocking devices so they cannot be switched or removed inadvertently by anyone other than the worker who applied them.

On the BC Hydro power system, two methods are used to secure these devices:

- On the Transmission and Distribution systems, under PSSP, a "Do Not Operate" tag is attached to every device that is switched for safety protection purposes.
- In the Integrated and Non-Integrated Generating Stations and their associated facilities, under WPP, locks are placed on the protective devices.

Note: In many applications, "system" locks are used to secure switches and other devices in position to keep workers or the public from tampering with the device, for operational reasons. Such a lock is shown in the top photograph on the next page. These system locks must not be confused with the locks used for safety protection purposes.

Figure 10. PSSP tag, WPP and system locks

Equipment to be treated as energized

SPR 504 states that workers must treat all equipment as energized until it has been isolated, grounded/bonded and blocked, and tags or locks have been applied according to either PSSP or WPP procedures.

Before the equipment is completely tagged or locked out, you must:

- Observe the Limits of Approach for electrical equipment.
- Stay clear of mechanical equipment.
- Use approved protective equipment and tools when approaching or working on the equipment. For example, you must use an insulated tool (a hotstick) to connect a ground lead to an isolated conductor.

Figure 11. Ensure there is a Safety Protection Guarantee or lockout in place and check that it is appropriate for your work

Note: Remember, no equipment is safe to work on until a full PSSP tag-out or WPP lockout is in place

Your notes

Safety protection roles and responsibilities

Purpose: The purpose of this lesson is to introduce the key roles and responsibilities for BC Hydro's safety protection processes.

Objectives: On completion of this lesson, you will be able to:

- Identify which authority is responsible for safety protection in your area of the power system.
- Explain the responsibilities of the Person in Charge (PIC).
- Explain the purpose of alphanumeric identifiers.
- Explain the purpose of the PIC's Mimic Display.
- Indicate the purpose of pre-job conferences and tailboard meetings.

Topics: This lesson covers the following topics:

- Responsibility for operating the system
- Division of authority for work on the system
- The Person in Charge (PIC)
- System operation and safety aids
- PSSP roles and responsibilities
- WPP roles and responsibilities
- Tailboards
- Personal safety responsibilities

Responsibility for operating the system

BC Hydro's power system is a very complex structure. It incorporates:

- 30 hydro-electric generating stations
- 2 thermal generating stations
- 18 diesel generating stations
- Over 79,000 kilometres of transmission and distribution lines
- Interconnections with the Alberta and American power systems and with independent power producers
- Connections with tens of thousands of industrial, commercial, and residential customers

BC Hydro T&D System Operations has the overall responsibility for operating the power system to provide a safe and reliable source of energy for our customers. BC Hydro has two control centres:

- Primary control centre: Fraser Valley Operations in Langley
- Backup control centre: Southern Interior Operations in Vernon

The Control Centre in Langley is normally responsible for operating the integrated Generating Stations and the Transmission and Distribution systems to produce and distribute power. The control centre in Vernon is a completely redundant backup centre that takes control in unusual circumstances.

Besides the main power system, BC Hydro has several separate **Non-Integrated Areas** (NIA). These systems, in remote areas, consist of one or more generating stations and a distribution network for providing power to local customers. Each NIA has a control facility that is responsible for its operations.

Note: The responsibility to operate the power system to produce, transmit and distribute electrical energy is known as **operating responsibility**.

Division of authority for work on the system

Any work on the power system—to maintain, repair, replace or construct lines and equipment—has to be carefully managed for two reasons:

- To ensure that it can be carried out without disrupting the supply of power to the customers.
- To minimize the risk of injury to workers by establishing a safe work environment.

To ensure the safety of workers while maintaining the power supply, BC Hydro has assigned the role of authorizing work activities and establishing safety protection as follows:

- BC Hydro's control centre has responsibility for authorizing and directing all work on the Transmission and Distribution systems.
- Each Integrated Generating Station has responsibility for authorizing and directing all work on the equipment within its boundaries, which may include part of the switchyard associated with the station.
- Each Non-Integrated Area is responsible for authorizing and directing all work on the generation, substation and distribution equipment within its boundaries.

Note: The right to control an assigned portion of the power system for the purposes of establishing the conditions for safe work is known as **operating authority**.

The Person in Charge

Each designated portion of the power system has one Person in Charge (PIC), who is assigned the role of controlling all work being done within the area:

- For work on the Transmission/Distribution networks, the operators on duty at the control centre assume PIC duties for the equipment under their control. There is always a PIC on duty at the control centre.
- For work in an Integrated Generating Station, an authorized worker is assigned PIC duties for the portion of the station that is being worked on. In most generating stations, there is no resident PIC when no equipment is isolated or no changes are being made to existing safety protection.
- For work in Non-Integrated Areas, an authorized worker assumes PIC duties either for a specified shift or when required to establish safety protection in a station.

Only the PIC on duty has the right to authorize work and to establish safe conditions for that work to be carried out. Anyone who needs to perform work on power system equipment must contact the PIC and arrange for whatever safety protection is required.

Note: PIC is not a job title. It is a role that a trained and authorized worker assumes when he or she signs on for specific duties. At any time, there is only one PIC for any one portion of the power system.

The PIC's responsibilities

The PIC assumes both operating responsibility and operating authority for the equipment under his or her control. He or she has sole responsibility to operate the system and sole authority to establish work protection. This dual role ensures that no other individual can make any changes to the system that might place a worker in danger.

The PIC is responsible for:

- Deciding whether the work can be done without jeopardizing the power supply.
- Checking whether the workers requesting safety protection are qualified to perform the work.
- Planning and implementing (or directing) the isolation of equipment.
- Maintaining a record of the status of all equipment under their control, including the details of all safety protection measures.

System operation and safety aids

To ensure consistent and clear communication about equipment on the power system, and to facilitate operations and control, BC Hydro has established the following measures:

- Equipment identification scheme
- Operating Orders
- Operating one-line diagrams
- Isolation schematics
- Mimic Display

It is important that you understand each of these measures so you can perform your job efficiently, effectively, and safely.

Equipment identification

As mandated by SPR 505, every piece of equipment on the BC Hydro power system, from switches and fuses to transmission lines and stations, has been assigned a unique numeric or alphanumeric identifier.

For electrical equipment, the identifier usually has three parts. For example:

- **60CB8**
  - The first number identifies the voltage of the device. In this case, the number 60 indicates 60 kV.
  - The letters in the middle identify the type of equipment. The letters CB in the example means this is a circuit breaker.
  - The last number distinguishes this particular device from other similar equipment in the system. In this case, this is 60 kV circuit breaker number 8.
- 5D21 indicates 500 kV disconnect switch number 21
- 5L72 indicates 500 kV transmission line number 72

In some cases, the identifier has a prefix that indicates the location. For example, REV5D21 indicates the 500 kV disconnect number 21 at Revelstoke. At generating stations, the identifier may have a suffix indicating the generating unit. For example, 13VT3G2 indicates the 13.8 kV voltage transformer number 3 for generating unit 2.

Mechanical devices have slightly different identification schemes, but the principle is the same: every device has a unique identifier.

An example is a valve with the unique identifier: 3/4G1GV10.

3/4 indicates the pipe size, G1 identifies it as on generator #1 and GV10 distinguishes it as governor valve #10.

Whenever any worker refers to a piece of equipment in conversation or in writing, he or she must use the correct identifier. This minimizes the risk of workers attempting to perform work on the wrong device and so placing themselves in great danger.

Operating Orders

The BC Hydro control centre and every generating station and substation has a set of **Local Operating Orders** (LOOs) for the portion of the power system under its control. Local Operating Orders are documents that describe:

- The power system equipment in a portion of the power system.
- Any special procedures and precautions for operating, maintaining, and repairing the equipment.
- The security, evacuation, rescue, and other procedures for the area.

BC Hydro has System Operating Orders (SOOs) that provide information and define policies and procedures for the system as a whole.

Operating one-line diagrams

An operating one-line diagram is a schematic representation of equipment in a portion of the primary Generation, Transmission and Distribution system. On the diagram:

- Each electrical device is represented by a symbol and its alphanumeric identifier.
- Non-electrical devices (such as the water passages and gates in hydro-electric generating stations) are itemized in a list.

Equipment that is shown or listed on operating one-line diagrams is under direct control of the Person in Charge (PIC) of that portion of the system. No other worker can operate this equipment without the PIC's permission. Electrical equipment shown on the one-line is categorized in Levels I to IV, according to voltage.

Equipment that is **not** shown or listed on operating one-line diagrams may be operated for the purpose of safety protection without first getting the PIC's permission, as long as system risk is assessed and the operation does not affect the primary power system. If the system can be affected, the PIC's permission is required. Equipment in this group is categorized in Level V. Examples of this type of equipment are: transmission cable oil pumping system, high-voltage distribution lines that can be isolated by a single device, low-voltage distribution lines, and low-voltage station equipment.

Operating one-line diagrams are used extensively by authorized workers to plan and execute safety protection. To take responsibility for your own safety, it is important to:

- Learn how to interpret the diagrams, including the symbols used for different types of devices.

- Become familiar with the diagrams for the area or station in which you work so you know what conditions affect your work.

PSSP/WPP boundary at BC Hydro generating stations

Because different BC Hydro safety protection practices are used on the transmission and distribution systems (PSSP) and in the generating stations (WPP), it is critical that everyone understands precisely where the boundary between the two practices lies. When you need to work on any piece of equipment near a BC Hydro generating station's fence, you have to know whether to apply PSSP or WPP procedures.

Usually, WPP rules and procedures apply to equipment in the BC Hydro generating station itself and to equipment in the station switchyard.

To ensure that there is never confusion over who is in charge and which safety protection practices apply, the boundary between PSSP and WPP at each station is:

- Clearly defined in a joint or Local Operating Order, in terms of the devices to which WPP practice applies.
- Depicted as a dotted line on the operating one-line diagrams for the station and the transmission system.

When you are working close to a BC Hydro generating station boundary, whether on the Transmission/Distribution side or the Generating Station side, you must be aware of the boundary and which safety protection process applies to the equipment you are working on.

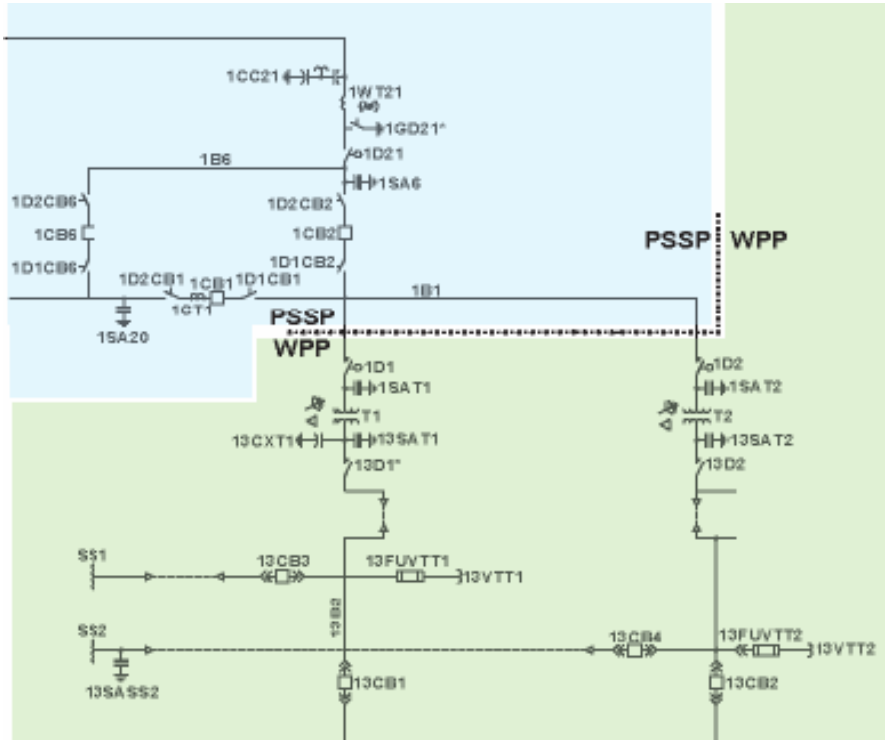


Figure 12. Part of an operating one-line showing the PSSP/WPP boundary

Unit isolation schematics

BC Hydro generating stations have a unit isolation schematic for each of their generating units. The unit isolation schematic displays the:

- Hazardous energy sources
- Pipes and electrical conductors in the system
- Devices for isolating the unit

The unit isolation schematic is used as a visual aid for understanding and planning isolation. It cannot be used to identify or distinguish equipment levels or to determine whether the PIC's intervention is required.

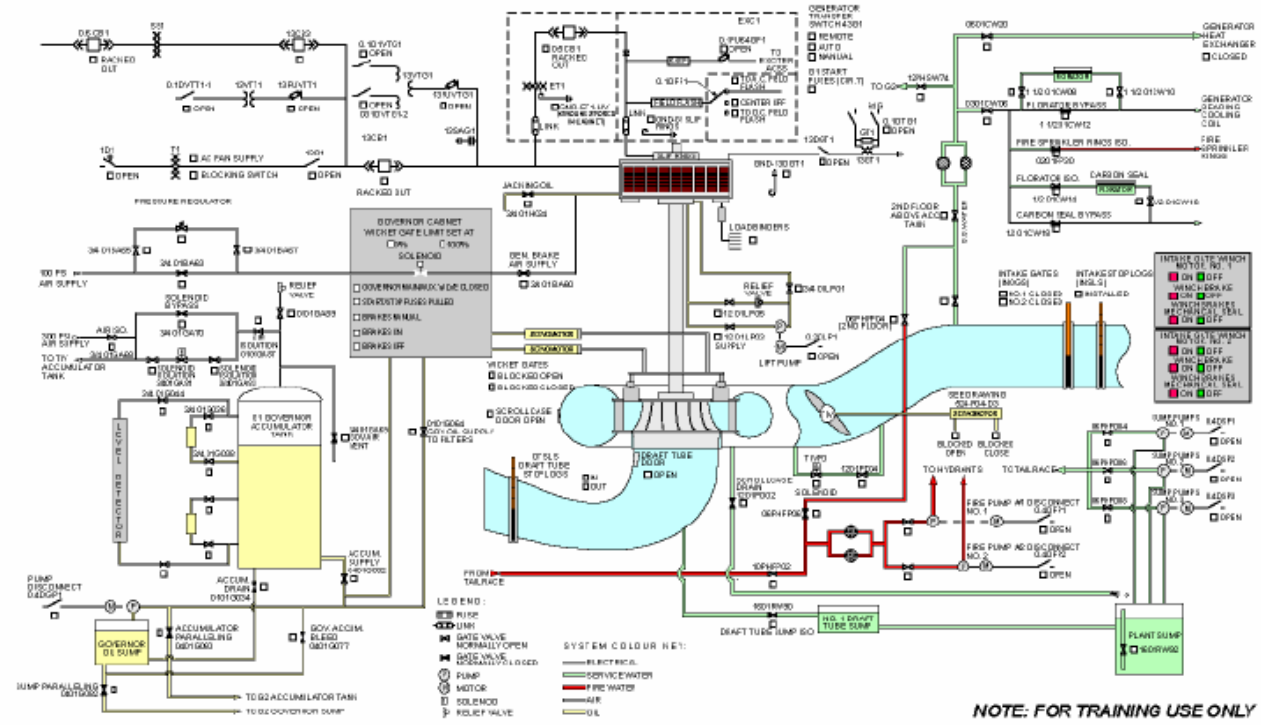


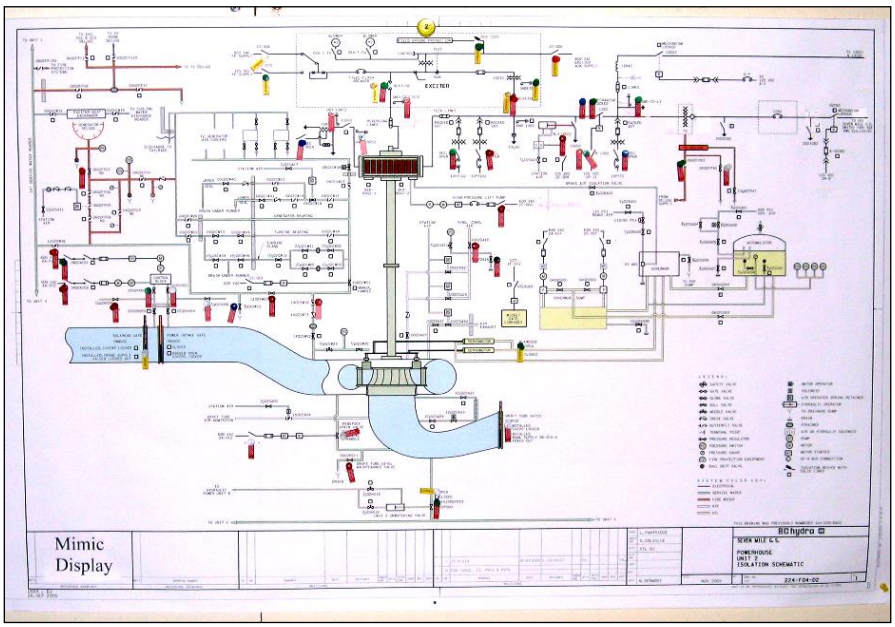
Figure 13. Unit isolation schematic

Mimic Display

Every PIC maintains an official representation of the portion of the system under his or her control, called the **Mimic Display**. The Mimic Display shows the configuration of the system and the current status of each device in the system. It is the PIC's primary device for planning and implementing safety protection for workers.

The Mimic Display may be an electronic display (in the control centre), an operating one-line diagram, or a unit isolation diagram (in BC Hydro generating stations). Each PIC has only one Mimic Display at any one time, so there can be no confusion about the current state of the system.

Before signing on for PIC duties, it is the worker's responsibility to review the Mimic Display carefully so they have a clear understanding of the work being done and the status of all equipment within their area of responsibility.



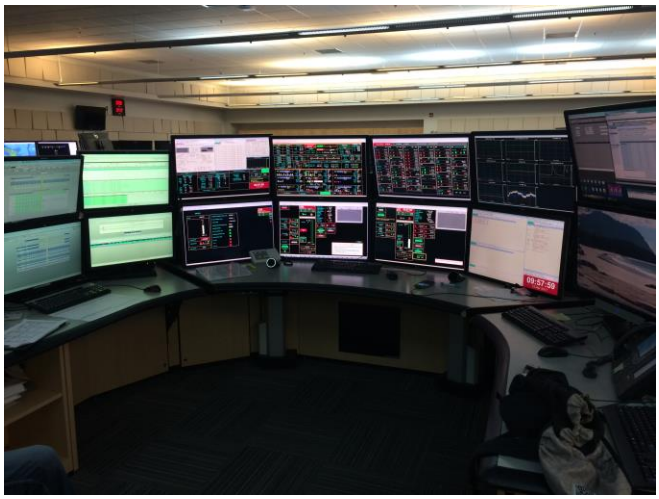


Figure 14. Mimic Displays

PSSP roles and responsibilities

PSSP uses **Safety Protection Guarantees (SPGs)** to ensure that lines and electrical or mechanical equipment are isolated and safe to work on. A Safety Protection Guarantee is a stated assurance that a specified line or piece of equipment is isolated and that it is safe to apply grounding/ bonding and blocking. There are several types of SPG, which are used for different types of work on the system.

With a Safety Protection Guarantee:

- The PIC initiates or directs the isolation of equipment, including the application of Do Not Operate tags to the switching devices, then issues the SPG to a worker authorized to PSSP Category 5 or 6 (the SPG holder).
- The SPG holder applies or directs the application of the necessary worker protection grounding/bonding and blocking devices.
- Both the PIC and the SPG holder document the details of the protection on Safety Protection forms, and the PIC updates the Mimic Display to show the status of the equipment.
- The safety protection provided by these measures applies to all workers in the SPG holder's crew. The SPG holder is responsible for explaining the risks and the protections to every crew member.

The use of SPGs makes it possible for one PIC to oversee the work being performed over a large geographical area and provides the flexibility required to work on equipment that might be miles from the isolation points.

Note: If you are seeking authorization under PSSP, you will learn more about your roles and responsibilities within the process in the next course, *Working under PSSP Tag-Out*.

WPP roles and responsibilities

WPP uses personal and group lockouts to ensure that electrical or mechanical equipment is isolated and safe to work on.

Under personal lockout procedures, each worker attaches their personal locks on each isolation, grounding/bonding and blocking device to ensure that work protection is not removed before all work is completed.

For group lockout (GLO):

- A worker who is authorized to WPP Category D at the station signs on as PIC for the group lockout.
- The PIC identifies the hazardous energy sources for the work to be done, records the isolating, worker protection grounding/bonding and blocking devices and their status on a group lockout sheet, lists the switching steps on a switching order, and issues the switching order.
- Once a group lockout is in effect, each worker reviews the safety protection measures and attaches his or her personal lock to the group lockout board before going to work.
- Workers remove their locks when they leave the site or complete their work.
- While the PIC is responsible for establishing safe work conditions, each worker is ultimately responsible for their own safety, through the application and removal of their personal locks.

The use of personal locks for work protection is well adapted to the generating station environment, in which a large number of workers might be working on several projects within a fairly restricted space. Additionally, it is also well suited to NIA diesel generating stations and associated substations where a few workers might be working with a small number of isolating devices.

Protection devices cannot be restored or removed until every worker has removed his or her personal locks.

Note: If you are seeking authorization under WPP, you will learn more about your roles and responsibilities within the process in the next course, *Working under WPP Lockout*.

Job planning and communications

A key element of both PSSP and WPP is job planning and communication. Pre-job conferences and tailboard meetings provide the opportunity to apply safety protection procedures to the requirements of a particular job and to communicate the plans to all workers.

Pre-job conferences

Pre-job conferences are held before a large or complex job begins so that the participating crews can coordinate the work they are doing and fully discuss the hazards involved, the safety protection required, and any other issues or concerns. These conferences include representatives from management and from the BC Hydro and contractor crews that are involved in the work.

Pre-job conferences include discussions of:

- The nature of the work.
- The composition of the work force.
- The type of equipment to be used.
- Any constraints imposed by the job location and working environment.
- Scheduling of crews' activities.

Contractors and crew leaders are responsible for briefing their personnel on the plans defined at the conference.

For further details on pre-job conferences, see OSH Standard 122 and Generation Safe Work Standard 108.

Tailboard meetings

SPR rule 106 requires documented tailboards to be held for all high hazard work involving one or more workers:

- Before work commences each day
- And/or whenever there is a significant change in the work plan

A documented tailboard is also required for switching, even if the only work being done is switching.

The purpose of the tailboards is to ensure that everyone participating in the job understands:

- The work to be done.
- The hazards involved.
- The multiple independent barriers to be put in place for each hazard.
- Other precautions to be taken.
- Their own roles and responsibilities.

OSH 122 says that each hazard with the potential for fatality or permanent disability must be confirmed and individually recorded on the applicable job planning/tailboard form. See OSH 122 for more details.

Every documented tailboard form must be retained for two years.

At the tailboard meeting, the worker in charge reviews the following information:

- All the known hazards and the multiple independent barriers that will be put in place for each hazard.
- The scope and sequence of tasks for the planned work, including any applicable procedures.
- A review of any relevant preliminary or pre-job documentation.
- The location and boundaries of the work, and the placement of barriers to establish safety zones.
- Environmental conditions which could impact the work.
- Communication requirements and the systems that will be used.
- Rules and regulations applicable to the work being performed.
- Required personal protective equipment.
- Emergency plans, first aid, rescue plans, emergency response contacts and locations.
- Other work that could affect the work area.
- Worker experience and knowledge of the job at hand.

It is your responsibility as a crew member to make sure you understand the job, the hazards, the protection, the procedures, and your own role and responsibilities. If you have any concerns, communicate them clearly in the tailboard meeting and make sure they are resolved to your satisfaction. Before beginning work, you must initial the tailboard form to indicate that you are satisfied with the plans and safety precautions for the job.

If you miss the tailboard, you must contact the work leader and complete a tailboard discussion and initial the tailboard form before beginning work.

Personal safety responsibilities

BC Hydro's safety protection policies and procedures are intended to establish a safe working environment for everyone who works on the power system. However, only **you** can ensure that the environment is safe for the work you are doing and that you work safely in that environment.

In order to take responsibility for your own safety:

- Be sure you understand your category of authorization, the limits of what you are allowed to do, and the procedures you must follow.
- Make sure you understand the equipment you are working on and the potential hazards of the work you are doing.
- Make sure you understand the protection that has been put into place and are confident it serves your safety.
- If you have any questions or concerns, communicate with the SPG holder, work leader, or the PIC for the project. It is their responsibility to respond to any concerns you might have.
- In everything you do, exercise care and caution to ensure your own safety, as well as the safety of your fellow workers and the public.