PHYSICAL HAZARDS

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A. Hazard Identification and Control Review

Detailed information on the legislated requirements for hazard assessment is included in the chapter on legislation. Detailed information on the process for identifying and controlling hazards and sample hazard assessment forms are included in the chapter on health and safety management systems. A brief overview is provided here to reinforce the importance of the basic principles of hazard identification, assessment and control.

What Is a Hazard?

A **hazard** is any situation, condition or thing that may be dangerous to the safety or health of workers.

(OHS Code Part 1)

Identifying Hazards

The first step in preventing incidents, injuries or illness in the workplace is identification of all the hazards within the workplace that could cause injury or illness. In Alberta, the employer is responsible for conducting an overall hazard assessment in the workplace (Alberta OHS Code, Part 2); however, all workers should be able to recognize and identify hazards in the workplace on an ongoing basis. As work conditions change, so may the hazards. It is essential that workers be alert and aware of their surroundings at all times.

Controlling Hazards

The hierarchy of controls applies to all types of hazards and is outlined below.

Whenever possible, hazards should be **eliminated**. If this is not possible, hazards must be controlled. **Control** means reducing the hazard to levels that do not present a risk to worker health. Controls, in order of preference, include:

- Engineering Controls
- Administrative Controls
- Personal Protective Equipment (PPE) (Used only when other levels of control are not possible or if additional protection is required to ensure the health andsafety of workers.)

B. Physical Hazards Overview

Physical hazards are a risk to your physical safety. Physical hazards not only include things you see that can hurt you, such as machinery, tools or knives, but also forms of physical energy, such as noise, vibration, radiation and extremes in temperature. Injuries from physical hazards can be immediate, such as from a fall, or can be delayed for many years, such as gradual loss of hearing from noise exposure.

Bruises, sprains, fractures, concussions and lacerations are injuries that result from some form of physical contact. Usually, the worker is moving and hits a stationary object or the moving object hits a stationary worker. On occasion, both the worker and the object are moving.

Loss of hearing, burns, hypothermia, heat stroke, skin rash and blistering are some of the injuries or illnesses caused by exposure to unseen physical hazards.

Physical hazards that are discussed in this section include:

- slips, trips and falls
- electricity
- tools and machinery
- heat stress
- cold stress
- noise
- vibration
- radiation
- fire

Protecting Paulomi

Alberta's Worst Handyman Cartoon

C-SlipsTripsFalls.ppt
Slides 1–3

C. Slips, Trips and Falls

It is amazing we do not fall more often than we do. As our leg swings forward each time we take a step, our toe rushes past the ground at a speed of 14 to 18 km/hr and is often less than 1 cm above it. As we land our heel, it normally slips forward along the ground for a distance of up to 2 cm, without causing us to lose balance.

Slips

Slips most commonly occur when the back heel strikes the ground and you start to transfer your body weight to the lead foot. If this foot slips out from under you, you lose your support base and fall. Although you may often manage to recover from slips, you can easily strain muscles while trying to regain your balance. Many lower back injuries occur when someone carrying or lifting an object tries to recover from a slip or loss of balance.

To prevent slips:

- Wear appropriate footwear and keep walking surfaces clean.
- Introduce high resistance nonslip surfaces in situations where they can be useful BUT – be aware that they can increase the potential for trips. Consider carefully.
- Ensure walking surfaces are suitable for the pushing, pulling and carrying tasks performed on them. They should provide adequate foot grip but allow wheels to roll freely.

Trips

Trips are caused when your forward-moving leg suddenly and unexpectedly stops. Your body continues its forward motion but does not have a foot on which to land, so you fall.

Abrupt changes in the height of a walking surface present a tripping hazard, even if the change is as little as 1 cm. Making the transition from a slippery surface, such as a sand-covered loading ramp, to a slip-resistant surface, such as a clean, dry, asphalt pad, can also cause trips. Make a point of adapting your walk to the surface.

To prevent trips:

- Keep as few objects as possible on walking and working surfaces.
- Eliminate abrupt changes in walking surface heights.
- Replace stairs with ramps between levels, where possible. Be aware that when a ramp angle increases as much as 20 degrees, the slip resistance of the surface must increase approximately threefold to prevent slips.

Activity

Use the following as a review of slips and trips.

Identify methods that can help prevent slips and trips:

- Clean up spills and put salt or sand on ice.
- Wear footwear with good traction and appropriate for the kind of work you are doing.
- Clean up after a lab exercise, a project in the technology lab or at work.
- Return all tools and equipment to proper storage areas.
- Keep floors and aisleways clear and clean.
- Install appropriate flooring surfaces, such as anti-slip paint in interiors and open grates for stairs and exterior locations.
- Install handrails, grab bars and guardrails in appropriate locations.

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Ladder Safety

Falls (to a lower level)

On average, approximately 19% of workplace injuries at Alberta workplaces that result in time lost from work are due to falls. The seriousness of falls is often underestimated; serious injuries or even death have resulted from falls of less than 3 metres. Unsafe ladder use, particularly in construction and maintenance, causes falls but even stairs present a hazard. People lose their balance, slip on poor slip- resistant material on the nose of the stair or neglect to use handrails, perhaps because they are carrying something.

Falls associated with the operation of vehicles and equipment are often the result of a combination of slips, loss of balance and misjudging surface or step height.

Falls from a height to a lower level are often the result of safety equipment not being used or being used incorrectly.

Preventing Falls to a Lower Level

Portable Ladders

The following safety precautions should be followed when using a stepladder:

- Unless specifically allowed by the manufacturer in its instructions for use, a worker must never work from the top two rungs, steps or cleats of a portable ladder. Unless designed to permit such use, portable ladders can become unstable or workers can lose their balance for lack of siderails to hold while working from the top two rungs, steps or cleats (see Figure 1).

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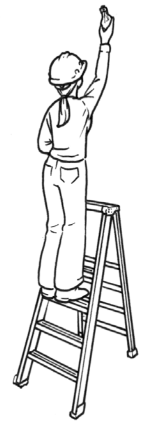

Figure 1—Safely working from a stepladder

- Always face the stepladder treads when using a stepladder.
- Do not use a stepladder for entry to or exit from another work area.
- Do not lean to one side or overreach while using a stepladder.
- Unless permitted by the stepladder manufacturer, never use a stepladder as a support for a working platform; the ladder is too unstable.
- Always visually inspect the ladder before each use.
- Place a stepladder on a firm, flat surface.
- Do not place a stepladder on boxes or scaffolds to gain extra height.
- Always take care when positioning a stepladder in corridors or driveways where it could be hit by a person or vehicle. Set up suitable barriers, where necessary.
- Set the ladder base on a secure, even surface. Shim the base, if necessary (see, Figure 2).

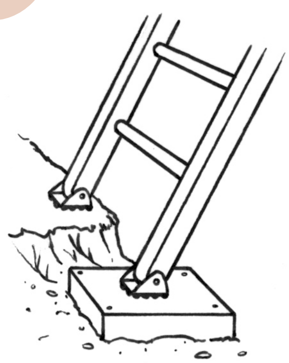

Figure 2—Shimming the ladder base on uneven ground

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Securing the Ladder to Prevent Movement

A portable ladder can be secured against movement in many ways. Because it can move at both its upper and lower ends, it should ideally be secured at both ends.

Slip-resistant or rubber safety feet at the bottom of a metal or reinforced plastic ladder are considered to offer securement if they rest on a firm, nonslippery surface. If the surface that the ladder rests on is slippery or it is possible for the base of the ladder to move, then the ladder must be secured. Examples of acceptable securement methods include:

- spikes driven through the feet into the surface upon which the ladder base rests
- cleats nailed into the surface to prevent movement
- tying the feet of the ladder to stakes in the ground to stop it from slipping (place a large flat wooden board underneath to help prevent it sinking)
- butting the base of the ladder against a fixed structure, such as a curb or wall, heavy blocks or sandbags
- having a person stand at the base, one foot on the lowest rung, holding a siderail in each hand

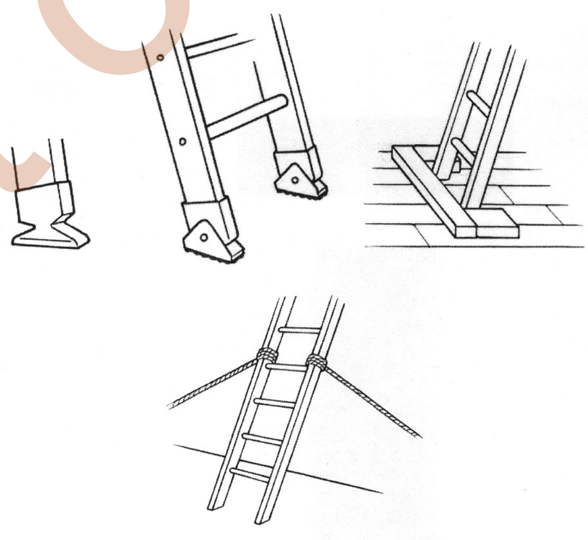

Figure 3—Securing the base of a ladder

At the top of the ladder, both rails should be supported unless the ladder has a single support attachment. Ladder ties to the support at the top are often used. An alternative might be to tie ropes or straps from the siderails (not the rungs) to a fixed object (see Figure 4).

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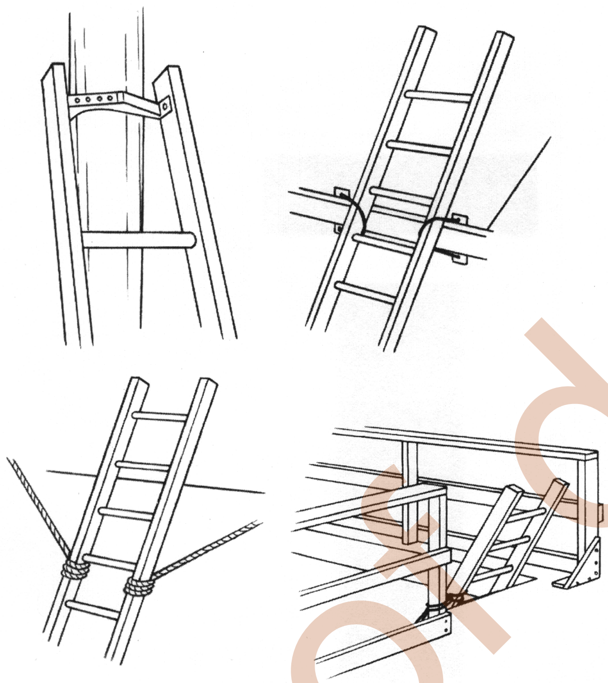

Figure 4—Securing a portable ladder at the top

Ladders must be set up so that the base is out 1 metre for each 4 metres up (see Figure 5). "Four up – one out" gives the right slope – approximately 75° from the horizontal. This position offers the ladder and the worker standing on it the greatest stability.

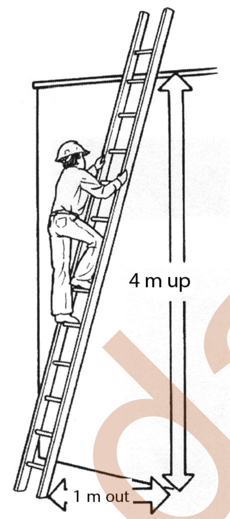

Figure 5—Proper placement of ladder

The siderails of a portable ladder must extend at least 1 metre (3 feet) above any platform, landing or parapet where the ladder is used as a means of access to the platform, landing or parapet (see Figure 6). Doing so provides the worker using the ladder with handholds for getting on and off the ladder.

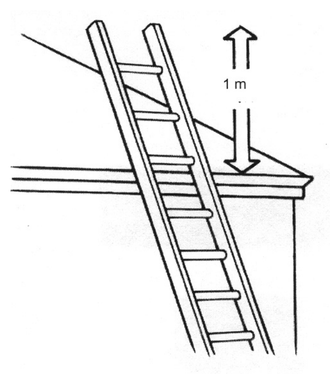

Figure 6—Top of ladder extending above access level

Preventing Falls to a Lower Level

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Fall Protection

According to Alberta's Occupational Health and Safety Code, workers must use a fall protection system:

- if a worker can fall 3 metres or more
- if falling from a lower height can cause an injury that might be worse than an injury resulting from landing on a solid, flat surface; e.g., falling onto protruding rebar, into a vat of acid

The simplest and most reliable way of preventing workers from falling from an elevated work area is to install guardrails at the perimeter of the work area. Guardrails must be of a certain height and strength to prevent workers stumbling over the top rail or the guardrail collapsing. Examples of acceptable guardrails are shown in Figure 7.

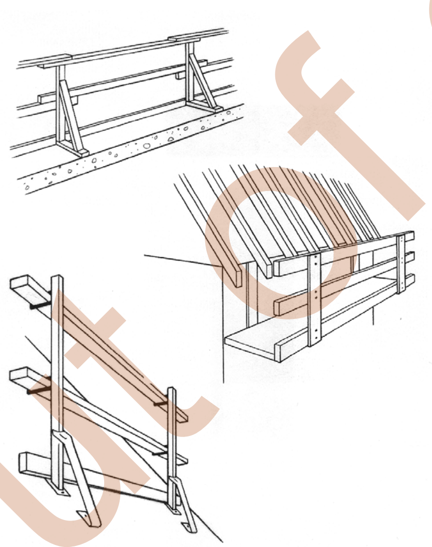

Figure 7—Acceptable guardrail systems

If the use of a guardrail is not practicable, the employer's second choice is to protect workers by having them use a travel restraint system. The purpose of a guardrail or travel restraint system is to prevent a worker from reaching an edge from which the worker could fall. In contrast, a fall arrest system is intended to catch a falling worker in mid-air, safely bringing the worker to a complete stop, without hitting a lower surface.

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Travel Restraint and Fall Arrest

Travel restraint prevents the worker from getting to an edge from which the worker could fall.

Fall arrest catches a falling worker in mid-air, safely stopping the worker and preventing the worker from hitting a lower surface.

Travel Restraint Systems

In any situation where a worker is in danger of falling more than 3 metres and a guardrail cannot be used, a travel restraint system is the next option that should be used.

This type of system prevents the worker from getting to the edge of a floor opening, roof or similar surface. A travel restraint system is similar to the idea of a leash – workers are free to move around and do their work, but the travel restraint is organized and designed so that the workers cannot get to the edge from which they could fall. The system typically involves the use of a full body harness, lanyard and secure anchor point. A lanyard is a line, made of webbing or synthetic wire rope, that connects the harness and the worker to the anchor.

Examples of where travel restraint systems are used:

- Construction workers wear travel restraint while installing windows in highrise buildings (from inside the building).
- Theatre staff that operate the ropes for curtains and backdrops use travel restraint to keep from falling over the open end of the work platform.
- Roofers may use travel restraint when working on flat or sloped roofs.

Fall Arrest System

If the previous methods cannot be used, a fall arrest system must be used. Unlike the other methods, this system does not prevent the worker from falling. If the worker does fall, it is designed to catch the worker in mid-air before the worker hits a lower surface. In order to provide this special type of protection, the basic system consists of several components, including:

- a full body harness, with rings where the lanyards can be attached (see Figure 8)
- a lanyard with a shock absorber to absorb the stress applied when a worker falls and lessen the impact on the worker (see Figure 9)
- a secure anchor point

Important note: sit harnesses, as used in sport climbing and mountaineering, are unacceptable for industrial fall protection – workers can end up suspended upside down, can fall out of the harness and can suffer catastrophic back injuries.

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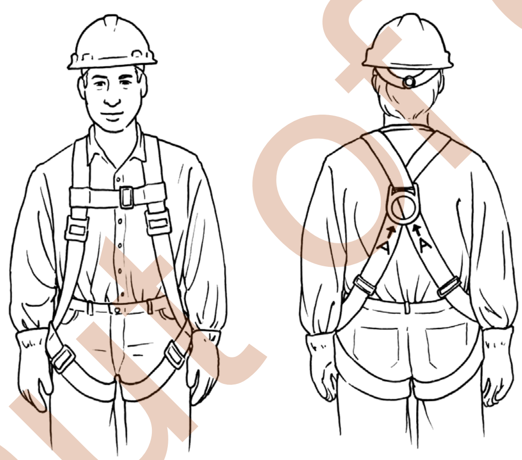

Figure 8—Full body harness

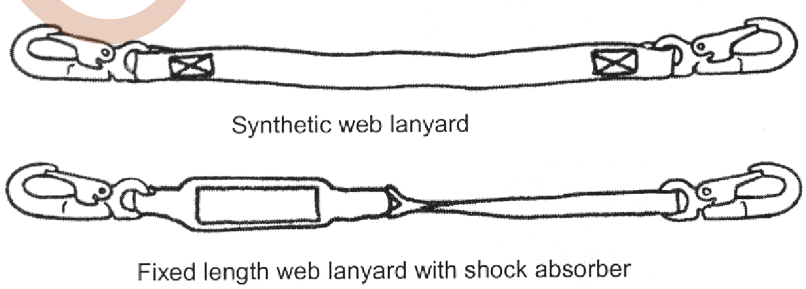

Figure 9—Lanyards

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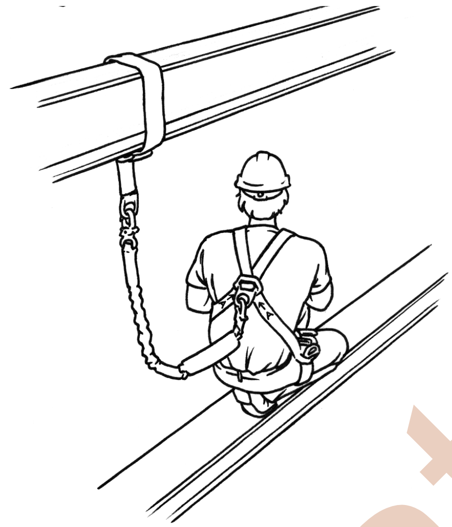

Figure 10—Fall arrest system connected to anchor point

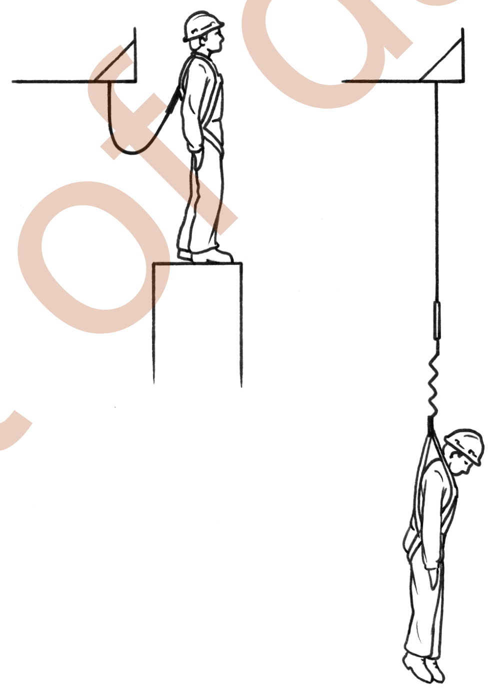

Figure 11—Shock absorber extended, worker hanging upright

Anchor Point

How strong should an anchor point be? Considering that you are literally depending on it with your life, it should be strong.

You may tug or reef on a potential anchor point to see if it will hold. This "test" is completely inadequate as the force generated during a tug rarely approaches even half the worker's body weight. A better approach is to imagine a passenger vehicle hanging from the anchor point by a lanyard (see Figure 12). If the vehicle, having a weight approaching 1600 kilograms (3600 pounds) can be held, then the anchor is a good one.

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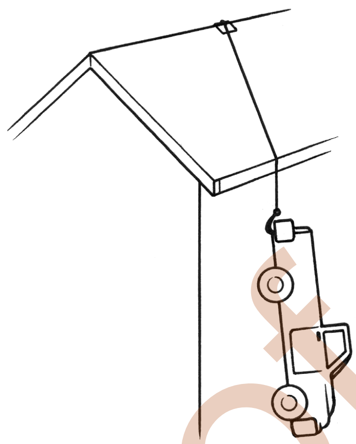

Figure 12—A fall arrest anchor point must be strong enough to support the weight of a pickup truck

Requirements for Travel Restraint and Fall Arrest Systems

The following are mandatory for travel restraint and fall arrest systems:

- A worker must be trained in how to use the equipment.
- The equipment must be appropriate for the situation. There are various types of fall protection equipment and the employer must make sure the right kind is used for the work.
- The equipment must be used correctly. Wearing fall protection equipment and not using it properly is no protection at all. There have been instances of workers who were wearing fall arrest harnesses but suffered serious injuries or died from falls because they had not attached their system to an anchor point.
- The equipment must be anchored to a secure point. A fall arrest or travel restraint system without an anchor point that can withstand the forces from movement or a fall is no protection.

Activity

Use the following activity as a review about fall hazards.

Students should be able to discuss when and why falls occur; e.g., falls on the same level, falls to a lower level. A possible way to lead the discussion would be to have the students identify situations where falls may occur, including:

- working on an elevated platform, such as in theatre rigging
- using ladders to change light bulbs
- placing posters on the walls
- painting homes
- unloading packages from the back of a panel truck

Ask students to identify some conditions that could cause falls, such as:

- slippery footing; e.g., icy, oily, wet
- cannot hold on to a support when on a ladder, tree or a scaffold
- reaching too far from a ladder or scaffold
- poor visibility

Identify methods that can help prevent falls, such as:

- hands-on training about safe procedures for working at heights
- use of proper equipment to reach heights

Activity

Case Study

The Fall Guy: Recognizing, Assessing and Controlling Hazards

A company wants to have a 5 metre by 6 metre mural painted on its exterior store wall and has hired a high school student to paint it. The student, who also does recreational sport climbing, was asked to use her climbing gear while painting the mural.

Class Discussion

Hazard Recognition:
- The employer has recognized that there is a potential for falling, as indicated by his request for the student to use her sport climbing gear.
- The student is aware that working over 3 metres from the ground requires the use of fall protection when there is a risk of falling.

Assessing the Hazard: What Should the Student Do?
- The requirements of the Occupational Health and Safety Regulation and Code apply.
- Find out if the building has anchor points on the roof to which to attach fall protection equipment.
- Do some research to find out if the mountain climbing gear is appropriate for this type of work. A check in the Occupational Health and Safety Code and its Explanation Guide show that a sport climbing harness is unacceptable for this work. (Without shoulder straps, workers can end up suspended upside down and can fall out of the harness; the low attachment point means a fallen worker can suffer a catastrophic back injury if the worker falls in a reverse jackknife position.)

Controlling the Hazard: What Is Next?
- Let the employer know that the sport climbing gear is not appropriate for this type of work and, further, that there are no anchor points for fall protection.
- Talk about alternative ways to access the wall to do the work and protect the student from falling; e.g.,
  - scaffolding
  - ladder
  - scissor lift
  - man lift

The employer should help determine that a scissor lift, including a fall protection system, along with training for the student on how to use it safely is the best solution. The scissor lift offers flexibility to move around while doing the job and provides the student with a work platform that has a guardrail on all four sides and a fall protection system.

D-Electricity.ppt
Slides 1–4

Don't Overload Circuit – Power Calculations

Resistors are Hot

Win, Lose or Draw Electrical Safety

D. Electricity

The electrical current available from a household electrical outlet has enough power to electrocute and kill a person. Even changing the light bulb of a portable lamp, without unplugging the lamp, or changing the bulb in a ceiling outlet, without switching off the circuit breaker to the outlet, can be hazardous. In each case, you could contact the hot or live part of the socket and receive a shock.

Type of Injuries

There are four main types of injuries associated with contacting electricity:

- electrocution, which kills
- electric shock, which can interfere with the function of organs, such as the heart
- burns, both surface and full-thickness tissue burns
- injuries from falls that result from being startled or losing control of muscles

How These Injuries Happen

Injuries associated with electrical contact occur when:

- Direct contact is made with the electrical energy.
- Electricity arcs (jumps) through a gas, such as air, to a person who is grounded. (Grounding means the person provides an alternative route to the ground for the electricity.)
- Heat generated by an electric arc causes thermal burns.
- Materials that catch on fire (from heating or ignition by electrical currents) cause flame burns.
- High voltage contact burns internal tissues, while leaving only very small injuries on the outside of the skin. (The injured person is literally burning from the inside out (a horribly painful and disfiguring injury).
- Muscle contractions or a startle reaction cause a person to fall. The resulting injuries can be particularly serious if the person falls from a ladder, scaffold or other height.

Unsafe Activities that Can Lead to Injury

The following is a list of examples of unsafe activities that can lead to injury:

- failure to de-energize and lock out, where necessary, equipment and machines being inspected, serviced or repaired
- use of defective and unsafe tools
- use of tools or equipment too close to energized parts; e.g., a metal wrench slipping off a nut and contacting an energized wire can result in a surprising and possibly injury-causing event
- use of three-wire cord with a two-wire plug, thereby losing the safety ground
- removal of the third prong (ground pin) to make a three-prong plug fit a two-prong outlet
- overload of outlets with too many appliances
- not verifying that the power is off when making repairs to electrically powered equipment or tools
- working from an elevated platform, such as a rolling scaffold, near overhead power lines

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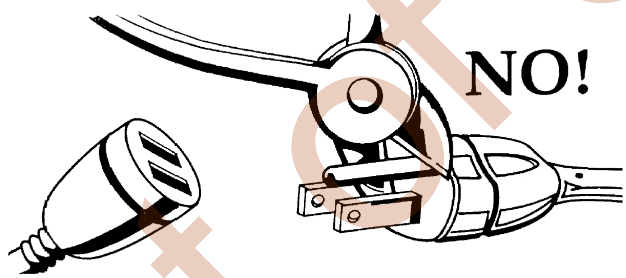
Slides 5–8



Safety Tips for Working with or near Electricity

The following is a list of safety tips for working with or near electricity:

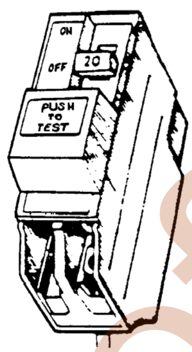
- Inspect tools, power cords and electrical connections for damage or wear prior to each use. Repair or replace damaged equipment immediately.
- Make sure that tools are properly grounded or double-insulated. A grounded tool will have a three-wire cord with a three-prong plug. This plug should be plugged in a properly grounded three-pole outlet. Double-insulated equipment is specially built and does not require a three-prong plug – it will have a two-prong plug. Double insulated tools will bear a square-within-a-square mark. Look for it.
- Always tape cords to walls or floors, when necessary. Nails and staples can damage cords and cause fire and shock hazards.
- Always use the correct size fuse. Replacing a fuse with one of a larger size can cause excessive currents in the wiring and possibly start a fire.
- Always use ladders made of wood or other nonconductive materials when working around exposed, energized electrical equipment and wires.
- The risk of electric shock is greater in locations that are wet or damp. Install Ground Fault Circuit Interrupters (GFCIs), which interrupt the electrical circuit before a current sufficient to cause death or serious injury can build up.
- Know where the breakers and boxes are located, in case of an emergency.
- Do not touch a person or potentially energized equipment if electrical contact happens. Confirm that the power is off before touching anyone or anything in the area.
- Use extension cords only to temporarily supply power to an area that does not have a power outlet. Extension cords should not be used as permanent wiring.
- Do not allow vehicles to pass over unprotected power cords. Cords should be put in conduit or protected by placing planks alongside them.

Ground Fault Circuit Interrupter (GFCI)

What is that strange-looking plug on your new hair dryer or outlet in the kitchen or bathroom of your home? It is a Ground Fault Circuit Interrupter (GFCI), a safety device designed to improve safety when electricity is used in and around wet places.

D-Electricity.ppt
Slides 9–10

The GFCI monitors the flow of electric current. If an imbalance in the flow occurs, the GFCI stops the current to avoid danger. GFCIs are required in the bathrooms, kitchens and garages of new homes as well as on some basement and outdoor outlets. Many new small appliances also feature GFCIs. If your home is not equipped with GFCIs, they can be added as temporary plug-in adapters.



GFCI

Overhead Power Lines

Overhead power lines are dangerous because they carry an electric current that can instantly cause injury or possibly death. Whereas the outlet in a home normally supplies power at 110 volts a.c., overhead power lines in neighbourhoods routinely carry 4,000 to 13,000 volts of power and transmission lines transmit electricity at up to 500,000 volts.

Power Lines Top 10 List

To protect workers from contact with overhead power lines, safe limit of approach distances have been developed. These distances are intended to prevent power line contacts and the resulting injuries and fatalities. If work is done or equipment is operated within 7 metres of an energized overhead power line, the employer must contact the power line operator to determine the voltage of the power line. As shown in Table 1, the power line voltage determines the safe approach distance. Until the power line operator verifies the voltage, the employer must ensure a safe clearance distance of at least 7 metres is maintained.

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Slide 11

Table 1: Safe Limit of Approach Distances

Operating Voltage between Conductors of Overhead Power Line	Safe Limit of Approach Distance for Persons and Equipment
0-750 volts Insulated or polyethylene covered conductors (1)	300 millimetres
0-750 volts Bare, uninsulated	1.0 metre
Above 750 volts Insulated conductors (1) (2)	1.0 metre
750 volts-40 kilovolts	3.0 metres
69 kilovolts, 72 kilovolts	3.5 metres
138 kilovolts, 144 kilovolts	4.0 metres
230 kilovolts, 260 kilovolts	5.0 metres
500 kilovolts	7.0 metres

Notes:
(1) Conductors must be insulated or covered throughout their entire length to comply with this group.
(2) Conductors must be manufactured to rated and tested insulation levels. (OHS Code, Schedule 4)

Despite what you may think, contacts with energized overhead power lines are a common occurrence in Alberta. In the 12-month period ending December 31, 2009, 256 contacts with overhead power lines were reported to Alberta Municipal Affairs. An additional 96 contacts with underground power lines were reported in the same time period. The 352 contacts are believed to represent just a small fraction of the total number of annual power line contacts – most go unreported.

Regulations under the *Safety Codes Act* require all electrical incidents and power line contacts to be reported to Alberta Municipal Affairs, Safety Services. The telephone number of the Safety Services office to which reports should be made is 1-866-421-6929. The e-mail address for Safety Services is safety.services@gov.ab.ca.

Table 2 presents historical power line contact and fatality data for the 8-year period ending in December 2009. Table 3 lists the type of contact or damage associated with the contacts that occurred in the 12-month period ending December 2009.

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Slide 12

Table 2: Historical Summary of Power Line Contacts and Associated Fatalities in Alberta

Year	2002	2003	2004	2005	2006	2007	2008	2009
Reported contacts – overhead lines	346	369	471	348	353	264	255	256
Fatalities – overhead lines	1	1	1	1	1	1	1	1
Reported contacts – underground lines	54	68	79	70	63	80	71	96
Fatalities – underground lines	0	0	0	0	0	0	0	0

Source: Alberta Municipal Affairs, Safety Services

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Table 3: Type of Contact or Damage Associated with Overhead Power Line Contacts that Occurred in the 12-month Period Ending December, 2009

Nature of Contact	Number of Line Contacts
Vehicle-mounted equipment; e.g., booms, hoists, cranes	27
Trucks with raised boxes and vehicles transporting high loads	26
Excavating or earth moving vehicles	19
Farm implements	46
Relocating structures; e.g., grain bins	1
Vehicles out of control	64
Aircraft, parachutes, kites	1
Falling, brushing or trimming trees	
(a) utility tree trimmers/workers	10
(b) others	24
Drilling and seismic equipment	1
Other inadvertent contacts	37
TOTAL	256

Source: Alberta Municipal Affairs, Safety Services

E. Machine Guarding

Crushed hands and arms, severed fingers, permanent eye damage – these are injuries that can be prevented through appropriate safeguarding of machines and equipment. Any machine part, function or process that could cause injury must be safeguarded. When the operation of a machine or accidental contact with it can injure the operator or other workers in the vicinity, the hazards must be eliminated or controlled.

E-MachineGuard.ppt
Slide 1

E-MachineGuard.ppt
Slides 2–3

Where Mechanical Hazards Occur

Dangerous moving parts in three basic areas require safeguarding:

- *The point of operation* – that point where work, such as cutting, shaping or boring is done on the material.
- *Power transmission system* – all components of the mechanical system that transmit energy to the part of the machine performing the work. (These components include flywheels, bullwheels, pulleys, belts, connecting rods, couplings, cams, spindles, chains, cranks and gears.)
- *Other moving parts* – all parts of the machine that move while the machine is working. These can include reciprocating, rotating and transverse moving parts as well as feed mechanisms and auxiliary parts of the machine.

Investigate Force Used for Three Pulley Systems

Hazardous Mechanical Motions and Actions

A variety of mechanical motions and actions can present hazards to workers. These can include the movement of rotating members, reciprocating arms, moving belts, meshing gears, cutting teeth and any parts that impact or shear. The basic types of hazardous mechanical motions and actions that must be recognized are:

Hazardous Motions

a) **Rotating, including in-running nip points** – even smooth, slowly rotating shafts can grip clothing and, through mere skin contact, force an arm or hand into a dangerous position. Injuries due to contact with rotating parts can be severe (see Figures 13 – 16).

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Slide 4

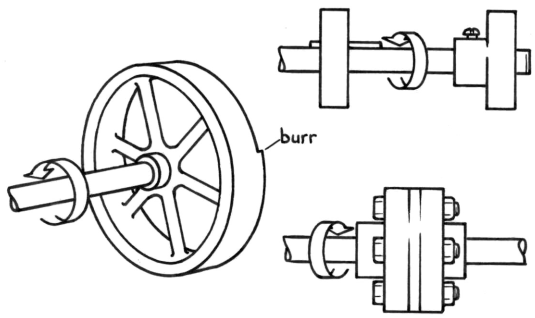

Figure 13—Hazardous projections on rotating parts

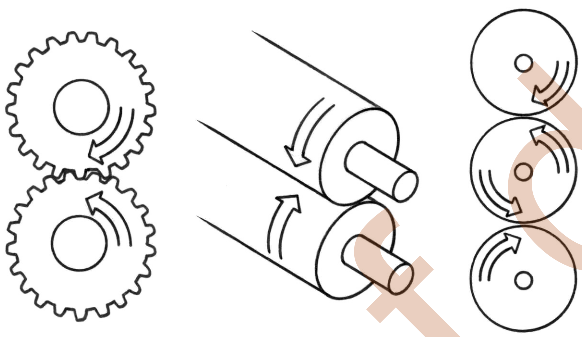

Figure 14—Common nip points on rotating machinery

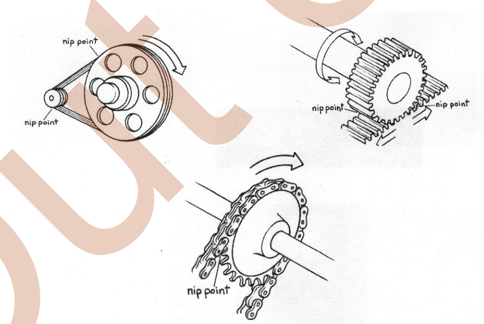

Figure 15—Nip points between rotating parts and parts with linear motion

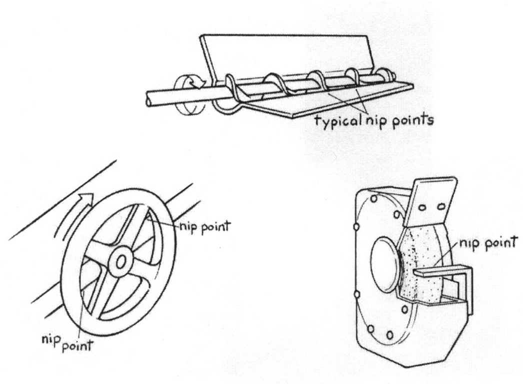

Figure 16—Nip points between rotating machine components

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Slides 5–6

b) **Reciprocating** – during back-and-forth or up-and-down motion, a worker may be struck or caught between moving and stationary parts (see Figure 17).

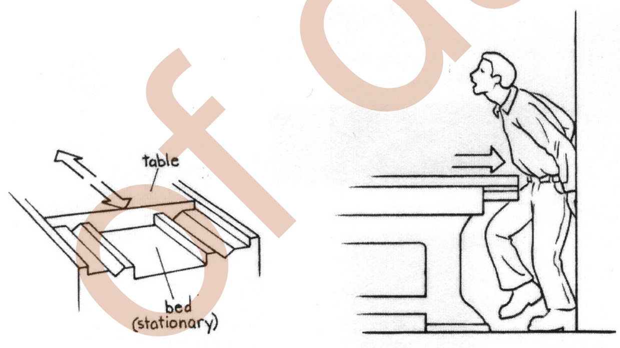

Figure 17—Hazardous reciprocating motion

c) **Transverse** – movement in a straight, continuous line creates a hazard because a worker may be struck or caught in a pinch or shear point by the moving part (see Figure 18).

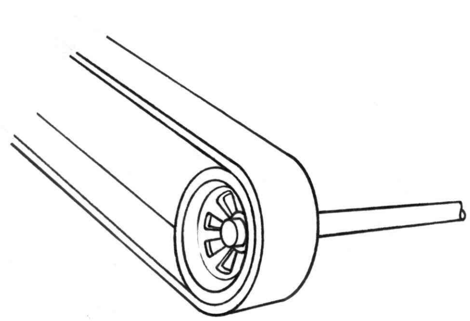

Figure 18—Transverse motion

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Slide 7

Hazardous Actions

a) **Cutting** may involve rotating, reciprocating or transverse motion. The danger of this action is at the point of operation where finger, arm and body injuries can occur and where flying chips or scrap material can strike the head, particularly in the eyes or face. Such hazards are present at the point of operation in cutting wood, metal or other materials. Examples of machinery involving cutting hazards include band saws, circular saws, boring or drilling machines, lathes and milling machines (see Figure 19).

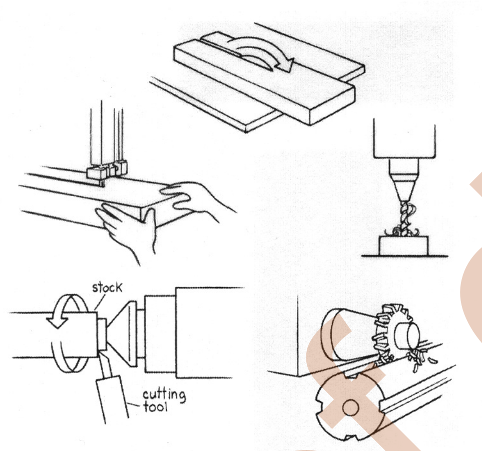

Figure 19—Cutting hazards

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Slides 8–9

b) **Punching** occurs when power is applied to a ram for the purpose of blanking, drawing or stamping metal or other materials. The danger of this type of action occurs at the point of operation where material is inserted, held, and withdrawn by hand, as may be the case with power or punch presses (see Figure 20).

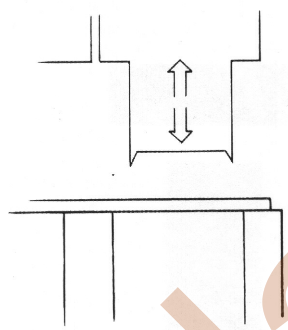


Figure 20—Punching operation

c) **Shearing** involves applying power to a ram or knife to trim or shear metal or other materials. A hazard is present at the point of operation where stock is inserted, held and withdrawn. Examples of machines used for shearing operations are mechanically, hydraulically or pneumatically powered shears (see Figure 21).

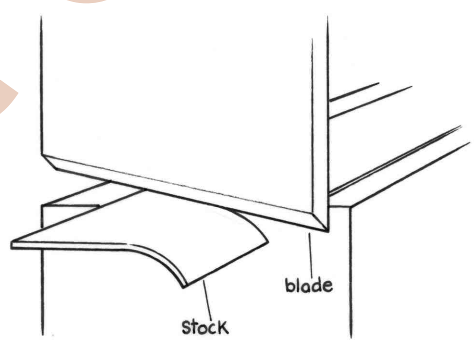


Figure 21—Shearing operation

d) **Bending** occurs when power is applied to a ram to draw or stamp metal or other materials. A hazard is present at the point of operation where material is inserted, held and withdrawn. Equipment that uses bending action includes power presses, press brakes and tubing benders (see Figure 22).

E-MachineGuard.ppt
Slide 10

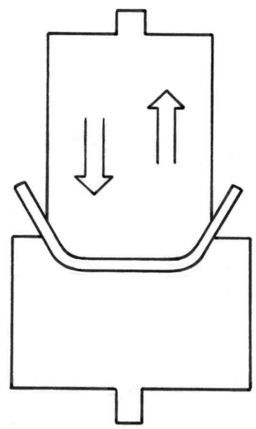


Figure 22—Figure 22: Bending operation

E-MachineGuard.ppt
Slides 11–16

General Requirements for Safeguards

All safeguards should:

- *Prevent contact* – the safeguard must prevent the worker's hands, arms and any other part of the body from making contact with dangerous moving parts. A good safeguarding system eliminates the possibility of the operator or another worker placing parts of his or her body near hazardous moving parts.
- *Be secure* – workers should not be able to easily remove or tamper with the safeguard. Guards and safety devices must be able to withstand conditions of normal use.
- *Protect moving parts from the entry of falling objects* – the safeguard should ensure that objects, such as tools and materials, cannot fall into moving parts.
- *Create no new hazards* – a safeguard must not create a hazard of its own, such as a shear point, a jagged edge or an unfinished surface that can cause a cut. The edges of guards, for example, should be rolled or bolted in such a way as to eliminate sharp edges.
- *Create no interference* – any safeguard that prevents workers from doing their work quickly and comfortably may soon be overridden, ignored or disabled.
- *Permit safe lubrication* – if possible, workers should be able to lubricate the machine without having to remove safeguards. Locate oil reservoirs outside the guard, with a line leading to the lubrication point.

F. Locking Out

F-LockingOut.ppt
Slide 1

Purpose

From time to time, equipment has to be serviced, repaired, cleaned or adjusted. When that happens, it is vital that the equipment cannot be started while the work is going on. For example, a worker has been asked to clean the meat slicer at the deli, repair a big piece of log cutting equipment or help someone service or adjust a forklift. At some point, hands and arms may be inside the machine or in close contact with parts that move and cut.

To ensure the equipment cannot be started or hurt workers while they are working on it is called locking out. Locking out is a way of making sure workers can work on the equipment safely. It means:

- power cannot be restored to the equipment while a worker is working on it
- the equipment cannot be started up without the worker knowing
- the equipment cannot release any stored energy (e.g., liquids or gases under pressure, gravity causing the elevated forks of a forklift to fall on someone beneath them)

A warning sign on its own, without a personal lock or some other type of locking device, is NEVER enough. If a warning sign is used to tell workers about the work going on, then a lock must also be used.

Why is Locking out Important?

Workers have been injured or even killed because:

- The equipment's energy was not completely released or blocked; e.g., workers working under the raised box of a dump truck have been crushed when the box came down.
- Other workers didn't know maintenance work was being done and started up the equipment; e.g., a truck was parked in a yard with a worker underneath, working on it; another worker hopped in and drove away, running over the first worker.

F-LockingOut.ppt
Slides 2–5

One Worker, One Lock, One Key

In its simplest form, locking out means that each worker working on the equipment puts a personal lock on the machine. That lock has a unique marking or identification tag on it so that everyone knows who the lock belongs to and, therefore, who is working on that equipment. Each lock has its own unique key so that workers have complete control over their lock; i.e., no one else can come along and remove the lock, except under special circumstances.

Where Does the Lock Go?

The lock has to be placed on what is known as an energy-isolating device. This is a mechanical device that physically prevents the transmission or release of energy. The lock holds the energy-isolating device in its OFF (or safe) position. Once put in place, the lock cannot fall off or allow the energy-isolating device to move out of its OFF position. Examples of energy-isolating devices include:

- manually operated circuit breakers
- disconnect switchs
- line valves
- blocks or similar devices that isolate energy

Sometimes, people get confused about what is or is not an energy-isolating device. The following are NOT energy-isolating devices:

- push buttons
- selector switches
- other control circuit type devices

Option – Make the Equipment Inoperative

In some situations, it may be impossible or impractical to place a personal lock on a piece of equipment. An acceptable alternative is to disable the equipment to make it inoperative. Examples of how to do this include:

- remove mechanical linkages, by dismantling push rods or removing belts
- use blocking devices, such as wood, chains or metal pins, to prevent movement
- close hydraulic or pneumatic valves: bleed
- remove printed circuit module

F-LockingOut.ppt
Slides 6–8

What about that Meat Slicer?

If the meat slicer has an electrical cord that can be disconnected from the wall socket, unplug it and:

- use a lockable plug cover
- use a special lock that passes through one of the holes of the plug's electrical pins or
- keep the plug in sight and within reach, and maintain control over the plug at all times (e.g., no one else can plug it in)

This approach applies to any type of cord-connected equipment that a person may need to work on.

F-LockingOut.ppt
Slides 9–11

Make Sure!

Once the equipment has been locked out and before a worker begins working on it, he or she must check to make sure that the equipment cannot operate. This means trying to turn the equipment on, usually by using the ON/OFF switch. This check of the isolation is sometimes called a bump test.

A worker must not work on equipment until a bump test has been done to confirm it is safe to work on the equipment.

Ending a Lock out

Once the work is completed, only the worker(s) who installed the lock is allowed to remove it. This ensures no one else can return the equipment to service, without the worker performing the work knowing about it.

Situations may arise in which the worker who installed the lock is unavailable (e.g., the worker left for the day and forgot to remove the lock) or an emergency involving the equipment arises. In such situations, a worker designated by the employer to remove the lock may remove it. This ensures that the employer is aware of what is going to be done and that an appropriate worker performs the removal.

The person about to return equipment to operation must first make sure that he or she and other workers are not in any danger. Audible and/or visual signals and warnings are often used to warn of equipment start-up. Personally contacting workers in the area who might be at risk of injury may be necessary in some circumstances to let them know that the equipment is being started up. Every precaution must be taken to ensure that no workers are in/working on the equipment or that starting it up will not create a hazard.

G. Heat Stress

G-HeatStress.ppt
Slide 1

How Hot We Feel

Playing sports like soccer on a hot summer day makes you feel hot. When you work harder, you feel hotter. When you stop to take a rest, even though you are still in the same hot environment, you feel cooler.

How hot we feel depends on:

1) **air temperature** – measured with a normal thermometer, this is the temperature of the air around us. Although it is the easiest factor to measure, it is actually the least important under hot conditions.

2) **humidity** – this is the amount of water in the air. Under hot conditions, people feel even hotter when the air is more humid than when it is drier. Although a person will sweat, the sweat will not evaporate as quickly if the air is filled with moisture. Less evaporation means less cooling.

3) **radiant heat** – this is heat given off by anything that is hot, such as the sun, molten metal, hot pipes or a heater. It eventually heats the air, but it heats people more quickly. Radiant heat affects a person working in sunlight or near a work process that radiates heat. By simply moving from sun to shade, a person can feel the difference that radiant heat makes.

4) **air speed** – also known as wind speed. Moving air that is cooler than the skin cools a person.

5) **physical activity** – body temperature increases with physical activity. Under warm or hot conditions, physical activity can increase the effect of heat on a person.

6) **clothing** – clothing can help or hinder. It can shield you from radiant heat, prevent sweat from evaporating or help to transfer heat. Some protective clothing is not appropriate under hot conditions and can pose a problem; e.g., chemical suit that does not allow air or moisture to pass through it.

Other factors that may affect a person's ability to work in the heat include his or her age, health status, level of fitness, body weight, level of hydration and use of prescription and nonprescription drugs.

How Does Heat Affect the Body?

The human body works at its best within a narrow temperature range. Move 2°C or more above or below the body's normal temperature of 37°C and problems can start to happen. 37°C is the body's core temperature – the temperature of the brain, heart and other organs. Skin temperature may differ from core temperature by a few degrees.

The body controls its core temperature in a few ways. Sweating lowers the temperature and shivering raises it. Increasing blood flow to the skin helps remove heat and reducing the flow of blood helps conserve heat.

As a person works in a hot environment, his or her core temperature rises. To keep cool, the body sweats. The sweat then evaporates and cools the body. If the fluid lost as sweat is not replaced, the person becomes dehydrated and unable to sweat. The body then loses its ability to control its core temperature and serious heat problems can result.

The human body can adapt to hot conditions and work safely and comfortably. This is known as acclimatization. Depending on the person, acclimatization may take about four to seven days of working in hot conditions. Full heat adaptation takes up to three weeks of continued physical activity under hot conditions. Physically fit workers make this adjustment faster than unfit workers. Acclimatization is lost quickly – one week away from the hot conditions and a person loses his or her adaptation to the heat. A small percentage of people are unable to acclimatize at all.

Heat stress happens when hot working conditions start to harm a worker. It can be of two types:

- not life threatening – including conditions, such as dehydration and heat exhaustion
- life threatening – heat stroke, a condition during which the body is unable to regulate its temperature

Heat Stress Conditions and Their Symptoms

G-HeatStress.ppt
Slide 2

Heat rash (prickly heat)

- tingling and burning of the skin, red itchy rash
- sweat glands plugged due to prolonged exposure of skin to heat, humidity and sweat

Heat cramps

- painful spasms of muscles that do the hardest work; i.e., in the arms, legs and abdomen

Fainting

- increased flow of blood to the skin to get rid of heat means less blood to the brain

Heat exhaustion

- tired, weak, dizzy, clammy skin and slow weak pulse
- pale or flushed skin colour
- higher than normal heart rate (i.e., 160 to 180 beats/min)

Heat stroke

- person usually stops sweating, body core temperature is high (40° – 43°C), skin is hot and dry
- headache, dizziness, confusion, may lose consciousness or have fits
- fatal if treatment is delayed – this is a medical emergency!

G-HeatStress.ppt
Slide 3

What Can You Do to Protect Yourself?

Heat stress is less likely for a person wearing the appropriate clothing, performing light to moderate physical activity and having the sun as the only heat source. Heat stress is possible if, in addition to the weather (or sometimes on its own), the work involves one or more of the following factors:

- high radiant heat; e.g., from a dryer, oven, furnace or molten metal
- high humidity; e.g., from a kitchen or laundry
- intense physical activity
- clothing; e.g., protective clothing that reduces the rate at which sweat evaporates and cools a person

To prevent heat stress:

- Drink plenty of water (e.g., one cup every 20 minutes), even if you do not feel thirsty.
- Wear loose clothes in light colours. (Technical fibres that wick away sweat and allow it to evaporate are preferred.)
- Take frequent rests in shaded areas, if possible; do not over-exert.
- Acclimatize yourself slowly to hot weather.

Pages 165–169

More information about heat stress is found in the supplemental information. As well, Handouts 1–3, at the back of the supplemental information, address heat stress issues.

H. Cold Stress

H-ColdStress.ppt
Slide 1

What is Cold Stress?

The human body functions most efficiently within a narrow temperature range.

At 2°C above or below the body's normal temperature of 37°C, additional stress is placed on the body to regulate its temperature, such as shivering to keep warm and perspiring to keep cool. However, preserving the heat generated internally by the body and maintaining the body's ability to produce this heat are key to maintaining personal comfort and performance in the cold. Susceptibility to cold injury varies from person to person. Some of the factors involved in cold stress include:

Environmental

- temperature
- wind
- humidity

Personal characteristics

- age
- weight
- fitness
- impaired circulation
- previous cold injury
- acclimatization

Other

- clothing
- physical activity
- fatigue
- use of medication(s)
- consumption of alcohol or use of nicotine

H-ColdStress.ppt
Slide 2

Body heat can be lost in any of the following ways:

Radiation
Radiation is the loss of heat to the environment. In this case, it is the difference between the temperature of the air and the temperature of the body. Another factor important in radiant heat loss is the size of the surface area exposed to cold.

Conduction
Conduction is the loss of heat through direct contact with a cooler object. Heat loss is greatest if the body is in direct contact with cold water. With wet clothing, heat loss will be significantly more than when clothing is dry.

Convection
Convection is the loss of heat from the body to the surrounding air as the air moves across the surface of the body. The rate of heat loss from the skin by contact with cold air depends on the air speed and the temperature difference between the skin and the surrounding air. At a given air temperature, heat loss increases with wind speed.

Evaporation
Evaporation is the loss of heat due to the conversion of water from a liquid to a gas. In humans, it is:

- Perspiration/sweating – evaporation of water to remove excess heat.
- Insensible perspiration – body sweats to maintain humidity level of 70% next to skin. (Particularly in a cold, dry environment, you can lose a great deal of moisture this way and not notice that you have been sweating.)
- Respiration – air is heated as it enters the lungs and is exhaled with an extremely high moisture content.

It is important to recognize the strong connection between fluid levels, fluid loss and heat loss. As body moisture is lost through the various processes, the overall circulating volume is reduced, which can lead to dehydration. This decrease in fluid level makes the body more susceptible to hypothermia and other cold injuries.

The body maintains its heat balance in two main ways:

- *Restricting blood flow* – the body automatically reduces the amount of blood circulating through the skin and cooled body parts by narrowing the blood vessels supplying blood to those regions. By doing so, warm blood is diverted to the body's core, maintaining the temperature of internal organs and the brain.
- *Shivering* – this can temporarily raise a person's body temperature. Slight to moderate shivering is not uncomfortable and will warm a person. Severe, uncontrolled shivering occurs when body temperature falls to 35°C. During severe shivering, body heat production can rise to as high as four to five times normal. Severe shivering is a sign of danger and a severely shivering person should be immediately removed from exposure to the cold.

Can You Become Acclimatized to Cold?

Acclimatization is the term given to the development of resistance to or tolerance for an environmental change. Although people easily adapt to hot environments, they do not acclimatize well to cold. However, frequently exposed body parts can develop some degree of tolerance. This adaptability is noticeable among fishermen who are able to work with bare hands in extremely cold weather. The blood flow in their hands is maintained in conditions that would cause extreme discomfort and loss of dexterity in unacclimatized persons.

Jobs in which Cold May Be an Occupational Hazard

- outdoor work, including:
  - road building and other construction work
  - electrical and telecommunications linemen
  - police officers, fire fighters, emergency response workers, military personnel
  - transport workers, bus and truck drivers
  - fishers, hunters and trappers
  - divers
- outdoor recreation workers (e.g., ski lift operators)
- work in refrigerated warehouses
- meat packaging and meat storage

How Can Cold Stress Affect You?

H-ColdStress.ppt
Slides 3–4

As temperature decreases and the duration of exposure increases, the following changes can be experienced:

- reduced dexterity of the hands and feet
- reduced tactile sensation
- impaired ability to perceive heat, cold and pain
- reduced joint mobility
- reduced grip strength
- hypothermia; e.g., reduced body temperature, which, in its extreme form, can result in death
- frostbite – frozen tissue or frostnip – very mild, superficial freezing of exposed skin
- reduced coordination
- reduced decision-making ability

To prevent cold stress:

- dress warmly
- drink warm fluids
- take regular breaks in a warm shelter
- move immediately to a warm shelter if excessive shivering starts

Note that the clothing worn to maintain comfort in the cold can limit performance:

- Hats and hoods may interfere with hearing, vision and movement.
- Bulky clothing layers may restrict movement.
- Gloves, mittens and overmitts may reduce dexterity and tactile feel.
- Footwear may be heavy and bulky, compromising the ability to use footholds and vehicle foot pedals.
- The weight and bulk of clothing increases the amount of effort required when moving.

More information about cold stress is found in the supplemental information.

H-ColdStress.ppt
Slide 5

I-Noise.ppt
Slide 1

I. Noise

Noise (sound) is what we hear. Noise can be hazardous to a person's hearing if it is loud enough or if there is prolonged or repeated exposure. Loss of hearing is the main concern from exposure to noise. Noise is present everywhere. The hazard depends on the level of noise and the duration of exposure. Certain noises may be annoying, such as a buzzing noise from a light fixture or an alarm clock in the morning, but they do not necessarily pose a hazard to hearing.

Sound is produced by vibrating objects and reaches the listener's ears as waves in the air. When an object vibrates, it causes slight changes in air pressure. These air pressure changes travel as waves through the air and produce sound.

> Imagine striking a drum surface with a stick. The drum surface vibrates back and forth. As it moves forward, it pushes the air in contact with the surface. This creates a positive (higher) pressure by compressing the air. When the surface moves in the opposite direction, it creates a negative (lower) pressure by decompressing the air. Thus, as the drum surface vibrates, it creates alternating regions of higher and lower air pressure. These pressure variations travel through the air as sound waves.

Sound pressure is expressed in units called Pascals (Pa). A healthy, young person can hear sound pressures as low as 0.00002 Pa. A normal conversation produces a sound pressure of 0.02 Pa. A gasoline-powered lawn mower produces about 1 Pa. A sound is painfully loud at levels around 20 Pa. Thus, the common sounds we hear have sound pressure over a wide range (i.e., 0.00002 Pa to 20 Pa). It is difficult to work with such a broad range of sound pressures. To overcome this difficulty, we use the decibel (dB). The decibel scale is more convenient because it compresses the scale into a manageable range by using a logarithmic scale. The decibel is named after Alexander Graham Bell, the Canadian pioneer of the telephone.

How Does Noise Affect Hearing?

I-Noise.ppt
Slide 2

There are several possible effects, depending on noise level, type of noise and duration:

- Sudden hearing loss after a very loud noise, such as an explosion or gun shot.
- Temporary hearing loss after a noisy day. (The hearing loss disappears after a few hours in a quiet place.)
- Permanent hearing loss after noise exposure for several years or months. (This type of hearing loss cannot be cured; hearing loss becomes worse as we get older since we also lose our hearing as part of the aging process.)
- Permanent hearing loss because of nearness to impact sounds; e.g., jackhammer, pneumatic tools, pile drivers.
- Tinnitus, a ringing or roaring sound in the ears, is another possible effect from overexposure to noise.

The risk of having hearing loss increases as:

- the loudness of noise increases
- exposure time increases

To prevent hearing loss, reduce time spent in noisy environments and use the correct equipment to protect hearing. It is important to recognize that all sources of noise impact hearing: both unwanted and wanted sounds. If a person works all day in a noisy environment and listens to a loud stereo or has a noisy hobby at home, his or her exposure is much higher and the risk of hearing loss is greater.

I-Noise.ppt
Slide 3

How Do We Measure Noise Exposure?

There are different kinds of devices used to measure noise. The two most common are:

- **sound level meter (SLM)** – used to measure noise levels at a specific point in time
- **dosimeter** – a personal device that measures a worker's total noise exposure during his or her shift

The sensitivity of the human ear to sound depends on the frequency or pitch of the sound. Humans hear some frequencies better than others. If a person hears two sounds of the same sound pressure but different frequencies, one sound will appear louder than the other. This occurs because humans hear high frequency noise much better than low frequency noise.

Noise measurement readings can be adjusted to correspond to this peculiarity of human hearing. An A-weighting filter is built into sound level meters and dosimeters to de-emphasize low frequencies or pitches. Decibels measured, using this filter, are A-weighted and are called dBA. Legislation on workplace noise normally gives exposure limits in dBA.

Examples of Noise Sources

Source of Sound	Sound Level (dBA)
wood chipper	100 – 110
power mower, snowmobile	95 – 105
chainsaw	95 – 105
lawn mower	95 – 110
sidewalk snowplow	90 – 100
salt and sand truck	90 – 100
vacuum cleaner	80 – 85
normal conversation	60 – 65
background noise in a quiet office	40 – 45

In Alberta, occupational exposure limits (OELs) for noise are in Part 16 and Schedule 3 of the Alberta Occupational Health and Safety Code. Noise exposure must not exceed 85dBA L_{ex} and the limits in Table 1, Schedule 3 of the OHS Code. L_{ex} is a person's level of total exposure to noise in dBA, averaged over the entire work day and adjusted to an equivalent eight-hour exposure. For example, a person exposed to 88 dBA for four hours or 91 dBA for two hours would be exposed to 85 dBA L_{ex} (an exposure equivalent of 85 dBA for eight hours).

I-Noise.ppt
Slide 4

How Is Noise Controlled?

If noise is a problem, there are several methods that can be used to reduce worker exposure:

- Enclose the machine or equipment that is the source of noise.
- Install a device on the machine; e.g., a muffler, that will absorb the noise.
- Reduce the noise produced by the machine by modifying the machine to run more quietly.
- Modify the work area by installing acoustic materials that absorb sound. This reduces the echo effect that can make a noise in the workplace much louder.
- Implement administrative controls such as training, to inform the worker of the hazard and job rotation to reduce the total exposure of the worker.
- Provide appropriate hearing protection for workers.

If the above measures do not reduce the noise levels below the legal limits, workers should not enter the area.

Resource: CCOHS, "OSH Answers: Noise – Measurement of Workplace Noise" www.ccohs.ca/oshanswers/phys_agents/noise_measurement.html.

What if I want to find out more?

Special Note on Prevention

Hearing loss is preventable! Not all hearing loss is work related. If you go to a concert:

- Stay away from the speakers.
- Look around. You will notice that people who work in the concert hall are wearing earplugs to protect their hearing – do the same.

If you wear radio headsets:

- If someone else can hear your music 1 m away, it is too loud for your ears.
- You may not be able to hear warning messages or alarms and may risk injury.

More detailed information on noise and its effects is found in the supplemental information.

Here is a practical example of applying noise reduction methods in your home.

John is upstairs playing his stereo – it is loud and John is quite happy. Mom is on the first floor trying to read a book. She is not too pleased with the distraction, recognizes that it is too loud and is preventing her from enjoying her book. She asks John to turn down the stereo. Keeping in mind the noise reduction methods, how can John reduce the noise his mom is exposed to?

His options are:

- enclose by shutting the bedroom door and isolating the noise
- absorb by putting carpeting on the walls, floors and ceiling of the room
- reduce the noise by adjusting the bass and/or turning down the volume
- provide hearing protection for Mom; e.g., earmuffs or disposable ear plugs
- substitute speaker system with earphones for John

Although John has explored these options, Mom knows that the noise from the stereo is damaging John's hearing, so will tell him to reduce the noise.

Classroom Exercise

If you have a sound level meter, measure the dBA level of different noises, such as:

- TV, with normal volume and then with it turned up loud
- normal conversation and then shouting
- banging/slamming of a door
- sporting events, inside the gym
- the machines in the shop
- the car stereo, with the windows closed and with the windows open

J-Vibration.ppt
Slides 1–2

J. Vibration

Rotating and oscillating machines like sanders, chain saws, drills, handheld mixers and impacting tools, such as hammers, jackhammers or pneumatic tools, produce vibration. Exposure occurs from direct contact with vibrating or oscillating tools, or through the floor that holds the vibrating equipment/tools. It is very difficult to feel and tell whether a vibration level is harmful or not; one has to decide by measuring the vibration level.

Vibration Exposure to Hands and Arms

Short-term exposure to vibration may cause tingling and numbness or damage to blood vessels in fingers and hands. Long-term exposure to hand-arm vibration damages the blood vessels and nerves in the fingers and hands. Damage is especially painful when hands are cold. In severe cases, the person may lose some of the use of his or her hands. This condition used to be called hand-arm vibration syndrome (HAVS), raynauds syndrome or white finger disease.

Whole Body Vibration Exposure

Whole body vibration may cause neck injuries, damage to lower back and joints or cause fatigue, insomnia, headaches or shakiness during or shortly after exposure. Many years of exposure to whole body vibration can affect the entire body and result in a number of health disorders. Riding in a car or truck on a gravel road or taking some amusement rides may expose you to lower back and neck injury. Working in plants with motors, compressors or engines can expose a worker to significant vibration hazards.

How is Exposure to Vibration Prevented?

J-Vibration.ppt
Slide 3

The best way to prevent vibration exposure is to buy tools and equipment that produce as little vibration as possible. Such tools and equipment have controls built in to prevent harmful vibration exposure.

Heavy machines and equipment have vibration isolation mounting that stops machine vibration from affecting the attached structures. For example, many buses have driver seats with vibration isolation mounting.

Spring and shock absorbers in your car are types of vibration isolation. When these vibration isolators are defective, a car ride can be a source of vibration exposure.

Generally, to prevent exposure, workers should:

- limit the amount of time vibrating tools are used
- take a 10-minute break for every hour spent working with a vibrating tool
- alternate between vibrating and nonvibrating tools
- let the tool do the work and use as light a grip as possible
- service and maintain the tools in good working condition

NOTE: There isn't any proven Personal Protective Equipment that workers can wear to prevent exposure to vibration.

Class Activity

Name sources and activities with risk of vibration exposure.

Sources of vibration exposure include:

Hand-held manual tools: hammers, chisels, planers

Hand-held power tools: chainsaws, drills, grinders

Hand-held pneumatic tools: jackhammer, wrenches

Vibrating seats: buses, mining vehicles, construction vehicles

Activities: with potential for vibration exposure

School: grinder, sanding wood with an orbital sander, metal polishing

Work: brush saw, chainsaw, drill

K-Radiation.ppt
Slide 1

K. Radiation

Radiation is energy that is emitted through space or matter. Some types of radiation travel as waves and others as particles. When we switch on a light bulb, light comes to us as radiation. When the sun rises, we feel warm because the sun radiates energy in the form of light and heat.

Radiation does not need a medium in which to travel. If you place an old-fashioned alarm clock in a jar and evacuate the jar, using a vacuum pump, you will not hear the alarm because sound needs air as a medium to travel. You will still see the radium dial in the dark because light does not need a medium.

Radiation is divided into two categories:

- ionizing radiation
- non-ionizing radiation

Ionizing radiation is high energy electromagnetic radiation that is able to disrupt the structure of atoms or molecules. It is given off by X-ray machines and radioactive materials, such as plutonium. Some amount of background ionizing radiation is present everywhere. It comes from the earth and outer space.

Non-ionizing radiation does not have enough energy to disrupt the structure of atoms or molecules. Examples of non-ionizing radiation include radiation from the sun, light, electric power lines, radio and TV antenna, lasers, industrial heaters and driers, microvewave ovens and ultraviolet (UV) lamps.

Ionizing Radiation

Ionizing radiation can damage cells, the building blocks of the body. It can:

- kill a cell – no effect is noticeable if only a few cells are killed. In cases of extremely high exposure, too many cells may be killed and result in sickness or death
- alter a cell – damaged cells may multiply and cause cancer many years later
- alter a reproductive cell – an altered reproductive cell may cause genetic changes in children and grandchildren, referred to as hereditary effects

How Is Exposure to Ionizing Radiation Controlled?

Exposure to ionizing radiation is minimized by:

- minimizing exposure time and avoiding unnecessary exposure
- using shielding, such as lead sheets, during an X-ray to stop radiation before it reaches a person
- staying as far away as possible from a source

Ionizing radiation from radioactive sources that are part of the nuclear fuel cycle is regulated federally by the Canadian Nuclear Safety Commission (CNSC), under the *Nuclear Safety and Control Act*. Radiation from man-made equipment, such as X-ray machines and lasers, and radioactive material from natural sources are regulated in Alberta by the Radiation Protection Regulation.

Non-ionizing Radiation

Perhaps the most common source of non-ionizing radiation that we are exposed to is the sun. The sun is a significant source of ultraviolet radiation. Research indicates that long-term exposure to UV rays may increase the risk of skin cancer. You should avoid midday sun and use sun protection cream with an SPF (sun protection factor) of 15 or greater.

Common types of non-ionizing radiation and their sources include:

- **ultraviolet light**: welding, fluorescent lights, mercury and xenon lamps
- **infrared light**: industrial heaters and driers, welding, lasers
- **microwaves**: radar, cooking, communication, telemetry
- **radiofrequency**: industrial heating, sealing, gluing, melting, tempering, welding and sterilization, communication, metallurgy, cellular telephones
- **extremely low frequency**: electricity transmission, induction heaters, steel and aluminum industry
- **static magnetic fields**: the earth, magnetic resonance imaging, nuclear magnetic resonance

How Is Exposure to Non-ionizing Radiation Controlled?

Minimizing exposure to non-ionizing radiation is the key to protection. This is done by:

- staying as far away from the source as is practicable
- minimizing exposure time
- stopping radiation before it reaches people (e.g., sunglasses and barrier creams for protection against UV rays from the sun)

More information about both ionizing and non-ionizing radiation is in the supplemental information.

L. Fire Hazards

L-FireHazards.ppt
Slides 1–3

For a fire to occur, there are three elements that must come together at the same time and in the right proportions – fuel, heat and oxygen. Remove any one of the elements and the fire will go out. The fire triangle is commonly used as a model to understand how a fire starts and how it can be prevented.

Fuels: these are flammable or combustible materials and can be gases, liquids or solids.

Heat: these are ignition sources and include an open flame, lit cigarette, and sparks, such as from electrical currents and static electricity.

Oxygen: the most common source of oxygen is air, but oxygen can also come from chemicals called oxidizers. Examples of common oxidizers are some types of acids and chemicals, such as chlorine, chlorine dioxide, potassium permanganate and potassium chlorate.

The spread or propagation of fire is also dependent on a fourth factor – the chemical chain reactions that occur after the fire is started.

Fire prevention consists of making sure that the three legs of the fire triangle never meet. It is important to note that a fire will not always start, even when the legs of the triangle meet, unless all three elements are present in the right proportions. For example, vapours from a flammable liquid must be mixed with a certain amount of air and exposed to the right amount of heat to ignite and burn.

L-FireHazards.ppt
Slides 4–6

To prevent fires:

- limit the amounts of flammable and combustible materials present
- store materials properly – in appropriate container, with a closed lid
- control and eliminate ignition sources
- ensure that there is proper ventilation in storage areas so that flammable vapours do not accumulate

Workers must have proper training on fire prevention and on fire control systems used. If a fire starts, workers must always follow the fire control plan. In most cases, this will mean workers leave the area immediately, unless they have been provided with additional training on how to deal with the fire.

In your school and your workplace, you may find one or more of the following fire control systems:

- Fire sprinklers – these will be activated automatically in the event of fire.
- Standpipe and hose system – these are generally located in hallways and are used by trained persons only; i.e., trained firefighters.
- Portable fire extinguishers – these can be used to stop small fires if you are trained to use one. Only use the fire extinguisher if you know how to use it. Otherwise, follow the evacuation procedure. A fire is no time to try to figure out how to use a fire extinguisher

Class Activity

Check the extinguisher in the classroom to determine what type of fire extinguisher it is. Most fire extinguishers are type ABC and are good for any A,B or C type fire. ABC means:

A – ordinary combustibles
B – flammable liquids
C – electrical equipment

Things to check:

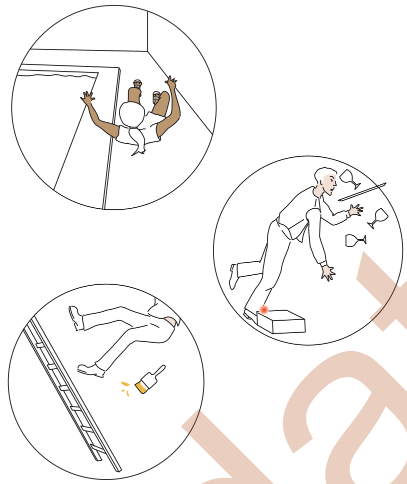
- The extinguisher is present in a designated location.
- The gauge reads charged in the green coloured zone on the dial.
- The hose is free of cuts.
- The nozzle is not blocked.
- The pin is in place.

TEACHER: Please explain the specific rules applicable to your school as well as the fire drill and escape route for this particular classroom.

More information about fire hazards can be found in the supplemental information.

PHYSICAL HAZARDS

Slips, Trips and Falls



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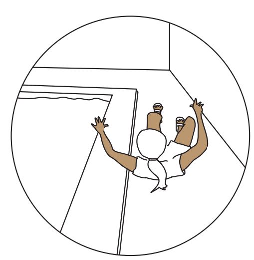
C-SlipsTripsFalls.ppt Slide 1

PHYSICAL HAZARDS

Slips

- foot slips out from underneath you
- can recover, but can easily strain muscles while trying to regain balance



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C-SlipsTripsFalls.ppt Slide 2

PHYSICAL HAZARDS

Preventing Slips

- Wear footwear appropriate for the work and the work environment.
- Keep walking surfaces clean and dry.
- Balance need for grip with need to push wheeled equipment on floor surface.
- Be aware that deeply textured surfaces may:
  - reduce the potential for slips
  - increase the potential for trips

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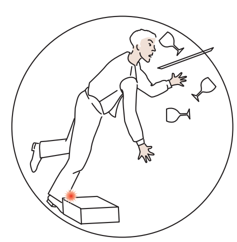
C-SlipsTripsFalls.ppt Slide 3

PHYSICAL HAZARDS

Trips

- forward-moving leg suddenly and unexpectedly stops – causing you to pitch forward and fall
- causes
  - abrupt changes in the height of a walking surface
  - objects in the path
  - transition from a slippery surface to a slip resistant surface



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C-SlipsTripsFalls.ppt Slide 4

PHYSICAL HAZARDS

Preventing Trips

- keep aisles clear
- eliminate abrupt changes in walking surface heights
- replace stairs with ramps between levels

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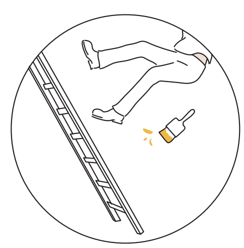
C-SlipsTripsFalls.ppt Slide 5

PHYSICAL HAZARDS

Falls from Heights

- account for 19% of all lost-time work related injuries
- occur from less than 3 metres, in most cases



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C-SlipsTripsFalls.ppt Slide 6

PHYSICAL HAZARDS

Stepladder Safety

- do not work from the top two steps of a stepladder
- face forward; i.e., face the stepladder treads
- work from within the rails; do not overreach
- do not use a stepladder as a support for a working platform – the ladder is too unstable

(continued)

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C-SlipsTripsFalls.ppt Slide 7

PHYSICAL HAZARDS

(continued)

- inspect the ladder visually before each use
- place a stepladder on a firm, flat surface
- do not place a stepladder on boxes or scaffolds to gain extra height
- watch out for doorways, vehicles and other hazards; set up barriers, where necessary
- set base on a secure, even surface and shim the base, if necessary

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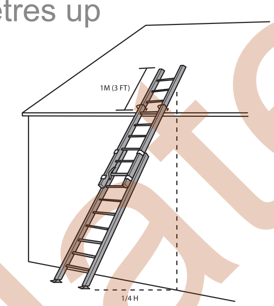
C-SlipsTripsFalls.ppt Slide 8

PHYSICAL HAZARDS

Portable Ladder Safety

- secure ladder at both the top and bottom
- base must be out 1 metre for each 4 metres up
- four up – one out offers the ladder (and the worker) the greatest stability
- ladder must extend at least 1 metre (3 feet) past the access point



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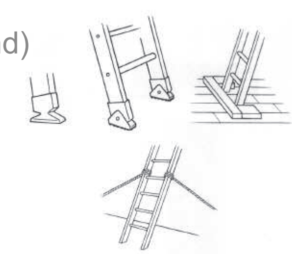
PHYSICAL HAZARDS

Securing Portable Ladders – Base

- rubber feet – if on firm nonslip surface
- spikes
- ties or ropes (tied to stakes in the ground)
- blocks
- person



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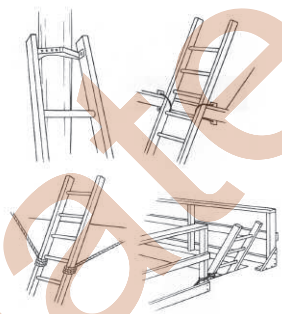
PHYSICAL HAZARDS

Securing Portable Ladders – Top

- use ladder's support attachment, if available
- ties or ropes – from each side rail to a secure object



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PHYSICAL HAZARDS

Fall Protection

- workers must use a fall protection system if:
  - a worker can fall three metres or more
  - falling from a lesser height could cause a significant injury; e.g., falling onto protruding rebar or into a vat of acid

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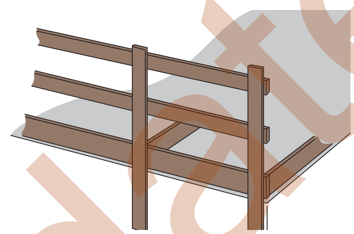
PHYSICAL HAZARDS

Fall Protection – Guardrails

- simplest and most reliable way of preventing falls
- install guardrails at the perimeter of the work area
- specifications are given for height and strength – to prevent workers stumbling over the top or the guardrail collapsing



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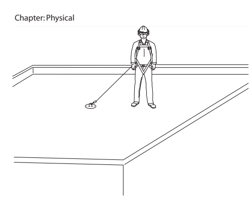
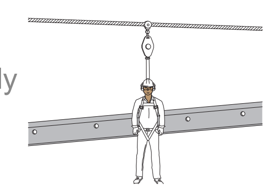
PHYSICAL HAZARDS

Fall Protection – Travel Restraint Versus Fall Arrest

- travel restraint
  - prevents a worker from reaching an edge from which he or she could fall
- fall arrest
  - catches a falling worker in mid- air, safely bringing him or her to a complete stop, without hitting a lower surface





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PHYSICAL HAZARDS

Travel Restraint System

- prevents the worker from reaching the edge (like a leash)
- includes a full body harness, lanyard and secure anchor point
- used when working near the edge of a roof or on an exposed platform; e.g., for theatre staff operating curtains and backdrops

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PHYSICAL HAZARDS

Fall Arrest Systems

- do not prevent the worker from falling
- catch the worker in mid-air
- include:
  - a full body harness
  - a lanyard, with a shock absorber to absorb the stress and lessen the impact on the worker
  - a **secure** anchor point; i.e., capable of holding > 1636 kg

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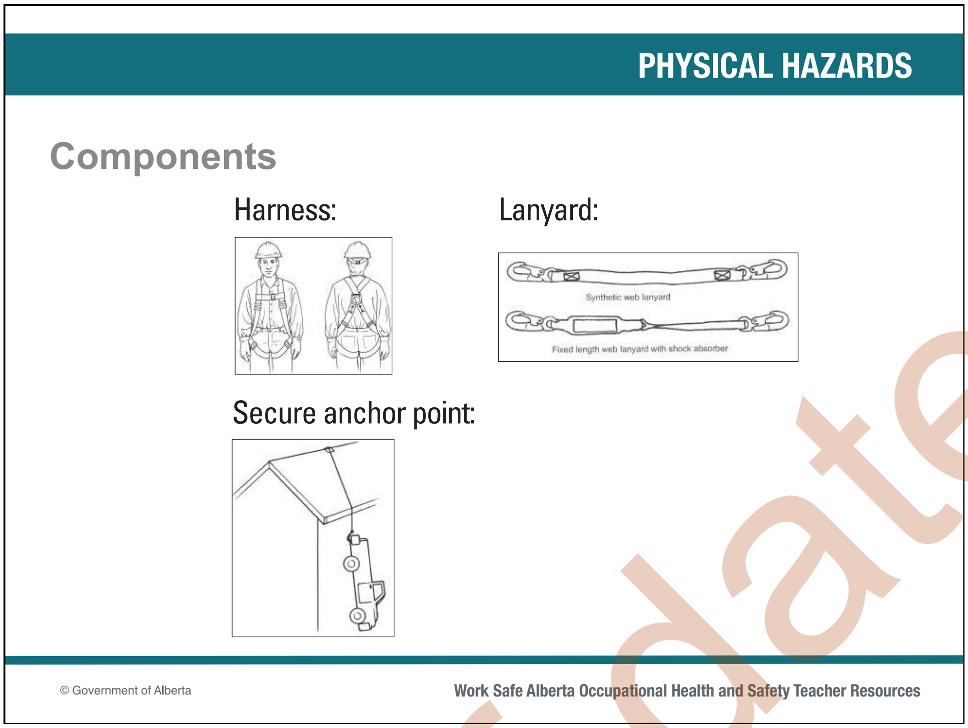

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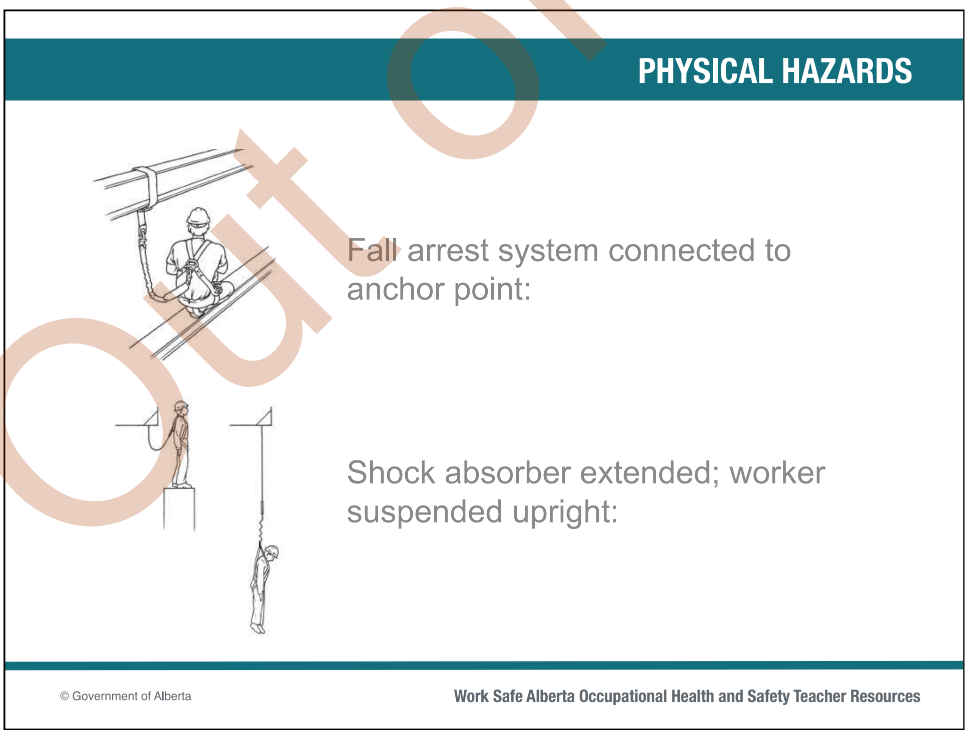

C-SlipsTripsFalls.ppt Slide 18

PHYSICAL HAZARDS

If Using Travel Restraint or Fall Arrest:

- A worker must be **trained** in how to use the equipment in the situation.
- The equipment must be **appropriate** for the situation.
- The equipment must be used **correctly**.
- The equipment must be **anchored**.

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C-SlipsTripsFalls.ppt Slide 19

PHYSICAL HAZARDS

Important Note:

Sit harnesses, as used in sport climbing and mountaineering, are unacceptable for industrial fall protection – workers can end up suspended upside down, can fall out of the harness and can suffer catastrophic back injuries.

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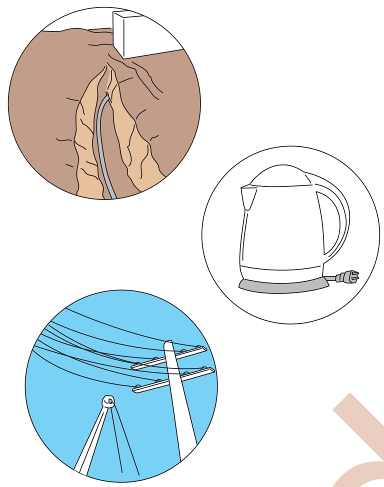
C-SlipsTripsFalls.ppt Slide 20

PHYSICAL HAZARDS

Electricity



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D-Electricity.ppt Slide 1

PHYSICAL HAZARDS

Types of Injuries

- electrocution – kills
- electric shock – can interfere with the function of organs and muscles, such as the heart
- burns – result in both surface and full-thickness tissue burns
- injury from falls – results from being startled or losing control of muscles

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D-Electricity.ppt Slide 2

PHYSICAL HAZARDS

How Electrical Injuries Happen

- direct contact with electrical energy
- electricity arcs (jumps) through air to a person who is grounded
- heat generated by an electric arc causes thermal burns
- materials catch on fire, causing flame burns
- high voltage contact, which can burn internal tissues, with only very small injuries on the surface of the skin
- muscle contractions or being startled, causing a person to fall

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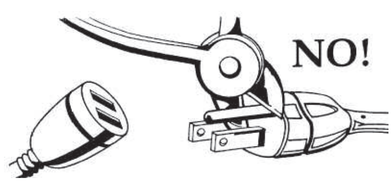
D-Electricity.ppt Slide 3

PHYSICAL HAZARDS

Electricity Safety Tips

- De-energize/lock out equipment when it is being inspected, serviced or repaired.
- Do not use defective or unsafe tools.
- Do not use tools or equipment too close to energized parts.
- Never break off the ground pin on a three-prong plug to fit a two-prong outlet.



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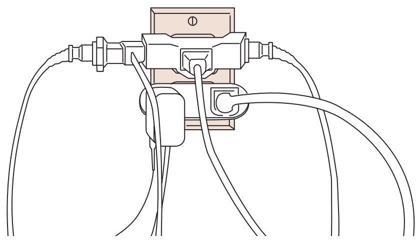
D-Electricity.ppt Slide 4

PHYSICAL HAZARDS

(continued)

- Do not overload outlets with too many appliances.



- Never work from a scaffold near overhead power lines.

(continued)

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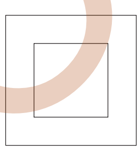
D-Electricity.ppt Slide 5

PHYSICAL HAZARDS

(continued)

- Make sure that tools are properly grounded or double-insulated.
- Grounded tool has a three-prong plug.
- Double-insulated tools are specially built, have a two-prong plug and bear a double-insulated mark.



- Tape cords down – do not use nails or staples.

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D-Electricity.ppt Slide 6

PHYSICAL HAZARDS

- Use the correct size fuse – the wrong size can cause excessive currents in the wiring.
- Use wooden or other nonconductive ladders when working around exposed wires.
- Install Ground Fault Circuit Interrupters (GFCIs) in wet or damp locations.
- Know where the breakers and fuse boxes are located, in case of an emergency.

(continued)

D-Electricity.ppt Slide 7

PHYSICAL HAZARDS

(continued)

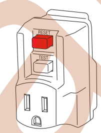
- Do not touch a person or potentially energized equipment if an electrical incident happens.
- Confirm that the power is off before touching anyone or anything in the area.
- Use extension cords only to **temporarily** supply power – they are not a permanent solution.
- Do not allow vehicles to pass over unprotected power cords.

D-Electricity.ppt Slide 8

PHYSICAL HAZARDS

Ground Fault Circuit Interrupter (GFCI)

- device to improve safety when electricity is used in and around wet places
- monitors the flow of current
- if a flow imbalance occurs, the GFCI stops the current
- required in the bathrooms, kitchens and garages of new homes
- found on many new small appliances
- can be added as temporary plug-in adapters



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D-Electricity.ppt Slide 9

PHYSICAL HAZARDS

Overhead Power Lines

- dangerous because they carry an electric current that can instantly cause injury or death
- hundreds of power line contacts every year in Alberta
- voltages range from
- 4000 to 13 000 volts in neighbourhood lines
- up to 500 000 volts in major transmission lines
- "safe limit of approach distances"
  – the voltage determines the safe approach distance
- if voltage is unknown, must stay at least seven metres away

 Work Safe Alberta Occupational Health and Safety Teacher Resources

D-Electricity.ppt Slide 10

PHYSICAL HAZARDS

Table 1: Safe Limit of Approach Distances

Operating Voltage Between Conductors of Overhead Power Line	Safe Limit of Approach Distance for Persons and Equipment
0-750 volts Insulated or polyethylene covered conductors	300 millimetres
0-750 volts Bare, uninsulated	1.0 metre
Above 750 volts Insulated conductors	1.0 metre
750 volts-40 kilovolts	3.0 metres
69 kilovolts, 72 kilovolts	3.5 metres
138 kilovolts, 144 kilovolts	4.0 metres
230 kilovolts, 260 kilovolts	5.0 metres
500 kilovolts	7.0 metres

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D-Electricity.ppt Slide 11

PHYSICAL HAZARDS

Table 2: Historical Summary of Power Line Contacts and Associated Fatalities in Alberta

Year (ending March)	2002	2003	2004	2005	2006	2007	2008	2009			
Reported contacts – overhead lines	346	369	471	348	353	264	255	256			
Fatalities – overhead lines	1	1	1	1	1	1	1	2			
Reported contacts – underground lines	54	68	79	70	68	80	71	96			
Fatalities – underground lines	0	0	0	0	0	0	0	0			

Source: Alberta Municipal Affairs, Safety Services

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D-Electricity.ppt Slide 12

PHYSICAL HAZARDS

Table 3: Type of Contact Associated with Overhead Power Line Contacts over a Typical 12-month Period

Nature of Contact	Number of Line Contacts
Vehicle-mounted equipment; e.g., booms, hoists, cranes	27
Trucks with raised boxes and vehicles transporting high loads	26
Excavating or earth moving vehicles	19
Farm implements	46
Relocating structures; e.g., grain bins	1
Vehicles out of control	64
Aircraft, parachutes, kites	1
Falling, brushing or trimming trees	
(a) utility tree trimmers/workers	10
(b) others	24
Drilling and seismic equipment	1
Other inadvertent contacts	37
TOTAL	256

Source: Alberta Municipal Affairs, Safety Services

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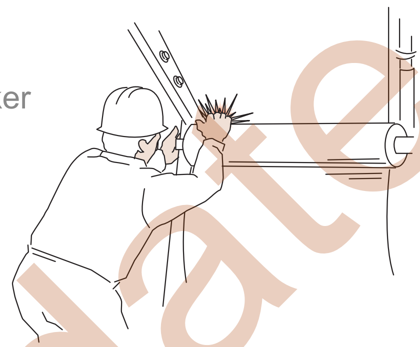
D-Electricity.ppt Slide 13

PHYSICAL HAZARDS

Machine Guarding

Dangers of getting caught in machines or equipment:

- amputations, crush injuries
- entanglement that pulls a worker into machine



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E-MachineGuard.ppt Slide 1

PHYSICAL HAZARDS

Where Are the Hazards?

(1) point of operation – where work, such as cutting, shaping and boring, is done on the material

(2) power transmission system – the mechanical system that transmits energy to the part of the machine doing the work; e.g., flywheels, bullwheels, pulleys, belts, connecting rods, couplings, cams, spindles, chains, cranks, gears

(3) other moving parts – all parts of the equipment machine that move while the machine is working;
e.g., feed mechanisms

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E-MachineGuard.ppt Slide 2

PHYSICAL HAZARDS

Hazards

- rotating parts
- reciprocating arms
- moving belts
- meshing gears
- cutting teeth
- any parts that impact or shear

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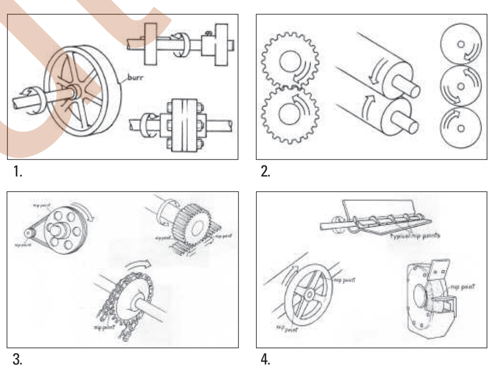
E-MachineGuard.ppt Slide 3

PHYSICAL HAZARDS

Rotating Motions, Including In-running Nip Points



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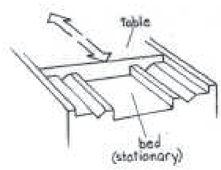
E-MachineGuard.ppt Slide 4

PHYSICAL HAZARDS

Reciprocating Motion – Back-and-forth or Up-and-down



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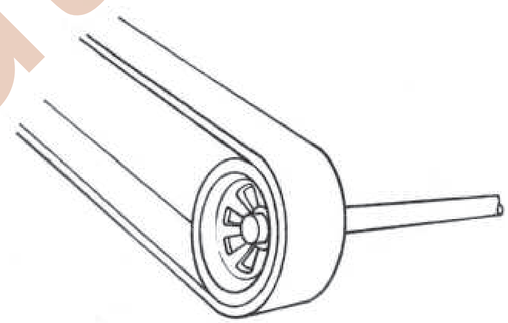
E-MachineGuard.ppt Slide 5

PHYSICAL HAZARDS

Transverse Motion – Straight, Continuous Movement



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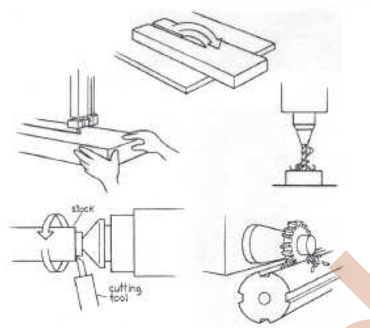
PHYSICAL HAZARDS

Cutting Motions

- Examples: band saws, circular saws, boring or drilling machines, lathes and milling machines.



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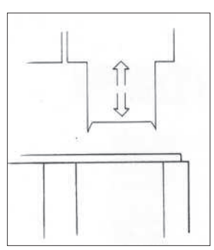
PHYSICAL HAZARDS

Punching

Power is applied to a ram to blank, draw or stamp metal or other material; e.g., a punch press.



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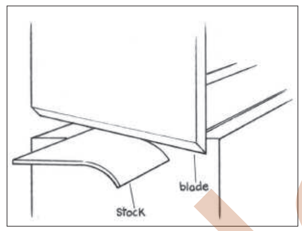
PHYSICAL HAZARDS

Shearing Actions

Power is applied to a ram or knife to trim or shear metal or other materials.



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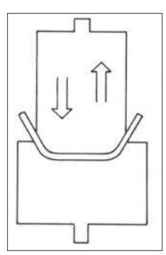
PHYSICAL HAZARDS

Bending Actions

Power is applied to a ram to shape metal or other materials; e.g., a tubing bender.



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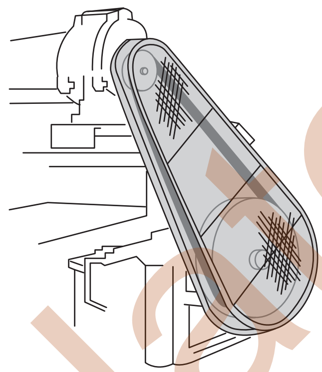
E-MachineGuard.ppt Slide 10

PHYSICAL HAZARDS

Controlling the Hazards

Fixed Enclosing Guard

- when a part on machinery does not need to be accessed
- enclosure permanently guards hazardous parts



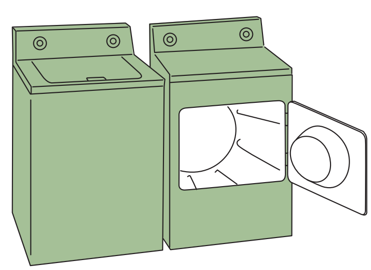
E-MachineGuard.ppt Slide 11

PHYSICAL HAZARDS

Controlling the Hazards

Movable Guard, with Interlock Switch

- when access to moving parts is required
- movable guard interlocked to machine power source – guard door opens, machine loses power and stops

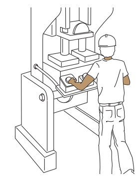


E-MachineGuard.ppt Slide 12

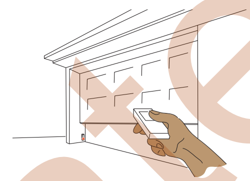
PHYSICAL HAZARDS

Controlling the Hazards

Two-hand Controls



- two start buttons have to be operated simultaneously for the machine to run
- keeps hands out of the machine



Infrared Light Curtains

- "curtain" of light beams run in front of the hazardous area
- if a beam is interrupted, a control circuit shuts off power

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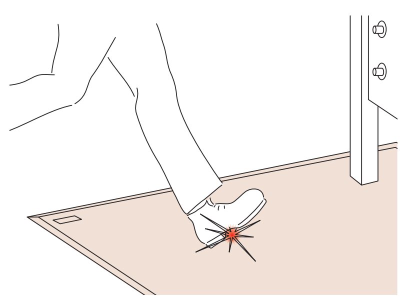
E-MachineGuard.ppt Slide 13

PHYSICAL HAZARDS

Controlling the Hazards

Pressure Sensitive Safety Mats

- placed around the hazardous area
- footstep on a mat triggers a pressure-sensing circuit to cut power



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E-MachineGuard.ppt Slide 14

PHYSICAL HAZARDS

Controlling the Hazards

Pressure-sensitive Edges

- flexible edging strip that can be added to a moving part, such as a powered door or moving machine table
- edging strip deforms and power is shut off in event moving part contacts operator

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E-MachineGuard.ppt Slide 15

PHYSICAL HAZARDS

Guards must:

- prevent contact
- be secure
- be tamper resistant
- protect moving parts from foreign objects
- create no new hazards
- create no interference
- allow safe routine maintenance

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E-MachineGuard.ppt Slide 16

PHYSICAL HAZARDS

Locking Out

- a way to ensure equipment cannot be started or hurt workers during maintenance
- power cannot be restored to the equipment while working on it
- equipment cannot be started up without prior knowledge
- equipment cannot release stored energy; e.g., release a gas from a line under pressure

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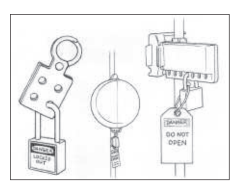
F-LockingOut.ppt Slide 1

PHYSICAL HAZARDS

One Worker, One Lock, One Key

- Each worker working on the equipment adds his or her personal lock.
- Each lock must be identifiable so that everyone knows to whom each lock belongs; i.e., who is working on the equipment.
- Each lock must have a unique key so no one else can remove the lock.



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F-LockingOut.ppt Slide 2

PHYSICAL HAZARDS

Where Do I Put the Lock?

- The lock must be placed on an energy-isolating device.
    - This is a mechanical device that physically prevents the transmission or release of energy.
- The lock holds the energy-isolating device in its OFF (or safe) position.
- Once put in place, the lock cannot fall off or allow the energy-isolating device to move out of its OFF position.

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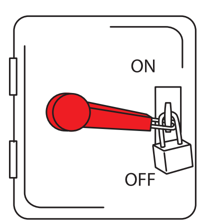
F-LockingOut.ppt Slide 3

PHYSICAL HAZARDS

Examples of Energy-isolating Devices Suitable for Locking

- manually operated circuit breaker
- disconnect switch
- line valve
- block or similar device that isolates energy



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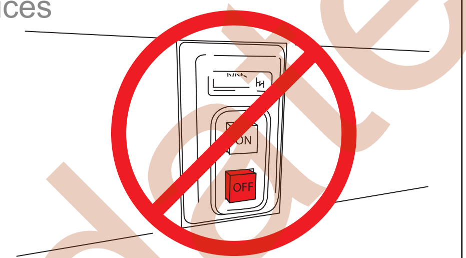
F-LockingOut.ppt Slide 4

PHYSICAL HAZARDS

Not Acceptable for Locking out (Not Energy- isolating Devices)

- push buttons
- selector switches
- other control circuit type devices



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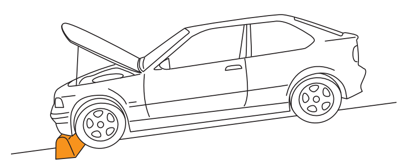
F-LockingOut.ppt Slide 5

PHYSICAL HAZARDS

Options

- If equipment cannot be locked out –make it inoperative.
- Remove mechanical linkages; i.e., dismantle push rods, remove belts and flywheels.
- Use blocking devices, such as wood, chains or metal pins, to prevent movement.
- Close hydraulic or pneumatic valves and bleed.
- Remove printed circuit modules.



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F-LockingOut.ppt Slide 6

PHYSICAL HAZARDS

What about Appliances? Where Do I Put My Lock?

If the appliance, e.g., a meat slicer, has an electrical cord that can be disconnected from the wall socket:

- unplug it and
  - use a lockable plug cover
  - use a special lock that passes through one of the holes of the plug's electrical pins
  - keep the plug in sight, or within reach and in your control at all times

These options work for any cord connected equipment or appliance.

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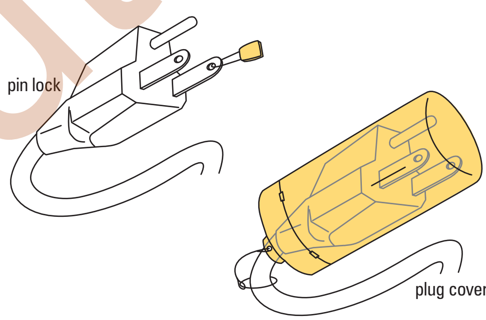
F-LockingOut.ppt Slide 7

PHYSICAL HAZARDS

Examples



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F-LockingOut.ppt Slide 8

PHYSICAL HAZARDS

Make Sure!

- Before working on equipment, the worker must check to make sure it cannot operate.
- Try to turn the equipment on, using the ON/OFF switch.
- A worker must not work on equipment until it has been tested and confirmed safe.

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F-LockingOut.ppt Slide 9

PHYSICAL HAZARDS

Case Study

- worker opens overhead crane's electrical disconnect switch
- worker secures personal lock to switch

but...

- disconnect switch lever has corroded, allowing it to physically separate from the disconnect switch assembly
- lever in OFF position, stub within box still in ON position

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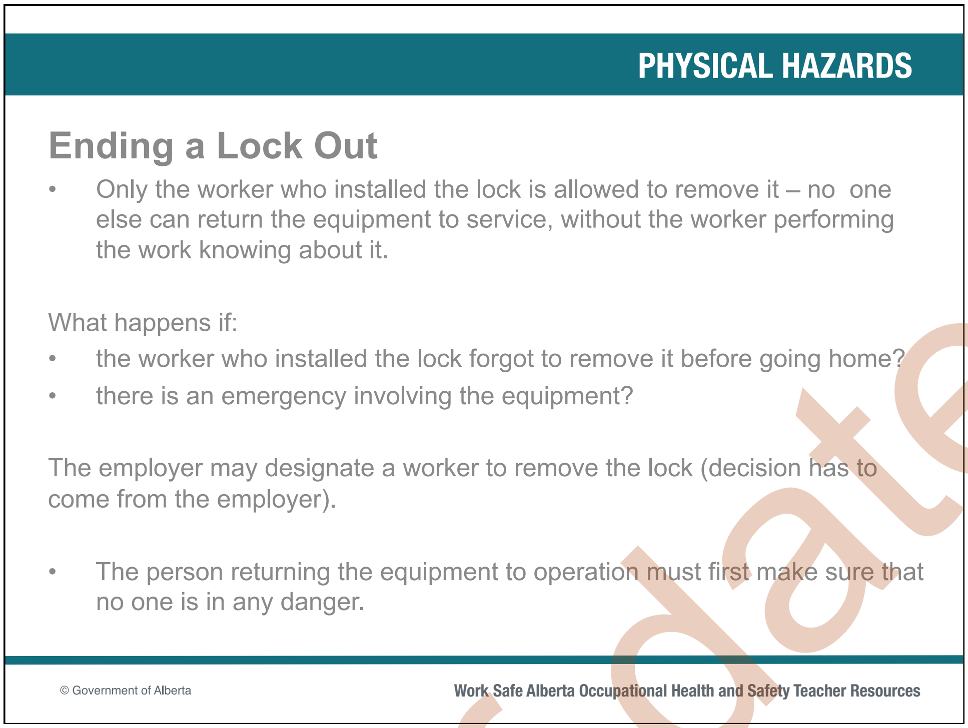
F-LockingOut.ppt Slide 10



F-LockingOut.ppt Slide 11

PHYSICAL HAZARDS

How Hot Do You Feel?

Depends on:

- air temperature
- humidity
- radiant heat
- air speed
- physical activity
- clothing
- age
- fitness/health/weight
- hydration
- medications or other drugs

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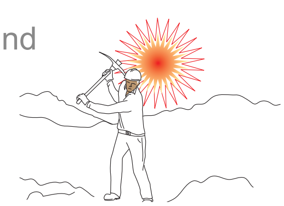
G-HeatStress.ppt Slide 1

PHYSICAL HAZARDS

Problems from Heat Exposure

- heat rash – tingling, burning, red rash
- heat cramps – spasms in the working muscles
- fainting – blood flow diverted from the brain to the skin
- heat exhaustion – clammy skin, dizzy, weak and rapid pulse
- heat stoke – sweating stops, skin hot and dry, dizzy – potentially fatal



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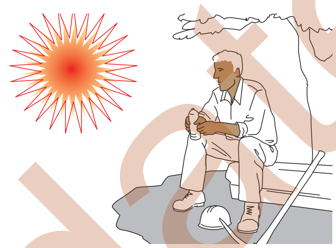
G-HeatStress.ppt Slide 2

PHYSICAL HAZARDS

Prevention

- Drink plenty of water or electrolyte replacement drinks.
- Wear loose clothes in light colours.
  (Moisture wicking fabrics are helpful.)
- Take frequent rests in a shaded area.
- Acclimatize by building up to a full workload over a period of days.
- Stay fit.



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G-HeatStress.ppt Slide 3

PHYSICAL HAZARDS

How Cold Do You Feel?

Depends on

- air temperature
- wind speed
- humidity
- age
- weight
- fitness
- health; e.g., circulation
- previous cold injury
- clothing
- physical activity
- fatigue
- medications or other drugs, including tobacco

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H-ColdStress.ppt Slide 1

PHYSICAL HAZARDS

How Do We Lose Body Heat?

- immersion in cold water
- contact with cold surfaces
- damp clothing
- cold air
- evaporation of sweat
- eating or drinking something cold

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H-ColdStress.ppt Slide 2

PHYSICAL HAZARDS

Problems from Cold Exposure

Chilblains

- from extended exposure to cool temperatures (above freezing)
- skin reddened, tingling, painful

Immersion foot/trench foot

- exposure to wet environment
- feet experience tingling, numbness, swelling, blisters

Frostnip/frostbite

- freezing of skin from exposure to cold or contact with cold objects

(continued)

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H-ColdStress.ppt Slide 3

PHYSICAL HAZARDS

(continued)

Hypothermia

- exposure to cold environments
- core temperature drops, initial cold and pain disappears as exposure continues, stupor, unconsciousness, death

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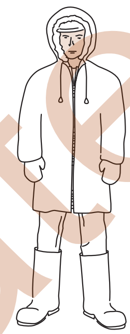
H-ColdStress.ppt Slide 4

PHYSICAL HAZARDS

Prevention

- dress warmly and cover exposed skin
- dress in layers
- drink warm fluids (no alcohol)
- take regular breaks in a warm area
- know the symptoms



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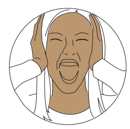
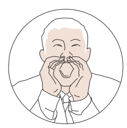
H-ColdStress.ppt Slide 5

PHYSICAL HAZARDS

Noise

Noise can be hazardous to your health and safety:

- hearing loss 
- other health effects include blood pressure, cholesterol, fatigue, stress 
- interferes with communications (safety hazard) 

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I-Noise.ppt Slide 1

PHYSICAL HAZARDS

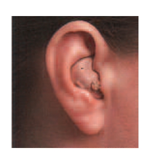
Types of Hearing Loss

Noise Induced

- sudden hearing loss from trauma; e.g., explosion
- temporary hearing loss after a short duration in a noisy environment; e.g., from a concert
- permanent hearing loss from working in a noisy environment for months or years

Age Induced

- in addition to any loss from noise exposure



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I-Noise.ppt Slide 2

PHYSICAL HAZARDS

Examples of Noise Sources

Source of Sound	Sound Level (dBA)
wood chipper	100 -110
power mower, snowmobile	95 – 105
chainsaw	95 – 105
lawn mower	95 – 110
sidewalk snowplow	90 – 100
salt and sand truck	90 – 100
vacuum cleaner	80 – 85
normal conversation	60 – 65
background noise in a quiet office	40 – 45

If you have to raise your voice to be heard by someone one metre away, the noise is too loud. Prolonged exposure to these kinds of noise levels can lead to hearing loss.

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I-Noise.ppt Slide 3

PHYSICAL HAZARDS

Controlling Noise

- Engineering Controls
  - enclosures
  - mufflers
  - acoustical treatments
- Administrative Controls
  - reduce duration of exposure; e.g., job rotation
- Personal Protective Equipment
  - ear muffs
  - ear plugs

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I-Noise.ppt Slide 4

PHYSICAL HAZARDS

Sources of Vibration

- rotating and oscillating tools
  e.g., chainsaw, sander, hand mixer
- impact tools
  e.g., jackhammer, nail gun
- seats or floors in contact with vibration
  e.g., backhoe, turbine room in power plant

J-Vibration.ppt Slide 1

PHYSICAL HAZARDS

Health Effects of Vibration Exposure

hand/arm (from vibrating tools or equipment)

- tingling/numbness in fingers and hands
- blood vessel damage to fingers and hands
- loss of function in fingers and hands

whole body (transmitted from seats or floors)

- injury to neck or back
- fatigue, insomnia, headache, general malaise
- internal organ disorders

J-Vibration.ppt Slide 2

PHYSICAL HAZARDS

Preventing Vibration Injuries

- reduce exposure time
- use vibration-free equipment and tools
- use vibration absorbing materials
- keep hands warm
- take breaks

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J-Vibration.ppt Slide 3

PHYSICAL HAZARDS

Radiation

ionizing radiation: high energy radiation – can disrupt structure of atoms

- X-ray machines
- radioactive materials; e.g., plutonium
- background ionizing radiation from the earth and outer space

non-ionizing radiation: lower energy radiation – does not disrupt structures at the atomic level

- sun; i.e., UVA, UVB
- visible light
- computer, TV, monitors
- lasers
- UV lamps

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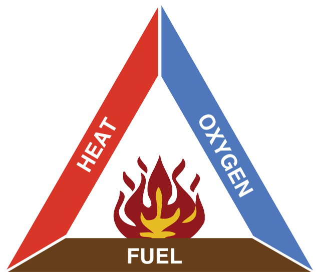
K-Radiation.ppt Slide 1

PHYSICAL HAZARDS

Fire Triangle



FUEL + OXYGEN + HEAT = FIRE

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L-FireHazards.ppt Slide 1

PHYSICAL HAZARDS

Fuels

- materials that burn
- the higher the temperature, the easier and quicker materials burn
- examples:
  - solvents, such as acetone, methanol and alcohols
  - gases, such as methane and propane
  - solids, such as wood and paper

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L-FireHazards.ppt Slide 2

PHYSICAL HAZARDS

Oxygen

- oxidizers: oxygen or other substances capable of releasing oxygen to a fire
- examples:
  - some acids, such as nitric and perchloric acids
  - chlorine dioxide
  - some chemicals, such as potassium permanganate and potassium chlorate

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L-FireHazards.ppt Slide 3

PHYSICAL HAZARDS

Heat

An ignition source can be:

- a spark
- static electricity
- arcs from electrical equipment
- a lit cigarette
- an open flame, such as a pilot light on a furnace
- a hot light bulb

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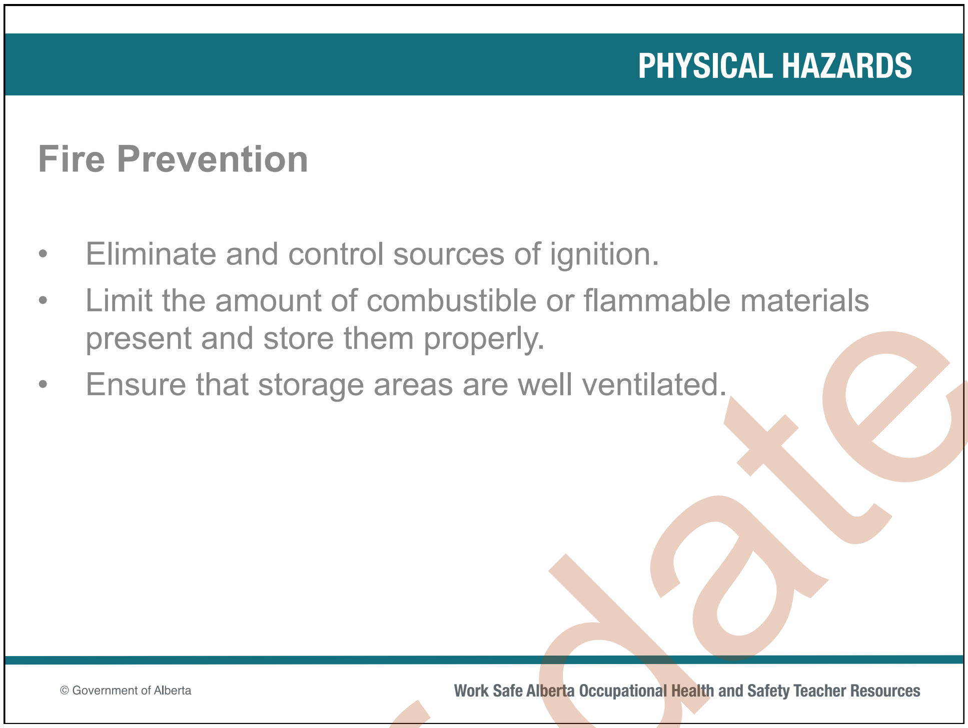
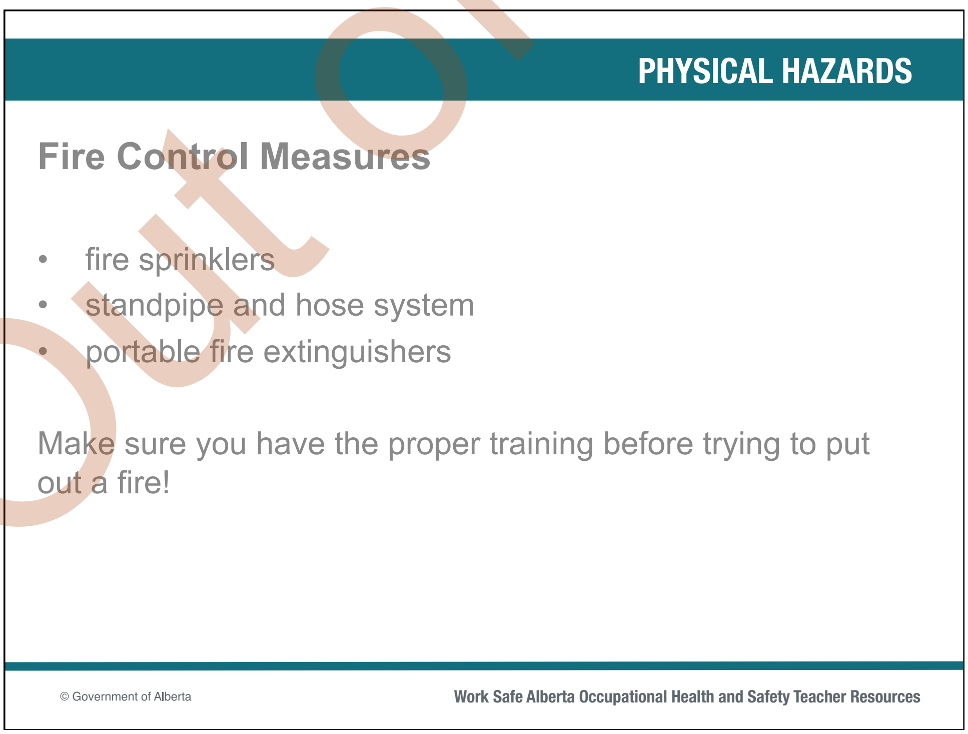
L-FireHazards.ppt Slide 4



L-FireHazards.ppt Slide 5



L-FireHazards.ppt Slide 6

TEACHER'S NOTES

SA-HeatStress.ppt
Slide 1

A. Heat Stress

Working in hot environments can cause a number of heat stress conditions:

- heat rash (prickly heat)
- heat cramps
- fainting
- heat exhaustion
- heat stroke

Additional information about the symptoms of these conditions, as well as treatments and prevention methods, is found in Handout 1 – Health Problems Resulting from Heat Exposure.

Page 165

Controlling Hot Conditions

The risk of heat-related illnesses can be reduced by:

- engineering controls to provide a cooler workplace
- safe work practices to reduce exposure
- learning to recognize the signs of heat stress and ways to prevent heat illnesses

Engineering Controls

Engineering controls are the most effective means to reduce heat exposure.

Reduce metabolic heat production (heat produced by the body).

- Reduce the need for physical activity by automation and mechanization of tasks.

Reduce radiant heat emission exposure.

- Cover hot surfaces with sheets of low emissivity material, such as aluminum or paint, to reduce the amount of heat radiated from the hot surface into the workplace.
- Use shielding to stop radiated heat from reaching work stations. Two types of shields can be used. Stainless steel, aluminum or other bright metal surfaces reflect heat back towards the source. Absorbent shields, such as a water-cooled jackets made of black-surfaced aluminum, can absorb and carry away heat.
- Move equipment that gives off heat.
- Use blinds, curtains or reflective coatings on windows to reduce direct sunlight.
- Insulate building walls. Insulation reduces the heat exchange between the source of heat and the work environment.

SA-HeatStress.ppt
Slide 2

Ventilate and use air conditioning.

- Ventilation, localized air conditioning and cooled observation booths are often used to provide cool work stations. Increasing the air movement or air speed will help cool workers. Fans or blowers can be used to circulate air and, if possible, open doors and windows to allow air to circulate.

Reduce the humidity.

- Air conditioning, dehumidification and elimination of open hot water baths, drains and leaky steam valves help reduce humidity. A good ventilation system can remove humid air. If the work process allows it, try to capture the humidity at its source with air evacuation units.

Administrative Controls

Reduce worker exposure.

- Rotate workers into tasks and areas that expose them to less radiant heat.
- Provide workers with shade from the sun or move the work to a shaded location.

Control physical activity.

- Have workers do less physically intense activities.
- Choose a time of day to carry out physical tasks; if possible, do them in the early morning or once it is cooler in the evening.
- Avoid intense physical activity during the hottest period of the industrial process or day.
- Use additional workers for the job.
- Select physically fit workers capable of doing the work under hot conditions.
- Rotate workers to less demanding activities.
- Reduce the pace of work.
- Implement a schedule of work and rest intervals. Provide cooled rest areas.

Drink plenty of fluids.

A person who does not drink enough fluids becomes dehydrated and less able to function in the heat. Dangerous levels of dehydration; i.e., more than 10% of body weight, can occur quickly under very hot working conditions. Two signs of dehydration are dark-coloured urine and having to urinate less often in smaller quantities. A worker who notices either of these signs should drink more fluids.

Do not rely on thirst as an indicator of when to drink. By the time you feel thirsty, you are well past the point at which you should have had more fluids. While the preferred fluid is water (cool, not cold), other recommended fluids include diluted fruit juice, tea or lemon tea. An electrolyte replacement drink, diluted to half strength with water, is also a good choice. Avoid alcohol and drinks that contain large amounts of caffeine, such as coffee, colas and other carbonated drinks. The caffeine acts as a diuretic, causing the body to produce more urine at a time when fluids need to be conserved.

As a rough guide, workers working under hot conditions should drink about one cup of fluid every 20 minutes. Salt pills are rarely required and their use is not recommended. (A person can have too much salt.) The normal salt content of the diet, including salt as a seasoning, is usually enough to replace salt lost through sweating. If salt replacement is a concern, try one of the electrolyte replacement drinks diluted to half strength with water.

Personal Protection

Wear appropriate clothing.

- Wear loose-fitting clothing that is light in weight, if possible.
- Try to wear clothing made of fabrics that wick sweat away from the skin and allow the sweat to evaporate.
- Wear aluminized reflective clothing near sources of radiant heat, such as hot furnaces.
- Wear insulated or cooled clothing, such as cooling vests, as necessary.
- Put on sunglasses and sunscreen to reduce sun exposure.

Refer to Handout 2 – Summary of Control Measures.

SA-HeatStress.ppt
Slide 3

Page 167

SA-HeatStress.ppt
Slide 4

Is It Too Hot to Work?

Scientists have developed several methods to determine if conditions are too hot to work. These include heart rate monitoring, measuring body core temperature and measuring sweat rate. The most popular and widely used method measures the wet bulb globe temperature (WBGT). This method uses a portable device, called a heat stress monitor, to measure a person's heat stress. WBGT takes into account air temperature, humidity, radiant heating from the sun or other sources and air movement. Air temperature is measured, using a normal thermometer called a dry bulb thermometer.

A black metal ball or globe that absorbs heat and has a thermometer inside it measures radiant heat. The wet bulb portion of the heat stress monitor measures the effect of evaporation and air movement. It consists of a regular thermometer bulb wrapped in a wick moistened with water.

The monitor uses these measurements to calculate the WBGT. For outdoor areas with direct sunlight, the calculation is:

WBGT = 70% of the wet bulb temperature + 20% of the black globe reading + 10% of the air temperature.

For areas without direct sunlight, the calculation is:

WBGT = 70% of the wet bulb temperature + 30% of the black globe reading.

Note that air temperature, measured with a normal thermometer, is the least important factor in both calculations.

To help assess heat stress, the American Conference of Government Industrial Hygienists (ACGIH) has prepared limits called threshold limit values or TLVs for heat stress. These take into account the WBGT reading, the intensity of the work being done, whether or not a worker is acclimatized and the type of clothing being worn. Combined, this information recommends what portion of each working hour a worker should be resting so that he or she does not suffer heat stress. Refer to Handout 3 –Screening Criteria for Heat Stress Exposure.

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Case Study

Using the WGBT exposure levels, consider the following example. What work/rest interval is appropriate?

- Workers perform moderate activity, such as walking about and doing moderate lifting and pushing.
- Workers have been working in the heat for the past week and are acclimatized.
- Workers are required to wear double-cloth overalls, requiring a +5°C correction to the WBGT reading of the heat stress monitor.
- The heat stress monitor gives a WBGT reading of 26, meaning that the air temperature is probably in the mid to high 30s.

Referring to Handout 3:

Acclimatized column, Moderate work intensity, WBGT temperature of 31°C (26 + 5), the work/rest interval should be "25% work/75% rest". This means that under these conditions, workers should work 15 minutes of each hour (25% of 60 minutes) and rest for the other 45 minutes of the hour (75% of 60 minutes). The recommended intervals assume that the rest area has the same WBGT reading as the work area. Rest does not have to mean that no work is done. It may be acceptable to have workers work in a cooler area doing tasks of equal or lesser intensity.

Humidex

Humidex is a measure of how hot we feel. It provides a number that describes how hot people feel, much in the same way the equivalent chill temperature or wind chill factor, describes how cold people feel. Humidex is used as a measure of perceived heat that results from the combined effect of excessive humidity and high temperature.

The Weather Service of Environment Canada uses humidex numbers to inform the public when conditions of heat and humidity are possibly uncomfortable ordangerous.

Humidex Range (°C)	Degree of Comfort
20-29	Comfortable
30-39	Some discomfort
40-45	Great discomfort, avoid exertion
Above 45	Dangerous
Above 54	Heat stroke imminent

If you know the temperature and relative humidity, a chart can be used to determine the humidex rating. For example, if the temperature is 30°C and the relative humidity is 70%, the humidex rating is 41°C. This level is considered a level of great discomfort and exertion should be avoided. The relation between humidex and comfort is subjective. It varies widely between individuals.

Direct comparison between WBGT and humidex is not possible; there are no conversion tables or mathematical formulas to do such conversions. However, one can estimate WBGT and humidex for a given ambient air temperature and humidity when there are no radiant heat sources (hot and cold surfaces) and air movement is less than 0.5 m/sec. (100 feet per minute). Under these conditions, the globe temperature equals room temperature and the natural wet bulb temperature (on the WBGT apparatus) is about 1.1°C (2°F) higher than the wet bulb temperature measured using a psychrometer.

B. Cold Stress

Cooling of body parts may result in nonfreezing injuries, freezing injuries and hypothermia, which is the most serious. Nonfreezing cold injuries include chilblain, immersion foot and trenchfoot. Frostnip and frostbite are freezing injuries.

Toes, fingers, ears and nose are at greatest risk because these areas do not have major muscles to produce heat. Also, the body will preserve heat by favouring the internal organs, reducing the flow of blood to the extremities under cold conditions. Hands and feet tend to get cold more quickly than the torso because:

- they lose heat more rapidly, since they have a higher surface area-to-volume ratio
- they are more likely to be in contact with colder surfaces than other parts of the body

If the eyes are not protected with goggles in high wind chill conditions, the corneas of the eyes may freeze.

The most severe cold injury is hypothermia from excessive loss of body heat and the resulting lowering of the inner core temperature (internal temperature of the body). Hypothermia can be fatal.

SB-ColdStress.ppt
Slide 1

Nonfreezing Injuries

Chilblains are a mild cold injury caused by prolonged and repeated exposure for several hours to air temperatures from above freezing (0°C) to as high as 16°C. In the affected skin area, there will be redness, swelling, tingling and pain.

Immersion foot occurs in individuals whose feet have been wet but not freezing cold for days or weeks. It can occur at temperatures up to 10°C. The primary injury is to nerves and muscle tissue. Symptoms include tingling and numbness; itching, pain, swelling of the legs, feet or hands; or blisters. The skin may be red initially and turn to blue or purple as the injury progresses. In severe cases, gangrene may develop. A similar condition of the hands can occur if a person wears wet gloves for a prolonged period under cold conditions. Symptoms are similar to immersion foot.

Trenchfoot results from prolonged exposure to a damp or wet environment from above the freezing point to about 10°C. Depending on the temperature, the onset of symptoms may range from several hours to many days, but the average is three days. Trenchfoot is more likely to occur at lower temperatures while immersion foot is more likely to occur at higher temperatures and longer exposure times.

Freezing Injuries

Frostnip is the mildest form of a freezing cold injury. It occurs when ear lobes, nose, cheeks, fingers or toes are exposed to the cold and the top layers of skin freeze. The skin of the affected area turns white and it may feel numb. The top layer of skin feels hard but the deeper tissue still feels normal (soft).

Frostnip can be prevented by wearing warm clothing and footwear. It is treated by gentle rewarming; e.g., holding the affected tissue next to unaffected skin of the victim or of another person. As for all cold-induced injuries, never rub the affected parts. Ice crystals in the tissue could cause damage if the skin is rubbed. Do not use very hot objects, such as hot water bottles, to rewarm the area or person.

Frostbite is a common injury caused by exposure to extreme cold or by contact with extremely cold objects, especially those made of metal. It may also occur at normal temperatures from contact with cooled or compressed gases. Frostbite occurs when tissue temperature falls below the freezing point (0°C) or when blood flow is obstructed. Blood vessels may be severely and permanently damaged and blood circulation may stop in the affected tissue. In mild cases, the symptoms include inflammation of the skin in patches accompanied by slight pain. In severe cases, there can be tissue damage, without pain, or there could be burning or prickling sensations and blisters. Frostbitten skin is highly susceptible to infection and gangrene may develop.

First Aid for Frostbite

First aid for frostbite and immersion or trench foot includes:

- Seek medical attention.
- Move the victim to a warm area, if possible.
- Gently loosen or remove constricting clothing or jewelry that may restrict circulation.
- Loosely cover the affected area with a sterile dressing.
- Quickly transport the victim to an emergency care facility.
- DO NOT attempt to rewarm the affected area on site but do try to stop the area from becoming any colder. Without the proper facilities, tissue that has been warmed may refreeze and cause more damage.
- DO NOT rub the area or apply dry heat.
- DO NOT allow the victim to drink alcohol or to smoke.

Hypothermia

In moderately cold environments, the body's core temperature does not usually fall more than 1°C to 2°C below normal because of the body's ability to adapt. However, in intense cold, without adequate clothing, the body is unable to compensate for the heat loss and the body's core temperature starts to fall. The sensation of cold followed by pain in exposed parts of the body is the first sign of mild hypothermia.

As the temperature continues to drop or as the exposure time increases, the feeling of cold and pain starts to diminish because of increasing loss of sensation. If no pain can be felt, serious injury can occur without the victim noticing it.

Next, muscular weakness and drowsiness are experienced. They usually occur when body temperature falls below 33°C. Additional symptoms of hypothermia include interruption of shivering, diminished consciousness and dilated pupils. When body temperature reaches 27°C, coma sets in. Heart activity stops around 20°C and the brain stops functioning at around 17°C.

Stage	Core Temperature	Signs and Symptoms
Mild Hypothermia	37.2 – 36.1°C (99 – 97°F)	Normal, shivering may begin.
	36.1 – 35°C (97 – 95°F)	Cold sensation, goose bumps, unable to perform complex tasks with hands, shivering can be mild to severe, hands numb.
Moderate Hypothermia	35 – 33.9°C (95 – 93°F)	Intense shivering, muscle incoordination becomes apparent, movements slow and laboured, stumbling pace, mild confusion, may appear alert. Use sobriety test, if unable to walk a 9 m straight line, the person is hypothermic.
	33.9 – 32.2°C (93 – 90°F)	Violent shivering persists, difficulty speaking, sluggish thinking, amnesia starts to appear, gross muscle movements sluggish, unable to use hands, stumbles frequently, difficulty speaking, signs of depression, withdrawn.
Severe Hypothermia	32.2 – 30°C (90 – 86°F)	Shivering stops, exposed skin blue or puffy, muscle coordination very poor, inability to walk, confusion, incoherent/irrational behaviour, but may be able to maintain posture and appearance of awareness.
	30 – 27.8°C (86 – 82°F)	Muscle rigidity, semiconscious, stupor, loss of awareness of others, pulse and respiration rate decrease, possible heart fibrillation.
	27.8 – 25.6°C (82 – 78°F)	Unconscious, erratic heart beat and respiration, a pulse may not be palpable.
	25.6 – 23.9°C (78 – 75°F)	Pulmonary edema, cardiac and respiratory failure, death. Death may occur before this temperature is reached.

First Aid for Hypothermia

Hypothermia is a medical emergency. At the first sign, find medical help immediately. The survival of victims depends on their co-workers' ability to recognize the symptoms of hypothermia. The victim is generally not able to notice his or her own condition.

First aid for hypothermia includes the following steps:

- Seek medical help.
- Ensure that wet clothing is removed.
- Place the victim between blankets so the body temperature can rise **gradually**. (Body-to-body contact can help warm the victim's temperature slowly.)
- Give warm, sweet (caffeine-free, nonalcoholic) drinks, unless the victim is rapidly losing consciousness, unconscious or convulsing.
- Quickly transport the victim to an emergency medical facility.
- Do NOT apply direct heat; i.e., hot water bottles.

What Factors Influence our Response to Cold?

A cold environment challenges the worker in three ways: by air temperature, air movement (i.e., wind speed), and humidity (i.e., wetness). To work safely, these challenges have to be counterbalanced by proper insulation, such as layered protective clothing, physical activity and by controlling exposure; e.g., work/rest schedule.

- *Air Temperature*: Air temperature is measured by an ordinary thermometer in degrees Celsius (°C) or degrees Fahrenheit (°F).
- *Wind Speed*: Various types of commercially-available anemometers are used to measure wind speed or air movement. Wind speed is usually measured in km/h or mph. The following is a suggested guide for estimating wind speed if accurate information is not available:
  - 8 km/h (5 mph): light flag moves
  - 16 km/h (10 mph): light flag fully extended
  - 24 km/h (15 mph): raises newspaper sheet
  - 32 km/h (20 mph): causes blowing and drifting snow
- *Humidity*: Water conducts heat away from the body 25 times faster than dry air.
- *Physical Activity*: The production of body heat by physical activity is difficult to measure. However, tables are available, in literature, that show metabolic rates for a variety of activities. Metabolic heat production is measured in kilo calories (kcal) per hour. One kilocalorie is the amount of heat needed to raise the temperature of one kilogram of water by 1°C.
- *Work/rest Schedule*: Regular rest breaks in a heated area are recommended for anyone working in the cold. The frequency of breaks depends on the air temperature and wind speed, as well as the degree of physical activity.
- *Protective Clothing*: To be protected from the cold, workers should dress in layers.

The inner layers should trap moisture and wick it away from the body; the middle layers provide insulation; the outer layers protect against the wind and weather. As work activity and environmental conditions change, workers should be able to easily add or remove layers.

What is Wind Chill?

At any temperature, you feel colder as the wind speed increases. The combined effect of cold air and wind speed is expressed as equivalent chill temperature (ECT) or simply wind chill temperature in degrees Celsius or Fahrenheit. It is essentially the air temperature that would feel the same on exposed human flesh as the given combination of air temperature and wind speed. It can be used as a general guideline for deciding clothing requirements and the possible health effects of cold.

In some parts of Canada, the term wind chill factor is used. This is a measurement of a heat loss rate caused by exposure to wind and it is expressed as the rate of energy loss per unit area of exposed skin per second (e.g., joules/[second-metre^2] or watts/metre^2, W/m^2).

In Canada, there are no maximum exposure limits for cold working environments. The work warm-up schedule, developed by the Saskatchewan Department of Labour, has been adopted by the American Conference of Governmental Industrial Hygienists (ACGIH) as Threshold Limit Values (TLVs) for cold stress.

Controlling Cold Stress

SB-ColdStress.ppt
Slides 2–3

(1) Environmental Measures

- Temperature and wind conditions should be known; e.g., weather report on the radio, current weather office information.
- Steps should be taken to protect workers from wind (or indoors from drafts or forced air from air handling units). The combination of low temperatures and even moderate winds can quickly create dangerous working conditions.
- Ensure that heated rest areas, such as a truck cab, tent or hut, are available.

(2) Equipment Design

For work below the freezing point, metal handles and bars should be covered by thermal insulating material. Also, machines and tools should be designed so that they can be operated without a person having to remove mittens or gloves.

(3) Work Practices

A schedule of regular rest breaks should be established to allow workers to warm up. These breaks should be not less than 10 minutes in length and should be taken in a heated area.

- Heated warming shelters; e.g., tents, cabins, rest rooms, should be provided.
- When entering the heated shelter, outer and middle clothing layers (as necessary) should be removed to prevent overheating and to allow dampness to evaporate. A change of dry clothing may be necessary since returning to cold work while damp or sweaty may result in rapid chilling.
- Warm fluids should be consumed at the work site to provide energy and warmth and to replace fluids lost during work.
- Recognize the symptoms of cold stress. The onset of severe shivering, the feeling of excessive fatigue, drowsiness, irritability or euphoria are indications to immediately return to the shelter.

The following additional precautions apply at colder temperatures:

- Workers should be under constant protective observation by a buddy or supervisor.
- Work rate should not be high enough to cause sweating. If heavy work must be performed, rest periods in heated shelters and the opportunity to change into dry clothing should be provided.
- New employees should not be required to work full-time in the cold during the first days of employment until they become accustomed to the working conditions and required protective clothing.
- Weight and bulkiness of clothing should be included in estimating required work performance.
- Work should be arranged to minimize periods of standing or sitting still.
- Workers should be appropriately trained.

(4) Personal Measures

Diet

Workers have increased energy requirements when working in the cold. Consider adding additional wholesome foods to the diet, such as pasta, potatoes, rice, dairy products, nuts, meat, herring and salmon. Light snacks and warm fluids should be taken during rest breaks. Alcohol must not be consumed when working in the cold. Alcohol produces a deceptive feeling of warmth but may contribute to dehydration and impair judgement.

Dressing for the Cold

Clothes must be layered to manage moisture and keep dry. Insulating layers must trap air for warmth, and the worker must be protected from the wind and weather.

To remain comfortable as weather and work conditions change, clothing layers should be added or removed, or ventilation openings in clothing opened or closed. Every effort must be made to avoid sweating and becoming damp. Clothing selections are normally made on the basis of staying warm while inactive. Consider the work to be performed and the weather conditions, then have workers dress so that layers can be shed and they can still remain comfortably warm. If clothing layers do become damp and remain that way, workers should be prepared to replace them before becoming chilled and hypothermic. If a worker is sweating, then his or her clothing is probably too warm for the conditions and tasks being performed.

Handwear

- Mittens keep hands warmer than gloves since fingers are together. With gloves, fingers are separated and lose heat from one another.
- Have workers wear thin liners under gloves or mittens. Liners need not be removed when removing the gloves.
- Removable glove and mitten liners can be replaced and dried when they become damp.
- New mitten styles, including three-finger lobster claws that keep fingers warm yet offer good dexterity are available.
- Windproof overmitts offer additional hand protection, without adding significant bulk.

SB-ColdStress.ppt
Slide 4

Headwear

- Up to 50% of body heat is lost through the head. A hat or other head protection must be worn in the cold.
- Avoid cotton and use synthetic fabrics or wool instead.
- Workers must use an appropriate hard hat liner to reduce heat loss when wearing a hard hat.
- Select a hat appropriate for the weather conditions and activity level. Consider thickness, extent of head coverage (e.g., openface, full balaclava, ear coverage), need for windproofness, effect on vision and hearing, and ability to fit into or over protective headwear, if required.
- A facemask and eye protection may sometimes be necessary.

Footwear

- Warm, insulated safety footwear is essential. Boots should have thick soles for insulation while standing in snow or on cold concrete. Footwear selection should be based on the work being performed, the surfaces on which the worker will work and the weather conditions to which the worker will normally be exposed. Tight-fitting boots reduce circulation and can make feet feel cold.
- Footwear should be sized so that it will accommodate an extra layer(s) of socks. A synthetic sock liner, worn beneath a synthetic blend or wool outer sock, wicks moisture away from the skin, keeping feet drier and warmer.

(5) Worker Training

Workers should be instructed in health and safety procedures appropriate to the tasks and environment in which those tasks are performed. This instruction should include:

- proper rewarming procedures and appropriate first aid treatment
- how to dress for the cold
- recognition of frostnip and frostbite
- recognition of the signs and symptoms of impending hypothermia
- additional special training for those workers working in remote locations

(6) Special Precautions

- Exposure to vibration may increase a worker's susceptibility to cold injury because of the way that vibration can reduce circulation, particularly in the extremities.
- Work performed in snow- or ice-covered terrain may require tinted safety eyewear and/or sunglasses with side shields. If there is a potential for eye injury from blowing snow or ice crystals, special safety goggles should be worn. As well, workers in such situations should be prepared for white-out conditions and have a plan in place regarding movement and navigation under such conditions.
- Alcohol must be avoided – it produces a deceptive feeling of warmth but can affect circulation, fluid balance and judgement.
- Limit the consumption of caffeine-containing beverages because they act as diuretics and affect hydration.
- Workers with health conditions that affect normal body temperature regulation or impair circulation, such as Raynaud's Syndrome or diabetes, should take appropriate precautions when working in the cold.
- This might include more layers, including hat and mitts, and less time in the cold environment.
- Body parts that have sustained a frostnip or frostbite injury are sensitive to re-injury, so extra care must be taken to protect/cover these areas.
- If loose or bulky clothing is worn, special care should be taken when working around moving equipment or machinery to prevent clothing entrapment.

C. NOISE

How Does the Body Respond to Noise?

At first, noise-induced hearing loss affects a person's ability to hear higher frequency sounds. Since normal speech does not use these high frequencies, little hearing change is noticed. With continued exposure, hearing deteriorates and, eventually, the loss spreads into those lower frequencies involved in speech. Affected individuals tend to automatically compensate by getting clues from reading lips without realizing it. Significant hearing loss is often experienced before it is even noticed.

The body's reaction to noise is similar to its response when under stress. Blood pressure and heart rate can increase and hormone and blood cholesterol levels can change. Exposure to too much noise can make a person feel tired. High noise levels can also interfere with being able to hear important messages in some jobs, causing potential safety problems unless alternative methods of communication are used.

Noise is one of the most common workplace health hazards. In industrial and manufacturing environments, permanent hearing loss is the main health concern. Annoyance, stress and interference with speech communication are the main concerns in noisy offices, schools and computer rooms.

To prevent adverse outcomes of noise exposure, noise levels should be reduced to acceptable levels. The best method of noise reduction is to use engineering controls that modify the noise source itself or the workplace environment. Where technology cannot adequately control the problem, personal hearing protection, such as ear muffs or plugs, can be used. Personal protection, however, should be considered as an interim measure while other means of reducing workplace noise are explored and implemented.

Technical Aspects of Noise

SC-Noise.ppt
Slide 1

Exchange Rate

Exchange rate is used to determine when time of exposure needs to be reduced. Exchange rate is the relationship between noise level and exposure time. The 3 dB exchange rate is the most commonly used and is also known as the equal-energy rule or hypothesis; i.e., equal amounts of sound energy produce equal amounts of hearing damage, regardless of how the sound energy is distributed in time. On an energy basis, the 3 dB exchange rate permits the calculation of a true time-weighted average exposure to noise. Based on the mathematical relationship for sound power level,

$L(\text{dB}) = 10\log_{10}(W/W_0)$

where:

L is the sound power level

W is sound power

W_0 is a reference sound power.

Every doubling of energy results in an increase in L of 3 dB. Therefore, for every 3 dB increase in noise level, the exposure time must be halved.

Working with Decibel (dB) Units

The decibel is a logarithmic scale. For mathematical calculations using dB units, we must use logarithmic mathematics. However, in our day-to-day work, we do not need such calculations. The use of the dB unit makes it easy to deal with the workplace noise level data provided. We use a set of simple rules.

Change in dB	Change in Sound Energy
3 dB increase	Sound energy is doubled
3 db decrease	Sound energy is halved
10 dB increase	Sound energy increases by a factor of 10
10 dB decrease	Sound energy decreases by a factor of 10
20 dB increase	Sound energy increases by a factor of 100
20 dB decrease	Sound energy decreases by a factor of 100

Adding Noise Levels

Sound pressure levels in decibels are based on a logarithmic scale and cannot be added or subtracted in the usual arithmetical way. If one machine emits a sound level of 90 dB and a second identical machine is placed beside the first, the combined sound level is 93 dB, not 180 dB.

Step 1: Determine the difference between the two levels and find the corresponding row in the left hand column.

Step 2: Find the number [dB or dB(A)] that corresponds to this difference in the right hand column of the table.

Step 3: Add this number to the higher of the two decibel levels.

Numerical Difference Between Two Noise Levels (dBA)	Amount to Add to the Higher of the Two Noise Levels (dB or dBA)
0	3.0
0.1 – 0.9	2.5
1.0 – 2.4	2.0
2.4 – 4.0	1.5
4.1 – 6.0	1.0
6.1 – 10	0.5
10	0

Example: You have two machines. One emits a noise level of 90 dB and the other emits 89 dB.

- Step 1: The numerical difference between the two levels is 1 dB (90 – 89 = 1).
- Step 2: The number corresponding to this difference of 1, taken from the right hand column, is 2.
- Step 3: Add 2 to the highest level, in this case 90. Therefore, the resulting noise level is 92 dB.

When the difference between two noise levels is 10 dB or more, the amount to be added to the higher noise level is zero. In such cases, no adjustment factor is needed because adding in the contribution of the lower in the total noise level makes no perceptible difference in what people can hear or measure. For example, if your workplace noise level is 95 dBA and you add another machine that produces 80 dBA, the workplace noise level will still be 95dBA.

SC-Noise.ppt
Slide 2

What Is a Noise Management Program?

As a first step in dealing with noise, workplaces need to identify areas or operations where excessive exposure to noise occurs. Where workers are exposed to excess noise (i.e., noise exceeding the OELs), the employer must develop and implement a noise management program. Such a program consists of the following elements:

- *Educating workers* – this includes the basics of noise-induced hearing loss and how workers can protect themselves.
- *Measuring and monitoring sound levels* – what needs to be done to protect workers depends on the level and type of noise at the workplace. Measuring sound levels identifies noise sources and those workers most likely to be exposed to noise exceeding the OELs.
- *Posting of suitable signs* – where the noise level exceeds 85 dBA, post signs.
- *Controlling noise exposure* – worker exposure to noise can be reduced through:
- engineering controls
- administrative controls
- by providing workers with appropriate personal hearing protection
- *Hearing protection devices* – this includes selection, use and maintenance of the equipment.
- *Conducting audiometric tests* – workers' hearing needs to be tested to determine the extent of any existing hearing loss and to monitor for ongoing changes in hearing ability.
- *Evaluating the program* – verifying that the program is doing what it is intended to do – prevent work-related hearing loss. Verification must be done at least annually.

How Are Sound Levels Measured?

SC-Noise.ppt
Slide 3

Part of a noise management program is to identify noise hazards in the workplace and those most likely to be exposed to noise over the legal limits. This is done by conducting a survey in which sound levels are measured and the duration of worker exposures in the various work areas is estimated.

Sound Level Meter

This is the basic measuring instrument for noise. It consists of a microphone that converts sound pressure variations into electrical signals, a frequency selective amplifier, a level range control, frequency weighting to shape the frequency response of the instrument and an indicator.

Noise Dosimeter

A noise dosimeter is a sound level meter worn by the worker. It measures and stores sound levels during an exposure period and computes the exposure as a percentage of a criterion level, such as an occupational exposure limit. The noise must be measured using an A-weighted filter, with a 3 dBA exchange rate, to compare the measured results to the legal limits.

In noise dosimetry, the microphone is attached to the worker whose noise exposure is being measured. Placement of the microphone is important in estimating exposure. The microphone is usually mounted on a shoulder, at the chest or in the ear. When noise levels are continuous and the worker remains essentially in one work area during the work shift, measuring noise exposure with a sound level meter is relatively straightforward. However, a noise dosimeter is preferred for measuring worker exposure when noise levels vary or are intermittent, when they contain components of impulse noise or when the worker frequently moves around during the work shift.

Integrating Sound Level Meter

This instrument is a sound level meter with properties similar to those of a dosimeter. Like a noise dosimeter, it can be used to measure varying or intermittent noise and impulse noise and the worker can move around while wearing the instrument.

Typical applications for integrating sound level meters are identical to those for standard sound level meters. However, integrating sound level meters can be used to measure the average sound pressure level around noisy equipment or other sound sources where the integrating capacity can be used to determine the average sound level in space as well as time. The two main differences between sound level meters and integrating sound level meters are:

- Averaging durations for an integrating meter are usually much longer than those for a standard sound level meter, extending to minutes or hours.
- The integrating meter gives equal emphasis to all sounds that occur during the selected averaging period, while the standard sound level meter gives more emphasis to recently occurring sounds.

Controlling Noise

SC-Noise.ppt
Slide 4

Engineering Controls

Four main types of engineering controls can be used to reduce or eliminate noise:

- *Substitution* – replace noisy equipment, machinery or processes with quieter ones.
- *Modification* – modify the way equipment operates so that it generates less noise.

This may include installing a muffler, reducing equipment vibration by dampening or bracing, improved lubrication, balancing rotating parts or operating equipment at a lower speed. Alternatively, the area itself can be modified. For example, reverberation or echo can be reduced by covering walls with sound absorbing materials.

- *Isolation* – this may involve isolating workers from a noisy area by having them work in an enclosed room. Examples of this approach include:
  - segregating noisy areas with sound barriers and partitions
  - isolating noisy equipment by placing it in an enclosure
  - using sound absorbent material and covers over noisy equipment
- *Maintenance* – malfunctioning or poorly maintained equipment generates more noise than properly maintained equipment. Noise control equipment must also be properly maintained to be effective.

Developing engineering controls may involve engineers, health and safety personnel and the workers who operate, service and maintain the equipment. The effectiveness of the controls will depend on a thorough assessment of the noise source and individual worker exposure. The contribution of each noise source to the overall noise level must be considered.

The control options available should be evaluated, based on their effectiveness, cost, technical feasibility and implications for equipment use, service and maintenance. Enclosing a piece of equipment, for example, may cause it to overheat or create maintenance difficulties. Other potential complications, such as effects on lighting, heat production, ventilation and ergonomics, should also be considered. The function and purpose of planned or existing controls must be fully discussed with workers so they understand the purpose of the controls and do not inadvertently interfere with them.

Administrative Controls

SC-Noise.ppt
Slide 5

Administrative controls involve changes in work schedules or operations that reduce worker noise exposure. Typical controls include rotating work schedules or changing production schedules to limit the amount of time workers are exposed to noise.

Protective Equipment

SC-Noise.ppt
Slide 6

When engineering and administrative controls cannot reduce noise exposure enough or where they are not practical, hearing protection must be used to protect workers. Hearing protection is considered to be a device designed to reduce the level of sound reaching the eardrum.

Earmuffs and earplugs are the most common types of hearing protection used. A wide range of hearing protection can be found within each of these categories. The amount of protection or sound reduction provided by a hearing protector depends on its characteristics and how it is worn. The selected hearing protector must be capable of keeping noise exposure at the ear below the occupational exposure limit for noise.

The following factors must be considered when selecting hearing protectors:

- who will be wearing the equipment
- compatibility with other safety equipment
- conditions, such as temperature, humidity and pressure
- comfort – protectors that are not comfortable will not be worn
- ease of use and handling
- impact on the wearer's ability to communicate

The hearing protectors selected must meet the requirements of CSA Standard Z94.2-02, *Hearing Protection Devices — Performance, Selection, Care and Use*. This Standard provides performance requirements for personal hearing protection devices. The Standard classifies muffs and earplugs as Class A, B or C, depending on the level of protection they provide. Class C provides the least degree of protection while Class A provides the greatest. Table 2 of Schedule 3 indicates the class of hearing protection to be used at various noise levels. The classification of hearing protectors is based on how much they reduce sound levels at nine different frequencies: 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3150 Hz, 4000 Hz, 6300 Hz and 8000 Hz. The manufacturer must provide this information to the equipment user.

Maximum Equivalent Noise Level (dBA Lex)	CSA Class of Hearing Protection	CSA Grade of Hearing Protection
90	C,B or A	1, 2, 3 or 4
95	B or A	2, 3 or 4
100	A	3 or 4
105	A	4
110	A earplug + A or B earmuff	3 or 4 earplug + 2, 3 or 4 earmuff
110	A plug + A or B earmuff and limited exposure time to keep sound reaching the worker's ear drum below 85dBA Lex	3 or 4 earplug + 2, 3 or 4 earmuff and limited exposure time to keep sound reaching the worker's ear drum below 85 dBA Lex

D. Vibration

SD-Vibration.ppt
Slide 1

What is Vibration?

If you could watch a vibrating object in slow motion, you could see movements in different directions. How far and how fast the object moves determine its vibrational characteristics. The terms used to describe this movement are frequency, amplitude and acceleration.

Frequency

A vibrating object moves back and forth from its normal stationary position. A complete cycle of vibration occurs when the object moves from one extreme position to the other extreme and back again. The number of cycles that a vibrating object completes in one second is called frequency. The unit of frequency is hertz (Hz). One hertz equals one cycle per second.

Amplitude

A vibrating object moves to a certain maximum distance on either side of its stationary position. Amplitude is the distance from the stationary position to the extreme position on either side and is measured in metres (m). The intensity of vibration depends on amplitude.

Acceleration

The speed of a vibrating object varies from zero to a maximum during each cycle of vibration. It moves fastest as it passes through its stationary position to an extreme position. The vibrating object slows down as it approaches the extreme, where it stops and then moves in the opposite direction through the stationary position toward the other extreme. Speed is expressed in units of metres per second (m/s).

Acceleration is a measure of how quickly speed changes with time and, therefore, acceleration is expressed in units of metres per second, per second or metres per second squared (m/s2). The magnitude of acceleration changes from zero to a maximum during each cycle of vibration. It increases as the vibrating object moves further from its normal stationary position.

Resonance

Every object tends to vibrate at one particular frequency that depends on the composition of the object, its size, structure, weight and shape. This frequency of natural vibration is called the resonant frequency. A vibrating machine transfers the maximum amount of energy to an object when the machine vibrates at the object's resonant frequency.

How Do We Get Exposed to Vibration?

Contact with a vibrating object transfers the vibration energy to a person's body. Depending on how the exposure occurs, vibration may affect a major part of the worker's body or only a particular organ. The effect of vibration exposure also depends on the frequency. Each organ of the body has its own resonant frequency. If exposure occurs at or near any of these resonant frequencies, the resulting health effect can be greatly increased.

Segmental vibration exposure affects an organ, part or segment of the body. The most widely studied and most common type of segmental vibration exposure is hand-arm vibration exposure that affects the hands and arms. Hand-arm vibration affects operators of chain saws, chipping tools, jackhammers, jack leg drills, grinders and many other workers who operate hand-held vibrating tools. Whole body vibration energy enters the body through a seat or the floor. It affects the entire body or a number of organs in the body. People who are exposed to whole body vibration include operators of trucks, buses, tractors and those who work on vibrating floors.

Refer to Handout 4 – Examples of Vibration Exposure.

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SD-Vibration.ppt
Slide 2

What Are the Health Effects of Hand-arm Vibration?

Vibration-induced white finger (VWF) is the most common health effect in operators of hand-held vibrating tools. Vibration can cause changes in tendons, muscles, bones and joints, and can affect the nervous system. Collectively, these effects are known as hand-arm vibration syndrome (HAVS). The symptoms of VWF are aggravated when the hands are exposed to cold.

Workers affected by HAVS commonly report:

- whitening (blanching) of one or more fingers when exposed to cold
- tingling and loss of sensation in the fingers
- loss of light touch
- pain and cold sensations between periodic white finger attacks
- loss of grip strength
- bone cysts in fingers and wrists

The development of HAVS is gradual and increases in severity over time. It may take a few months to several years for the symptoms of HAVS to become noticeable.

The severity of hand-arm vibration syndrome depends on several other factors, such as:

Physical Factors, including:

- acceleration
- frequency
- duration of exposure
- maintenance of the tool
- work practices

Work Procedures, including:

- how hard the worker grips the vibrating equipment
- amount of the body in contact with the source of vibration
- hardness of the material being contacted by hand-held tools
- position of the hand and arm relative to the body
- texture of the handle

Individual Factors, including:

- medical history of the worker; e.g., previous injury to the hand or fingers, such as frostbite
- how the tool is controlled by the worker
- machine work rate
- skill and productivity
- individual susceptibility
- exposure to other physical or chemical agents
- use of tobacco or drugs

SD-Vibration.ppt
Slide 3

What Are the Health Effects of Whole Body Vibration?

Whole body vibration can cause fatigue, insomnia, headache and shakiness shortly after or during exposure. After daily exposure over a number of years, whole body vibration can affect the entire body and result in a number of health disorders. Sea, air or land vehicles cause motion sickness when the vibration exposure occurs in the 0.1 to 0.6 Hz frequency range. Studies of bus and truck drivers found that occupational exposure to whole body vibration contributed to a number of circulatory, bowel, respiratory, muscular and back disorders. The combined effects of body posture, postural fatigue, dietary habits and whole body vibration are the possible causes for these disorders.

Studies show that whole body vibration can increase heart rate, oxygen uptake and respiratory rate, and can produce changes in blood and urine. East European researchers have noted that exposure to whole body vibration can produce an overall ill feeling that they call vibration sickness.

Many studies have reported decreased performance in workers exposed to whole body vibration.

Noise and Vibration Exposure

Since most vibrating machines and tools also produce noise, a vibration-exposed worker is likely to be exposed to noise at the same time. Studies of the effect of separate and simultaneous exposure to noise and whole body vibration have concluded that whole body vibration alone does not cause hearing loss. However, simultaneous exposure to noise and vibration produces greater temporary hearing loss than noise alone.

How Is Vibration Measured?

Acceleration in well-defined directions, frequencies, hand-grip force and duration of exposure must all be measured when assessing vibration exposure. However, most jurisdictions and agencies use acceleration as a measure of vibration exposure because:

- several types of instruments are available for measuring acceleration, the rate of change of velocity in speed or direction per unit time; e.g., per second
- measuring acceleration can also give information about velocity and amplitude of vibration
- the degree of harm is related to the magnitude of acceleration

A typical vibration measurement system includes a device to sense the vibration (i.e., accelerometer), a tape recorder, a frequency analyzer, a frequency-weighting network and a display, such as a meter, printer or recorder. The accelerometer produces an electrical signal. The size of this signal is proportional to the acceleration applied to it. The frequency analyzer determines the distribution of acceleration in different frequency bands. The frequency-weighting network mimics the human sensitivity to vibration of different frequencies. The use of weighting networks gives a single number as a measure of vibration exposure and is expressed as the frequency-weighted vibration exposure in metres per second squared (m/s^2), units of acceleration. Vibration meters equipped with accelerometers can be used for instantaneous vibration measurement. Some types of sound level meters can measure vibration.

How Can Hand-arm Vibration Exposure Be Controlled?

Engineering Controls

Using anti-vibration tools can reduce exposure. An anti-vibration chain saw can reduce acceleration levels by a factor of about 10, but these chain saws must be well maintained. A few pneumatic tool companies manufacture anti-vibration tools such as anti-vibration pneumatic chipping hammers, pavement breakers and vibration-damped pneumatic riveting guns.

Administrative Controls

1. **Safe work practices**
   - Let the tool do the work. Use as light a grip as possible to keep the tool under control. A tight grip restricts blood flow in the hands and fingers and allows more vibration to pass from the tool to the body.
   - Wear sufficient clothing, including gloves, to keep warm.
   - Take breaks. (Take a 10-minute break for every hour spent working with a vibrating tool.)
   - Rest the tool on the work piece, whenever practical.
   - Alternate work with vibrating and nonvibrating tools.
   - Maintain tools properly. Tools that are worn, blunt or misaligned vibrate more.
   - Consult a doctor at the first sign of vibration disease and ask about the possibility of changing to a job with less exposure.

2. **Education**

Training programs are effective to make workers more aware of the hazards of vibration in the workplace. Training should include proper use and maintenance of vibrating tools to avoid unnecessary exposure to vibration. Vibrating machines and equipment often produce loud noise as well. Therefore, training and education in controlling vibration should also address noise control.

Protective Equipment

Conventional protective gloves (e.g., cotton, leather) do not protect the hands from vibration. Gloves are available with vibration-damping material built into the palms and fingers but they have not been proven effective. However, gloves do provide protection from other industrial hazards, such as cuts and abrasions, as well as from cold temperatures that, in turn, may reduce the initial sensation of white finger attacks.

How Can Whole Body Vibration Exposure Be Controlled?

The following precautions help to reduce whole body vibration exposure:

- Limit the time spent working on a vibrating surface.
- Mechanically isolate the vibrating source or surface to reduce exposure.
- Ensure that equipment is well maintained to avoid excessive vibration.
- Install vibration damping seats.

Many Canadian jurisdictions do not have regulations for vibration exposure. However, the level of exposure should be reduced as much as practical since vibration causes adverse health effects. It is possible to do this through engineering controls, the use of protective equipment and safe work practices. The design of vibration-damped equipment and engine mountings are the most effective methods to control vibration exposure.

Canadian agencies often use the Threshold Limit Values (TLVs) and guidelines recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). These TLVs are based on the recommendations of the International Organization for Standardization (ISO).

For whole body vibration, the standards and guidelines are designed to reduce vibration to a level where most workers can perform job tasks without discomfort. The most widely used document on this topic is the Guide for the Evaluation of Human Exposure to Whole Body Vibration (ISO 2631). These exposure guidelines have been adopted as ACGIH TLVs. The ISO standard gives three different types of exposure limits:

- a reduced-comfort boundary
- the fatigue-decreased proficiency boundary
- an exposure limit

The reduced-comfort boundary is for the comfort of people travelling in airplanes, boats and trains. Exceeding these exposure limits makes it difficult for passengers to eat, read or write when travelling.

The fatigue-decreased proficiency boundary is a limit for time dependent effects that impair performance. For example, fatigue impairs performance in flying, driving and operating heavy vehicles.

The exposure limit is used to assess the maximum possible exposure allowed for whole body vibration.

A separate set of severe discomfort boundaries is given for eight-hour, two-hour and 30-minute exposures to whole body vibration in the 0.1 Hz to 0.63 Hz range. As with all standards, it is important to read and understand all the information before applying it in the workplace.

It is important to remember that people vary in their susceptibility to the effects of vibration exposure so the exposure limits should be considered as guides in controlling exposure. They should not be considered as an upper safe limit of exposure or a boundary between safe and harmful levels.

SE-Radiation.ppt
Slides 1–3

E. Radiation

The term radiation includes many different types of electromagnetic radiation, both ionizing and non-ionizing. It can range from extremely high frequency/short wavelength radiation, such as cosmic rays, through the visible light spectrum and on to extremely low frequency/long wavelength radiation, such as electrical power. The electromagnetic spectrum is the range of all possible electromagnetic radiation.

Ionizing Radiation

Ionizing radiation is radiation that has enough energy to remove electrons from atoms or molecules (i.e., groups of atoms) when it passes through or collides with some material. The loss of an electron, with its negative charge, causes the atom (or molecule) to become positively charged. The loss or gain of an electron is called ionization and a charged atom or ion is called an ion.

Forms of ionizing radiation include:

- gamma rays
- X-rays
- alpha particles
- beta particles
- neutrons

When ionizing radiation interacts with the human body, it gives its energy to the body tissues. The amount of energy absorbed per unit weight of the organ or tissue is called absorbed dose and is expressed in units of gray (Gy). One gray dose is equivalent to one joule radiation energy absorbed per kilogram of organ or tissue weight. Rad is the old and still used unit of absorbed dose.

1 Gy = 100 rads

Equal doses of all types of ionizing radiation are not equally harmful. Alpha particles produce greater harm than do beta particles, gamma rays and X-rays for a given absorbed dose. To account for this difference, radiation dose is expressed as equivalent dose in units of sievert (Sv). The dose, in Sv, is equal to absorbed dose multiplied by a radiation weighting factor depending on the type of ionizing radiation. Prior to 1990, this weighting factor was referred to as quality factor (QF). For gamma rays, X-rays and beta particles, the sievert is numerically equal to the gray.

NORM

In addition to radioactive sources and X-ray equipment, another source of ionizing radiation is naturally occurring radioactive materials (NORM). These are radioactive materials that have always been present in various concentrations in the environment and in the tissues of every living animal, including people.

SE-Radiation.ppt
Slide 4

Although the concentration of NORM in most natural substances is so low that risk is very small, higher concentrations may arise as the result of industrial operations, such as:

- *Mineral Extraction and Processing* – NORM may be released or concentrated in a process stream when ore is processed, such as in the phosphate fertilizer industry and the abrasives and refractory industries.
- *Oil and Gas Production* – NORM may be found in the fluids and gases from hydrocarbon-bearing geological formations.
- *Metal Recycling* – NORM-contaminated materials are redistributed to other industries, resulting in the formation of new NORM contaminated products.
- *Forest Products and Thermal-electric Production* – mineral ashes left from combustion may concentrate small amounts of NORM naturally present in plant material and coal.
- *Water Treatment Facilities* – fresh or waste water is treated through filters or ion- exchange resins to remove minerals and other impurities from the water being treated and may release radon (e.g., geothermal sources, fish hatcheries).
- *Tunnelling and Underground Working* – NORM may be found in areas where small amounts of naturally present radioactive minerals or gases may be present, such as underground caverns, electrical vaults, tunnels or sewer systems.

The concentration of radioactive substances in these materials may increase to levels at which special precautions are needed for handling, storing, transporting and disposing of material, by-products, end-products or process equipment.

Exposure Limits for Ionizing Radiation

One of the guiding principles of radiation protection is the ALARA principle. According to this principle, exposure of radiation workers and other persons to ionizing radiation is kept "as low as reasonably achievable – economic and social factors being taken into consideration." The Alberta Radiation Protection Regulation specifies maximum exposure limits for ionizing radiation. The exposure limits represent international consensus on radiation protection standards. The maximum exposure limits include exposure from all sources of ionizing radiation, except medical or dental radiation when the person is a patient, or natural background radiation. Radiation workers who use or are exposed to the operation of certain types of ionizing radiation equipment require personal exposure monitoring. Also, specific maximum exposure limits are applicable to pregnant radiation workers.

SE-Radiation.ppt
Slides 5–7

Non-ionizing Radiation

Non-ionizing radiation does not disrupt electrons but it can cause heating/burning of tissues, skin and eye damage, as in the case of UV-skin cancer.

Ultraviolet Radiation

On the electromagnetic spectrum, UV radiation comes between visible light and X-rays. Its wavelengths are shorter than the wavelengths of light and longer than those of X-rays. It is divided according to its effects on living tissue into three wavelength bands: UV-A, UV-B and UV-C. Common sources of UV light in the workplace include the sun, electric welding arcs, UV curing lamps, black lights, germicidal lamps, lasers, lighting and tanning lamps.

SE-Radiation.ppt
Slide 8

Health effects from UV radiation include the following:

Sunburn (Erythema)
This is a reddening of the skin, with blistering and peeling in severe cases. Of the three UV bands, UV-B is most effective in causing sunburn. To protect itself against UV radiation, the skin tans; i.e., the pigment that gives the skin its colour becomes darker and more of it is produced. Long-term exposure to UV radiation causes a thickening of the skin's outer layer. Since people with lighter skin, hair and eyes have less pigment, they are more sensitive to UV exposure. Damage to the skin accumulates over the day and the injury does not become obvious until a few hours later. Given time, sunburned skin repairs itself.

Welders' Flash (also known as arc-eye and snow-blindness [photokeratoconjunctivitis])
This is a painful irritation of the cornea and the conjunctiva; i.e., the membrane connecting the eyeball with the inner eyelid. There is a feeling of sand in the eye and sensitivity to light. UV-B is most effective in causing this sunburn of the eye. The eye is more sensitive than the skin to UV radiation because it lacks the skin's horny outer layer and protective pigment. Symptoms appear from six to 24 hours after exposure and usually disappear within 48 hours. No permanent damage to the eye results unless a severe exposure has occurred.

Photoaging
This is the premature aging of the skin, caused by chronic exposure to UV radiation. The resulting changes in the skin include excessive wrinkling, dark spots, loss of elasticity and a leathery appearance.

Skin Cancer
Long-term exposure to UV radiation, over many years, has been shown to increase a person's risk of developing skin cancer. The most common types of skin cancer, basal cell carcinoma and squamous cell carcinoma, are not usually life-threatening if treated early. Malignant melanoma is a rarer but much more dangerous form of skin cancer.

A person's chance of getting skin cancer increases with the total UV radiation he or she has received in his or her lifetime. The risk of getting malignant melanoma also increases with the number of blistering sunburns experienced during childhood. Lighter-complexioned people are more likely to develop UV-related skin cancers than darker-complexioned people, so they should be particularly careful to minimize their UV exposure.

Alberta does not have exposure limits for ultraviolet radiation, but threshold limit values (TLVs) recommended by the American Conference of Government Industrial Hygienists (ACGIH) for occupational exposure to UV radiation have been developed. These limits are based on UV doses that normally do not produce sunburn or welder's flash. They take into account the varying biological effects of different wavelengths of UV radiation. The guidelines limit the effective UV radiant exposure to three millijoules per square centimetre, accumulated over an eight-hour period.

SE-Radiation.ppt
Slide 9

How Is Exposure to UV Radiation Controlled?

Engineering Controls

- UV radiation should be contained or confined to a restricted area when practicable. UV radiation can be easily contained with opaque materials, such as cardboard or wood. Transparent materials, such as glass, polyvinylchloride, plexiglass and perspex, block UV radiation in varying degrees. Generally, carbonated plastics provide adequate UV protection. Some kinds of clear glass, including some kinds of window glass and optical glass, transmit significant amounts of UV-A radiation.
- A high-power UV source should have interlocked access, so that it is shut off when the protective enclosure is open.

Administrative Controls

- Whenever UV radiation cannot be contained or confined, worker exposure should be minimized by limiting exposure times and increasing the distance between workers and the sources. Measurements are required to determine safe working distances and exposure times.
- Areas where exposure to UV radiation is possible should have appropriate warning signs.

Personal Protection

- Wear UV-blocking safety eyewear (i.e., goggles, spectacles, face shields, welding shields), with side-shields, where applicable.
- Long-sleeved, closely-woven clothing that covers as much of the body as practicable should be used.
- Put sunscreen, with a sun-protection factor (SPF) of 15 or higher and effective against UV-A and UV-B, on all exposed skin.

Preventing Overexposure to UV Radiation from the Sun

- Make use of natural or artificial shade.
- Schedule alternative tasks when the sun is most intense.
- Wear a wide-brimmed hat.
- Use closely-woven clothing, that covers as much of the body as is practicable.
- Use sunscreen, with an SPF (sun-protection factor) of 15 or higher and effective in filtering both UV-A and UV-B, on all exposed skin.
- Protect lips with sunscreen or lipstick with an SPF of 15 or higher.
- Use UV-blocking sunglasses or safety glasses that meet the special purpose requirements of the Canadian Standard for nonprescription sunglasses (Z94.5-95).

Infrared (IR) Radiation

Infrared (or heat) radiation has a wavelength between 780 nm and 1 mm. It is felt by us as heat and is given off by very hot objects. Sources of IR radiation include furnaces, heat lamps and lasers.

Specific biological effectiveness bands have been defined by the CIE (Commission International de l'Eclairage or International Commission on Illumination) as follows:

- IR-A (near IR) (780 nm to 1400 nm)
- IR-B (mid IR) (1400 nm to 3000 nm)
- IR-C (far IR) (3000 nm to 1 mm)

IR radiation in the IR-A range that enters the human eye will reach and can be focused on the cells of the retina. For high irradiance sources in the IR-A, the retina is the part of the eye that is at risk. For sources in the IR-B and IR-C, both the skin and the cornea may be at risk from flash burns. In addition, the heat deposited in the cornea may be conducted to the lens of the eye. This heating of the lens is believed to be the cause of so called glass blower's cataracts because the heat transfer may cause clouding of the lens.

The potential hazard is a function of:

- exposure time; i.e., chronic or acute
- irradiance value; i.e., a function of both the image size and the source power
- environment; i.e., conditions of exposure

Evaluation of IR radiation hazards can be difficult but reduction of eye exposure is relatively easy by using appropriate eye protection. As with visible light sources, the viewing of high irradiance IR sources, such as plasma arcs or flash lamps, should be limited by using appropriate filters. Traditionally, welding goggles or shields of the appropriate shade number provide enough protection for limited viewing of such sources. Specialized glassblowers' goggles may be needed to protect against chronic exposures.

Radiofrequency (RF) and Microwave (MW) Radiation

Radiofrequency and microwave radiation span the frequency range from 3 kHz to 300 GHz, which includes wireless telecommunications devices, such as cellular telephones. Since they have similar characteristics, RF and MW radiation are usually treated together.

The main health effect of exposure to RF/MW fields is heating of body tissues as energy from the fields is absorbed by the body. Prolonged exposure to strong RF/MW fields may increase the body temperature, producing symptoms similar to those of physical activity. In extreme cases or when exposed to other sources of heat at the same time, the body's cooling system may be unable to cope with the heat load, leading to heat exhaustion and heat stroke.

Localized heating or hot spots may lead to heat damage and burns to internal tissues. Hot spots can be caused by nonuniform fields, by reflection and refraction of RF/MW fields inside the body or by the interaction of the fields with metallic implants; e.g., cardiac pacemakers, aneurism clips. There is a higher risk of heat damage with organs that have poor temperature control, such as the lens of the eye and the testes.

Other hazards include contact shocks and RF burns. These can result from the electric currents that flow between a conducting object and a person who comes into contact with it while they are exposed to RF fields.

Some laboratory studies have reported biological effects from RF/MW radiation at field levels too low to cause tissue heating. To date, these nonthermal effects are not known to result in health hazards. Although we are constantly exposed to weak RF fields from radio and television broadcasting, no health risks have been identified from this low-level exposure. Recent reports suggesting a relationship between either cellular telephone or traffic radar use and cancer have not been substantiated.

In Canada, Health Canada publishes Safety Code 6, Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz, which specifies the maximum exposure limits for both RF workers and members of the general public to prevent thermal effects or contact shocks. Industry Canada requires all operators of radio and television broadcast stations, cellular, land, mobile, amateur radio and other radiofrequency emitters to adhere to Safety Code 6. Operators must ensure that the radiofrequency fields produced by their installations do not exceed the maximum levels listed in the Safety Code. Industry Canada licenses this radiocommunication equipment, approves where cellular telephone base stations are located and conducts compliance assessments of both cellular telephones and base stations.

Engineering Controls

- Sources of RF/MW radiation should be properly shielded to minimize stray radiation.
- Devices that can produce acute thermal injuries, such as industrial MW ovens, should have interlocked doors.
- Devices that produce high levels of stray RF radiation, such as induction heaters and dielectric heaters, should be operated remotely, whenever possible.

Administrative Controls

- Exposure of workers to RF/MW radiation should not exceed the recommended exposure limits.
- Areas where worker exposure to RF/MW radiation is suspected to exceed the recommended limits should be surveyed to determine the exposure levels.
- Exposure to RF/MW fields should be avoided, when possible.
- Exposure times should be kept as short as reasonably possible.
- Potentially hazardous RF/MW devices should be appropriately labelled and areas of excessive exposure around them clearly demarcated. Notices with warnings and the necessary precautions should be posted.
- Electrically-activated explosive devices should not be placed near sources of RF/MW radiation.
- RF/MW devices should not be used in flammable or explosive atmospheres.
- Equipment sensitive to RF/MW radiation, such as telephone switchboards or control panels, should not be installed near sources of RF/MW radiation.

Personal Protection

- Protective suits, including head and eye protection, can be used. Suits should be tested to ensure they reduce worker exposure to levels below the occupational exposure limits and that they do not pose any safety hazards, such as overheating, shocks or fire.

Controlling RF Shocks and Burns

- Metallic structures that produce contact shocks should be electrically grounded and/or insulated.
- Insulating platforms or shoes; e.g., rubber-soled shoes, can be used to reduce energy absorption and currents to ground.
- When the above measures are ineffective or not reasonably possible, workers should wear insulating gloves.

What Are the Hazards from Cell Phones?

Cell phones are portable radio devices that transmit and receive signals from a network of fixed, low-power base stations. The transmitting power of a cell phone varies, depending on the type of network and distance from the base station. The power generally increases as you move farther away from the nearest base station.

The RF electromagnetic energy generated by cell phones can penetrate your body. The depth of penetration and the amount of energy you absorb depends on many factors, such as how close you hold the cell phone to your body and how strong the signal is. The important indication of RF exposure is the rate of energy absorbed in your body.

There is currently no convincing evidence from animal or human studies that the energy from cell phones is enough to cause serious health effects, such as cancer, epileptic seizures or sleep disorders. Some scientists have reported that cell phone use may cause changes in brain activity, reaction times or the time it takes to fall asleep. These findings have not yet been confirmed.

Cell phone use is, however, not entirely risk-free. Studies have shown that:

- using cell phones while driving increases the risk of collisions
- cell phones interfere with medical devices, such as pacemakers, defibrillators and hearing aids
- cell phones also interfere with aircraft electronics and navigation systems

Lasers

SE-Radiation.ppt
Slide 10

The term laser stands for Light Amplification by Stimulated Emission of Radiation. Laser light is a type of non-ionizing radiation that can be generated in different parts of the spectrum, including ultraviolet (UV), visible light and infrared (IR). Laser equipment produces and amplifies light that has unique properties that cannot be produced any other way.

Laser light has several unique characteristics. It is monochromatic, meaning that it is light with a single or selected wavelength. It is coherent, meaning that all the individual waves of light are in phase, moving together through time and space. It is also directional, meaning that the laser beam is very focused (collimated) and does not fan out like the light beam of a flashlight. Since the light beam can be contained in a very narrow beam, it has a high radiant power per unit area. These properties enable laser devices to produce powerful laser beams that can even cut metal. Lasers are also used in medicine for cutting, sealing and surgical procedures. The hazards from lasers include:

- eye injury, such as burns to the retina or cornea
- burns to the skin from exposure to high power, i.e., greater than 1 Watt in power, laser beams
- electrical hazards from high voltage equipment needed to generate the laser
- fire; a high power laser beam deflected onto flammable materials can cause them to ignite

For protection:

- Ensure that the equipment is properly used and maintained.
- Use eye protection, as appropriate. Never shine a laser in the eye.
- Follow proper fire safety procedures.
- Follow proper electrical safety procedures.

SF-FireHazards.ppt
Slide 1

F. Fire Hazards

Common Terms

Autoignition Temperature: the lowest temperature at which a flammable material will ignite on its own and burn without the introduction of a flame or spark.

Explosion: the very rapid buildup and release of pressure from the ignition of flammable gases or flammable liquid vapours in an enclosed container or space.

Flammable Range: the minimum and maximum concentration rate of a flammable vapour in air that can ignite on contact with an ignition source. The minimum concentration is called the lower explosive limit (or lower flammable limit) and the maximum concentration is called the upper explosive limit (or upper flammable limit).

Flashpoint: flammable and combustible liquids do not burn. The vapours given off by the liquid forms an ignitable mixture with air. The flashpoint is the lowest temperature at which a flammable or combustible liquid gives off enough vapour to form an ignitable mixture with air. The lower the flashpoint, the more easily the material will burn.

Static Electricity

Static electricity is an electric charge that cannot move. It is created when two objects or materials that are in contact with each other are separated. While the objects are in contact, the surface electricity charges try to balance each other. When the objects are separated, they are left with either an excess or shortage of electrons, causing them both to become electrically charged. If these charges do not have a path to the ground, they are unable to move and become static. If static electricity is not quickly removed, the charge builds up. Eventually, it will develop enough energy to jump, as a spark, to some nearby, less highly charged object. In an explosive or flammable atmosphere, the spark can set off an explosion or fire. The danger is greatest when flammable liquids are being poured or transferred.

Static electricity can be produced by:

- liquid flowing through a pipe or hose
- spraying
- blending or mixing
- filling containers or tanks
- movement and friction between materials
- movement of dry powdered material through chutes or conveyors
- movement of nonconductive conveyor belts or drive belts
- appliances that are plugged into electrical outlets
- flipping a light switch on or off

Static electricity can be controlled by:

- bonding and grounding
- humidification
- static collectors
- additives

Bonding and Grounding

Bonding and grounding are techniques that are used to prevent sparks (i.e., a source of ignition) from being created when liquids are transferred between containers.

Bonding is when there is an electrical connection between two or more conductive containers. Bonding ensures the containers have the same electrical charge. Without a difference in charge or electrical potential, a spark cannot be created that jumps from one container to another. Bonding also includes when parts of equipment and containers that are electrically separated (i.e., by gaskets or caulking compounds) are connected. Bonding does not eliminate the static charge, which is why it is used in combination with grounding.

A container is grounded when there is an electrical connection between it and the earth. Grounding quickly drains the static charge away.

Humidification

Keeping relative humidity between 60 and 70% at 210C may stop paper or layers of cloth and fibres from sticking together. However, high humidity will not prevent the accumulation of static electricity and should not be relied upon solely where there are flammable liquids, gases or dusts present.

Static Collectors

These are devices that are used on moving equipment parts and nonconductive materials, such as plastic film. Some examples include metallic tinsel bars and spring copper brushes. They work by capturing the static discharge. To work properly, these devices must be properly grounded.

Additives

Anti-static additives can be added to some flammable liquids. The additive changes the electrical properties of the liquid.

Electrical Equipment

Electrical equipment is recognized as having three sources of ignition:

- Arcs and sparks created by normal equipment operation – motor starters, contactors and switches can be ignition sources.
- High temperatures – equipment, such as lamps and lighting fixtures, can produce heat. If the heat produced is greater than the ignition temperature of the hazardous material present, a flammable atmosphere can be ignited.
- Electrical equipment failure – the shorting of an electrical terminal or set of contacts can create a spark.

Electrical equipment that is used in flammable environments must be specially designed and constructed. It is usually designed with an enclosure that must be strong enough to contain an explosion within it. This is because it is assumed that, in some environments, the hazardous gases or vapours will eventually seep into the enclosure and be ignited. The equipment must also provide a route or flame path for burning and expanding gases from the equipment if an internal explosion occurs. The gases must only be permitted to escape after they have cooled off and their flames have been quenched. This ensures that the escaping gases will not ignite the surrounding atmosphere. There are also specialized designs for equipment that will be used in dusty environments.

Hot Work

Hot work is work where a flame is used or sparks or other types of ignition sources can be produced, such as:

- cutting, welding, burning, riveting, drilling, grinding and chipping
- using electrical equipment, not specially designed for flammable environments
- using a combustion engine

If hot work is being done in an area where flammable materials are used or stored, work procedures must be in place to ensure that a fire does not occur. In addition, concentrations of flammable gases or vapours and dusts must be measured in the air before the work begins. If the concentration of flammable gases or vapours is greater than 20% of the substance's lower explosive limit or the minimum ignitable concentration for dust, work may not begin.

Health Problems Resulting from Heat Exposure

Problem and Symptoms	Treatment	Prevention
Heat rash (prickly heat) Tingling and burning of the skin, red itchy rash. sweat glands plugged due to prolonged exposure of skin to heat, humidity and sweat	• thorough drying • cool showers • calamine	• keep the skin as dry as possible • rest in a cool place • shower often • change clothes frequently • keep skin clean
Heat cramps Painful spasms of muscles that do the hardest work; i.e., in the arms, legs, abdomen	• massage the muscles(s) • eat salt-containing foods, unless to be avoided for medical reasons	• warm up muscles before heavy work • take rest breaks • eat a normal, healthy diet
Fainting Increased flow of blood to the skin to get rid of heat means less blood to the brain.	• lie down in a cool place • drink cool fluids to lower body temperature • see a doctor if fainting recurs	• drink plenty of fluids at regular intervals • avoid standing still in one position – move around
Heat exhaustion Tired, weak, dizzy, clammy skin, slow weak pulse. Pale or flushed skin colour. Higher than normal heart rate (160 to 180 beats/min).	• lie down with knees raised • drink cool, not cold, fluids • contact a doctor if condition does not improve quickly	• take four to seven days to adjust (acclimatize) to the heat • drink plenty of fluids at regular intervals • take rest breaks in a cool place
Heat stroke Person usually stops sweating, body core temperature is high (40° – 43°C), skin is hot and dry. Person experiences headache, dizziness, confusion, may lose conscioueness or have fits. Fatal if treatment is delayed.	• this is a medical emergency – person must be taken to a hospital as quickly as possible • move worker to a cool or shaded area, remove clothing, wrap in wet sheet, pour on chilled water and fan vigorouly – avoid overcooling • treat for shock once temperature is lowered	• take four to seven days to adjust (acclimatize) to the heat • drink plenty of fluids at regular intervals • take rest breaks in a cool place • wear clothing appropriate for the conditions • follow a work/rest schedule

Summary of Control Measures

Method of Control	Action
Engineering Controls	
Reduce body heat production	Mechanize tasks.
Stop exposure to radiated heat from hot objects	Insulate hot surfaces. Use reflective shields, aprons, remote controls.
Reduce convective heat gain	Lower air temperature. Increase air speed if air temperature below 35°C. Increase ventilation. Provide cool observation booths.
Increase sweat evaporation	Reduce humidity. Use a fan to increase air speed (movement).
Clothing	Wear loose clothing that permits sweat evaporation but stops radiant heat. Use cooled protective clothing for extreme conditions.
Administrative Controls	
Acclimatization	Allow sufficient acclimatization period before full workload.
Duration of work	Shorten exposure time and use frequent rest breaks.
Rest area	Provide cool (air-conditioned) rest areas.
Water	Provide cool drinking water.
Pace of Work	If practical, allow workers to set their own pace of work.
First aid and medical care	Define emergency procedures. Assign one person trained in first aid to each work shift. Train workers in recognition of symptoms of heat exposure.

Screening Criteria for Heat Stress Exposure (WBGT values in °C) for Eight-hour Work Day (five days per week with conventional breaks)

	Acclimatized				Unacclimatized			
Work Demands	Light	Moderate	Heavy	Very heavy	Light	Moderate	Heavy	Very heavy
100% work	29.5	27.5	26.0	–	27.5	25.0	22.5	–
75% work; 25% rest	30.5	28.5	27.5	–	29.0	26.5	24.5	–
50% work; 50% rest	31.5	29.5	28.5	27.5	30.0	28.0	26.5	25
25% work; 75% rest	32.5	31.0	30.0	29.5	31.0	29.0	28.0	26.5

* For unacclimatized workers, the permissible heat exposure TLV should be reduced by 2.5°C.

Examples of work loads:

Light work – sitting or standing to control machines, performing light hand or arm work

Moderate work – walking about, with moderate lifting and pushing

Heavy work – pick and shovel work, digging.

Adopted from *2001 TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices*. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 2001. p. 171-172.

The ACGIH exposure limits are intended to protect most workers from heat-related illnesses. The limits are higher than they would have been if they had been developed to prevent discomfort. If you are wearing heavier clothing, the exposure limit should be lowered. ACGIH recommendations for such situations are suggested in Table 2.

Correction of TLV for Clothing

Clothing type	WBGT correction (°C)
Summer work uniform	0
Cloth (woven material) overalls	–3.5
Double-cloth overalls	–5

Adopted from *2001 TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices*. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 2001. p. 169.

Examples of Vibration Exposure

Industry	Type of Vibration	Source
Agriculture	whole body	tractors
Boiler making	hand-arm	pneumatic tools
Construction	whole body hand-arm	heavy equipment, vehicles pneumatic tools, jackhammers
Forestry	whole body hand-arm	tractors chain saws
Iron and steel	hand-arm	vibrating hand tools
Mining	whole body hand-arm	vehicles rock drills
Sheet metal	hand-arm	stamping equipment
Shipyards	hand-arm	pneumatic hand tools
Shoe making	hand-arm	pounding machine
Stone dressing	hand-arm	pneumatic hand tools
Textile	hand-arm	sewing machine, looms
Transportation	whole body	vehicles

PHYSICAL HAZARDS

Preventing Heat Stress

- Engineering Controls
  - Automate/reduce physical effort required in hot environment.
  - Reduce radiant heat; e.g., shield hot surfaces, provide shade, move equipment that gives off heat away from work area.
  - Provide ventilation/air conditioning to work area.
  - Dehumidify air if work process involves water/steam.

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SA-HeatStress.ppt Slide 1

PHYSICAL HAZARDS

Preventing Heat Stress

- Administrative Controls
  - Rotate workers out of hot areas. e.g., job share.
  - Provide rest breaks in shady cool areas.
  - Have physically demanding work done during cooler parts of the day.
  - Provide fluids, such as water and electrolyte drinks, and encourage workers to drink regularly.

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SA-HeatStress.ppt Slide 2

PHYSICAL HAZARDS

Preventing Heat Stress

- Personal Protective Clothing
  - Wear loose fitting, light coloured, lightweight fabrics.
    - Choose materials that wick sweat away and allow I to evaporate.
  - Use aluminized reflective clothing near radiant sources of heat; e.g., furnaces.
  - Use cooling vests.

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SA-HeatStress.ppt Slide 3

PHYSICAL HAZARDS

Measuring Heat Stress

- heart rate monitoring
- body core temperature
- sweat rate
- wet bulb globe temperature (WBGT)
  - most popular/least invasive
  - considers a combination of air temperature, humidity, radiant heat and air speed

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SA-HeatStress.ppt Slide 4

PHYSICAL HAZARDS

Cold Stress Injuries

- nonfreezing
  - chilblains
  - immersion foot
  - trenchfoot
- freezing
  - frostnip
  - frostbite
- hypothermia

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SB-ColdStress.ppt Slide 1

PHYSICAL HAZARDS

Preventing Cold Stress

- Engineering Controls
  - Provide shields to protect from wind.
  - Ensure hand grips are insulated against the cold.
  - Make sure that controls and handles can be operated with mitts, if mitts must be worn.
  - Automate work so that workers are not required to work in cold environments.

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SB-ColdStress.ppt Slide 2

PHYSICAL HAZARDS

Preventing Cold Stress

- Administrative Controls
  - Provide rest breaks in a warm area.
  - Provide warm fluids; workers may need extra calories (e.g., nuts, grains, dairy) when working in the cold.
  - Manage the work process so that workers are not required to stand or sit still for extended periods.

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SB-ColdStress.ppt Slide 3

PHYSICAL HAZARDS

Preventing Cold Stress

- Personal Protective Equipment
  - Layer clothing; e.g., thermal layer(s), wind protection.
  - Wear mittens; they are more effective than gloves.
  - Cover all exposed skin.
  - Wear fabrics that wick sweat away, if doing any physically demanding work.
  - Exchange damp clothing before becoming chilled.

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SB-ColdStress.ppt Slide 4

PHYSICAL HAZARDS

Exchange Rate

- relationship between noise level and exposure duration
- the 3 dB exchange rate is the most commonly used
- for every 3 dB increase in noise level, the exposure time must be halved

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SC-Noise.ppt Slide 1

PHYSICAL HAZARDS

Noise Management Program

- required if workers are overexposed to noise
- components of a program include
  - education
  - measuring noise levels
  - posting signs
  - controlling noise levels
  - protective equipment
  - audiometric testing
  - evaluation

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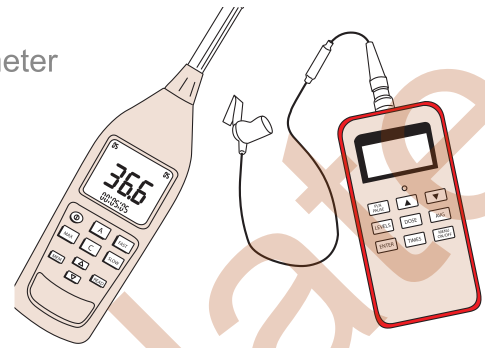
SC-Noise.ppt Slide 2

PHYSICAL HAZARDS

Measuring Noise

- sound level meter
- dosimeter
- integrating sound level meter



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SC-Noise.ppt Slide 3

PHYSICAL HAZARDS

Controlling Noise Exposure

- Engineering Controls
  - Substitute noisy equipment/machinery with quieter makes or models.
  - Install a muffler.
  - Reduce vibration; use dampening materials (e.g., set the equipment on a mat) or brace the equipment.
  - Reduce echo; e.g., place sound absorbing materials on walls, ceiling and floor.
  - Isolate the noisy equipment from workers (or vice versa).
  - Maintain equipment.

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SC-Noise.ppt Slide 4

PHYSICAL HAZARDS

Controlling Noise Exposure

- Administrative Controls
  - reduce total exposure (i.e., dose) by reducing time in noisy environment;
    e.g., job rotation between noisier and quieter areas

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SC-Noise.ppt Slide 5

PHYSICAL HAZARDS

Controlling Noise Exposure

- Personal Protective Equipment
  - earplugs
    - formable foam
    - preformed
    - custom moulded
  - ear muffs
- important considerations when using PPE
  - must offer adequate protection for noise levels
  - only works if used properly
  - adaption period
    - comfort
    - communication

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SC-Noise.ppt Slide 6

PHYSICAL HAZARDS

What is Vibration?

An object vibrating creates a periodic back-and-forth motion. The size and speed of this motion determines its vibrational characteristics. Terms used to describe the movement are:

- frequency
  - number of cycles of movement a vibrating object completes per second
- amplitude
  - size of the movement
  - intensity depends on amplitude
- acceleration
  - how quickly the vibrating object picks up speed as it moves from its neutral to extreme position

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SD-Vibration.ppt Slide 1

PHYSICAL HAZARDS

Controlling Hand-arm Vibration

- Engineering Controls
  - anti-vibration tools
  - vibration dampening grips
  - properly maintained equipment
- Administrative Controls
  - light grip
  - regular breaks
  - tool weight supported
- Personal Protective Equipment
  - nothing proven to work (vibration dampening gloves exist)

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SD-Vibration.ppt Slide 2

PHYSICAL HAZARDS

Controlling Whole Body Vibration

- Engineering Controls
  - isolate the vibrating equipment
  - maintain the equipment
  - install vibration dampening seats
  - use vibration dampening materials; e.g., set equipment on a mat
- Administrative Controls
  - limit time spent on vibrating equipment and around vibrating sources
- Personal Protective Equipment
  - nothing proven

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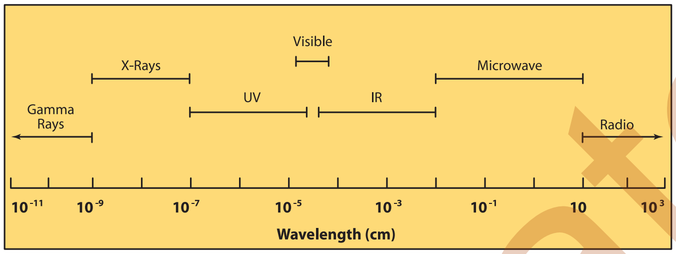
SD-Vibration.ppt Slide 3

PHYSICAL HAZARDS

Electomagnetic Spectrum



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SE-Radiation.ppt Slide 1

PHYSICAL HAZARDS

Ionizing Radiation

- gamma rays, X-rays
  - can travel forever unless they interact with an object
  - X-rays and gamma rays can pass right through you
  - shielded with lead and concrete
- alpha particles
  - travel a few centimetres in air and will not penetrate the skin
  - shielded with paper
  - become a problem if ingested

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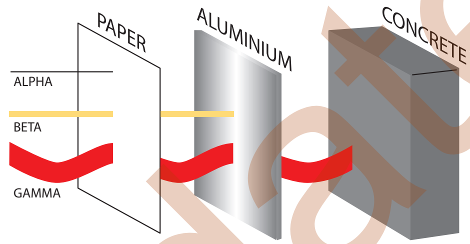
SE-Radiation.ppt Slide 2

Ionizing Radiation

- beta particles
  - can travel over 2 m in air
  - stop inside your skin and do not reach the internal organs
  - shielded with plexiglass and aluminum



SE-Radiation.ppt Slide 3

NORM

Naturally Occurring Radioactive Materials

- have always been present in various concentrations in the environment and in the tissues of every living animal, including people
- some industrial operations increase the concentration of NORM and, therefore, the hazard
- examples
  - mineral extraction and processing
  - oil and gas production
  - tunnel operations

SE-Radiation.ppt Slide 4

PHYSICAL HAZARDS

Health Effects from Ionizing Radiation

- cell damage
- cancer
- hereditary (i.e., genetic) effects
- effects on a developing fetus

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SE-Radiation.ppt Slide 5

PHYSICAL HAZARDS

Non-ionizing Radiation

- ultraviolet radiation
  - wavelengths are shorter than the wavelengths of light and longer than those of X-rays
  - sun is the most common source of UV radiation
- infrared radiation
  - wavelengths are between 780 nm and 1 mm
  - sources of infrared radiation include furnaces, heat lamps and lasers
- infrared radiation absorbed by the eye can damage the retina

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SE-Radiation.ppt Slide 6

PHYSICAL HAZARDS

Non-ionizing Radiation

- radiofrequency and microwave radiation
  - radiofrequency and microwave radiation span the frequency range from 3 kHz to 300 GHz
  - includes wireless telecommunications devices, such as cellular telephones

SE-Radiation.ppt Slide 7

PHYSICAL HAZARDS

Health Effects from Non-ionizing Radiation

- skin damage and cancer from exposure to UV rays from the sun
- burns and tissue heating
- damage to the eyes
- electric shock

SE-Radiation.ppt Slide 8

PHYSICAL HAZARDS

Protect Yourself from Radiation

- time – minimize exposure time
- distance – stay as far away from the source as possible
- shielding – put a barrier between you and the source

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SE-Radiation.ppt Slide 9

PHYSICAL HAZARDS

Lasers

- “Light Amplification by Stimulated Emission of Radiation”
- type of non-ionizing radiation
  - UV, visible, IR
- hazards
  - eye injury, such as burns to the retina or cornea
  - burns to the skin from exposure to high power laser beams
  - electrical hazards
  - fire

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SE-Radiation.ppt Slide 10

PHYSICAL HAZARDS

Hot Work

- any work using or producing a source of ignition
- examples:
  - work processes that use or create heat or sparks, such as cutting, welding, burning, riveting, drilling, grinding and chipping
  - using electrical equipment not specially designed for flammable environments
  - combustion engines
- specialized work procedures and monitoring are needed for hot work if done on/near flammable substances

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SF-FireHazards.ppt Slide 1

What if I want to find out more?

RESOURCES

Heat and Cold Stress

Alberta Occupational Health and Safety
Working Safely in the Heat and Cold
www.humanservices.alberta.ca/GS006

OSHA, "Cold Stress"
www.osha.gov/Publications/osha3156.pdf

Noise

CCOHS, "Noise — Measurement of Workplace Noise"
www.ccohs.ca/oshanswers/phys_agents/noise_measurement.html

NIOSH, "Noise and Hearing Loss Prevention"
www.cdc.gov/niosh/topics/noise/hpcomp.html

Radiation

NASA, "Imagine the Universe, Electromagnetic Spectrum"
www.imagine.gsfc.nasa.gov/docs/science/know_l1/emspectrum.html

Canadian Nuclear Safety Commission
www.nuclearsafety.gc.ca

Nuclear Safety and Control Act (Canada)
www.laws.justice.gc.ca/en/N-28.3/

Alberta Occupational Health and Safety,
"Radiation Health and Safety Resources"
www.humanservices.alberta.ca/SFW/12524.html

Fire Hazards

Municipal Affairs, "Fire Safety Publications"
www.aema.alberta.ca/pa_educational_resources.cfm

Ontario Industrial Accident Prevention Association,
"Guide on Static Electricity"
www.iapa.ca/pdf/2004_feb_Static%20Electricity.pdf