MANN ENGINEERING
ENERGY MANAGEMENT SPECIALISTS

Construction, Health & Safety Manual for Employees and Sub-Contractors

Professional Engineers
Ontario

Authorized by the Association of Professional Engineers of Ontario to offer professional engineering services.

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Responsibilities

1 LEGAL RESPONSIBILITIES

General

The health and safety responsibilities of all parties on a construction project are specified in the current *Occupational Health and Safety Act and Regulations for Construction Projects*.

Responsibilities are prescribed in particular for constructor, employer, supervisor, and worker. Each party has specific responsibilities to fulfill on a construction project.

For more detailed information, consult the current Act and Regulations.

Remember – safety begins with you!

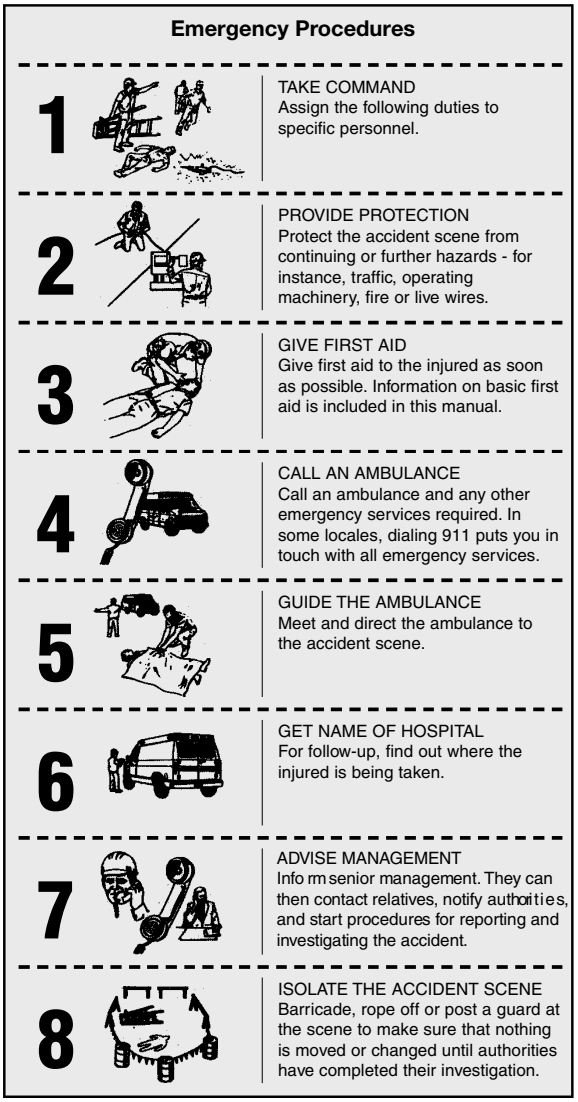


Figure 1

Health and Safety Representative

The health and safety representative must be familiar with

- the current *Occupational Health and Safety Act and Regulations for Construction Projects*
- procedures in the event of an emergency (Figure 1)
- procedures for refusal to work where health and safety are in danger (Figure 2).

Right to Refuse Work where Health or Safety in Danger
***(Occupational Health and Safety Act,* Part V)**

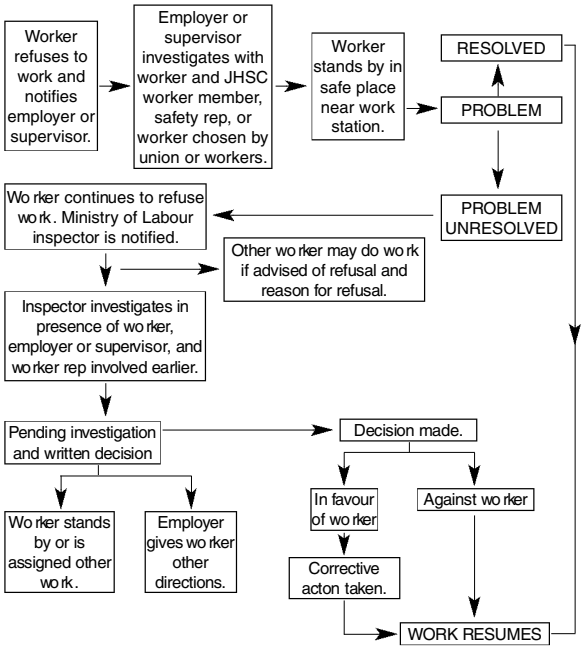


Figure 2

Accidents and Injuries

All accidents and injuries, regardless of severity, must be reported immediately.

Procedures for reporting accidents – and the type of accidents that must be reported – are spelled out in the *Occupational Health and Safety Act and Regulations for Construction Projects*.

Further information is available from the Workplace Safety and Insurance Board and Ministry of Labour.

Certified Committee Members

Where a project regularly employs 50 or more workers, the health and safety committee on the project must have at least one member representing workers and one member representing the constructor who are certified by the Workplace Safety and Insurance Board (Figure 3).

If no members of a health and safety committee are certified, the workers and constructor must each select one member of the committee to become certified.

A certified member who receives a complaint regarding a dangerous circumstance can investigate the complaint under the authority of the *Occupational Health and Safety Act*. The member may also ask a supervisor to investigate a situation where the member "has reason to believe" that a dangerous circumstance may exist.

The supervisor must investigate the situation promptly in the presence of the certified member.

The certified member may also request that another certified member representing the other party at the workplace investigate the situation if the first certified member "has reason to believe" that the dangerous circumstance still exists after the supervisor's investigation and remedial action, if any, has been taken.

The second certified member must promptly investigate the situation in the presence of the first certified member and, if both certified members agree, they may direct the constructor or employer to stop work or stop the use of any part of the workplace, including machines and other equipment. The constructor or employer must immediately comply with the order.

If both certified members do not agree that a dangerous circumstance exists, either may request that a Ministry of Labour inspector investigate the situation. The inspector must investigate and provide both members with a written report.

Ministry of Labour Inspectors

The inspector can visit a site at any time and exercise fairly broad powers to inspect, ask questions, and give orders. If the inspector approaches a worker directly, the worker must answer questions and cooperate. The supervisor must be informed of any orders given or recommendations made.

Health and Safety Representatives and Committee Requirements Under the *Occupational Health and Safety Act*

Size and Duration of Project	Representative or Committee	Who Creates Committee	Number of Members	Membership Requirements	Selection of Members	Powers and Rights
5 Workers or Less						
6-19 workers and more than 3 months **or** **6+ workers and less than 3 months**	One Health and Safety Representative				Representative selected by workers or union(s)	• Obtain information from a constructor or employer regarding the testing of equipment, materials, or chemicals in the workplace. • Inspect the workplace at least once a month, with the full cooperation of constructor, employers, and workers. • Ask for and obtain information regarding existing or potential hazards in the workplace. • Make health and safety recommendations to a constructor or employer, who must respond in writing within 21 days, either giving a timetable for implementation or giving reasons for disagreeing with the recommendations. • Where a person has been killed or critically injured in the workplace, investigate the circumstances of the accident and report findings to a director of the Ministry of Labour. • Exercise all the powers granted to the health and safety representative by virtue of a collective agreement.
20-49 workers and more than 3 months	Joint Health and Safety Committee	Constructor	At least two	At least one non-management worker at the project and one management representative from the project if possible.	Worker representatives selected from the site by workers or trade union(s) represented. Management representatives selected by constructor or employer.	• Identify situations that may be a source of danger or hazard to workers. • Make recommendations regarding health and safety matters. • Recommend the establishment, maintenance, and monitoring of programs. • Obtain information from constructors or employers regarding testing of equipment or environments and be present when testing is initiated.
50+ workers and more than 3 months	Joint Health and Safety Committee	Constructor	At least four	Half non-management workers from the workplace with at least one certified. Half management representatives from the workplace if possible with at least one certified.	Worker representatives selected from the site by workers or trade union(s) represented. Management representatives selected by constructor or employer.	
	Worker Trades Committee	Health and Safety Committee	At least one worker representative from each trade	One worker representative from each trade.	Members to be selected by trade workers or trade union(s) at the site. Members do not have to be workers at the site.	Advise the joint health and safety committee of the health and safety concerns of the workers in the trades at the workplace.

Figure 3

In some cases the health and safety representative, worker member of a health and safety committee, or worker selected by fellow workers or union has a right to take part in accident investigation.

The results of accident investigation and reporting should be made known to all personnel on site. Recommendations should be implemented to prevent the accident from happening again.

In all cases of injury, the **EMPLOYER** must do the following.

1. Make sure that first aid is given immediately, as required by law.
2. Record the first aid treatment or advice given to the worker.
3. Complete and give to the worker a Treatment Memorandum (Form 156) if health care is needed.
4. Provide immediate transportation to a hospital or a physician's office, if necessary.
5. Submit to the Workplace Safety and Insurance Board (WSIB), within three days of learning of an accident, an Employer's Report of an Accident/Injury/Industrial Disease (Form 7) and any other information that may be required.
6. Pay full wages and benefits for the day or shift on which the injury occurred when compensation is payable for loss of earnings.
7. Notify the Ministry of Labour, health and safety representative and/or committee, and union as required by legislation.

The **WORKER** must do the following.

1. Promptly obtain first aid.
2. Notify the employer, foreman, supervisor, and worker safety representative immediately of an injury requiring health care and obtain from the employer a completed Treatment Memorandum (Form 156) to take to the physician or the hospital. Failure to report promptly can affect your benefits and subject your employer to fines.
3. Choose a physician or other qualified practitioner with the understanding that a change of physician cannot be made without permission of the WSIB.
4. Complete and promptly return all report forms received from the WSIB.

2 WHMIS

Frequently construction trades are required to work with new hazardous materials or previously installed hazardous materials requiring repair, maintenance, or removal. Some materials used for many years and thought harmless are now known to be hazardous.

Proper handling requires careful planning, training, and use of personal protective equipment or controls.

Some hazardous materials common in construction are

- compressed gas (acetylene, nitrogen, oxygen)
- flammable and combustible materials (solvents)
- oxidizing materials (epoxy hardeners)
- solvents, coatings, and sealers
- asbestos and silica
- acids and alkalis.

Right to Know

The **Workplace Hazardous Materials Information System (WHMIS)** gives everyone the right to know about the hazards of materials they work with and provides the means to find out that information. It does this through

- labels
- material safety data sheets
- worker training and education.

All employers are required by law to provide WHMIS training for specific controlled products the worker will be working with or near. Training should be provided as new products are introduced – with a general updating on new products at least annually.

Controlled products under WHMIS include six classes, identified by symbols (Figure 6).

The requirements for supplier and workplace labels are shown in Figure 7.

CLASS	SYMBOL	EXAMPLE
Class A: Compressed Gas		oxygen
Class B: Flammable and Combustible Material		acetone
Class C: Oxidizing Material		chromic acid
Class D: Poisonous and Infectious material		
1. Materials causing immediate and serious toxic effects		ammonia
2. Materials causing other toxic effects		asbestos
3. Biohazardous Infectious Material		contaminated blood products
Class E: Corrosive Material		hydrochloric acid sodium hydroxide
Class F: Dangerously Reactive Material		acetylene

Figure 6

Supplier labels are required on controlled products with a volume of more than 100 millilitres and must include

- product identifier
- appropriate hazard symbol(s)
- risk phrases (such as “dangerous if inhaled”)
- precautions (such as “wear rubber gloves”)
- first aid measures
- supplier identifier
- statement that a material safety data sheet (MSDS) is available for the product.

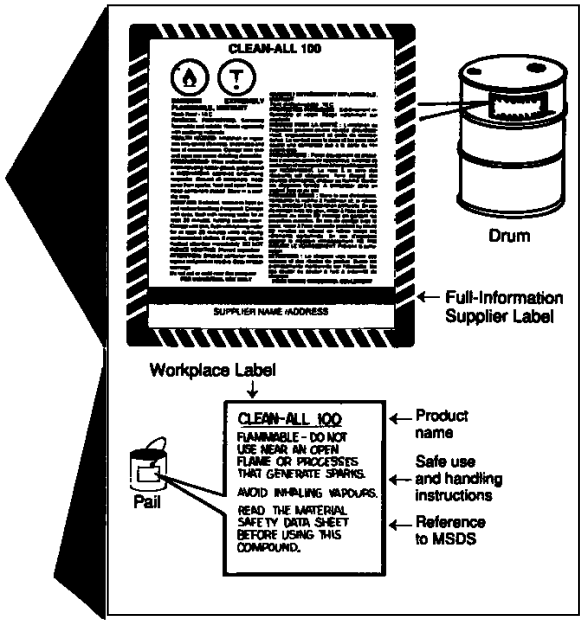


Figure7

Workplace labels are required when controlled products are produced onsite or have been transferred from a supplier-labelled container to a different container. Workplace labels must include

– product identifier
– safe handling instructions
– statement that an MSDS is available for the product.

If details on the ingredients, health effects, handling, and other aspects of a hazardous product are not available from suppliers or employers, call the Construction Safety Association of Ontario at 1-800-781-2726 and provide the following information.

- Product name (for example, Solvex 100)
- Manufacturer's name and place of manufacture (for example, ABC Chemical, Montreal, Quebec)
- What is the product being used for? (for example, to clean parts)
- How is it being used? (for example, sprayed on)
- Is it being mixed with something else?
- Is it being heated?
- In what area is it being used? (for example, outdoors or in a holding tank)
- What does the label say?
- How can information be conveyed to you?

Designated Substances

“Designated substances” are substances that have been targeted for special regulation by the Ministry of Labour. Generally these substances are well-known toxic materials which present serious risk of illness.

Designated substances encountered in construction include asbestos, lead, coal tar products, and silica. If any designated substances are present where construction, maintenance, or renovation is planned, the parties involved must be notified and informed.

The *Occupational Health and Safety Act* requires that owners notify contractors of the presence of any designated substances. Contractors also have a responsibility to advise subcontractors. This notification must take place before binding contracts are arranged.

For more information on designated substances, contact the Ministry of Labour.

Health

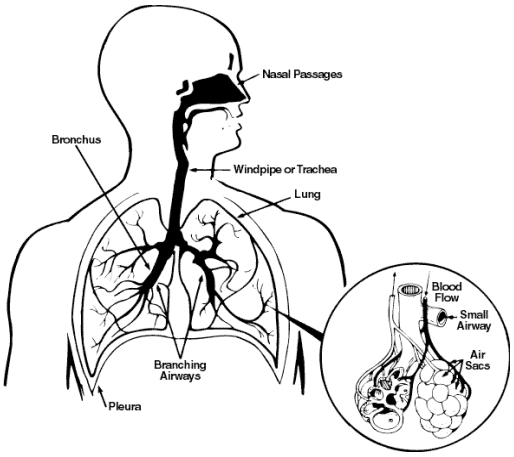
1 BASIC OCCUPATIONAL HEALTH

ROUTES OF ENTRY

Hazardous materials in the workplace may cause disease in the body at four main sites:

- where they enter the body—entry routes such as the lungs, skin, and intestines
- in the blood that carries the hazardous materials throughout the body
- in the central nervous system
- in the organs which have the ability to remove toxic agents from the body:
  i.e., the liver, kidneys, and bladder (exit routes).

This section briefly describes four routes of entry—inhalation, absorption, ingestion, and injection—and some of the workplace hazards and diseases commonly associated with them.



THE RESPIRATORY SYSTEM

INHALATION

The body's respiratory—or breathing—system is one of the most common routes of entry for a toxic substance. The substance may cause damage to the system itself or it can pass through the lungs to other parts of the body.

The main function of the respiratory system is to absorb oxygen from the air and pass it on to the blood. It also removes carbon dioxide—the waste gas produced by the body's processes—from the blood and releases it in exhaled air.

Air reaches the lungs through a branching system of tubes, starting with the trachea, or windpipe, which divides to form two bronchi, one to each lung. Each bronchus, in turn, branches into many smaller divisions, finally ending in a small cluster of tiny air sacs which are known as alveoli. The oxygen and carbon dioxide exchange takes place through a very thin membrane surrounding these air sacs.

The lung is covered by a delicate lining known as the pleura. (Mesothelioma, one of the cancers caused by asbestos, is a cancer of the pleura.)

Cancer

It's not well understood exactly how a chemical produces cancer. Some **carcinogens** (cancer-causing substances) are thought to interact with the genetic material of the cell; others may interact with the immune system; and still others are thought to act with other agents, but not initiate cancer themselves. Whatever the mechanism, the effect is very often delayed, sometimes up to 30 years.

Defining a chemical as carcinogenic usually involves animal studies as a first step. If the substance causes cancer in animals, particularly those that have biological systems similar to humans, it is classed as a suspected carcinogen. Some examples are benzene which causes leukemia, and beryllium and arsenic trioxide which cause lung cancer. Some chemicals have also been shown to be cancer-causing through industrial experience. These include asbestos (cancer of the larynx, lung, and abdomen), vinyl chloride (liver cancer), coal tar pitch (skin cancer), chromium (lung cancer), and benzidine (bladder cancer). All chemicals which have been classified as carcinogens should be handled with extra care.

Asbestos

Inhaling asbestos dust has been shown to cause the following diseases:

- asbestosis
- lung cancer
- mesothelioma (cancer of the lining of the chest and/or abdomen).

Asbestosis is a disease of the lungs caused by scar tissue forming around very small asbestos fibres deposited deep in the lungs. As the amount of scar tissue increases, the ability of the lungs to expand and contract decreases, causing shortness of breath and a heavier workload on the heart. Ultimately, asbestosis can be fatal.

Lung cancer appears quite frequently in people exposed to asbestos dust. While science and medicine have not yet been able to explain precisely why or how asbestos causes lung cancer to develop, it is clear that exposure to asbestos dust can increase the risk of contracting this disease. Studies of asbestos workers have shown that the risk is roughly five times greater than for people who are not exposed to asbestos.

Cigarette smoking, another cause of lung cancer, multiplies this risk. Research has shown that the risk of developing cancer is fifty times higher for asbestos workers who smoke than for workers who neither smoke nor work with asbestos.

Mesothelioma is a relatively rare cancer of the lining of the chest and/or abdomen. While this disease is seldom observed in the general population, it appears frequently in groups exposed to asbestos.

Other illnesses—There is also some evidence of an increased risk of cancer of the stomach, rectum, and larynx. However, the link between asbestos exposure and the development of these illnesses is not as clear as with lung cancer or mesothelioma.

The diseases described above do not respond well to current medical treatment and, as a result, are often fatal.

HOW HAZARDOUS MATERIALS EVADE THE LUNG'S DEFENCES

The airways of the respiratory system have developed an elaborate system of defences which trap all but the smallest dust particles. This system consists of hairs in the nose and mucus in the trachea or bronchi. The mucus is produced continuously by special cells in the walls of the larger airways. It is moved upward and to the back of the throat by the whipping action of cilia—tiny, hair-like projections on the cells of the trachea and bronchi.

Large dust particles are trapped in the mucus and are either swallowed or spit out. Particles smaller than 0.5 microns (1 inch has 25,400 microns) may remain airborne and are exhaled. The most dangerous size of dust particles is 0.5-7.0 microns. Much too small to be seen with the naked eye, they can evade the defence system and reach the lungs. Once in the lungs, these tiny particles of dust may cause extensive scarring of the delicate air sacs. This scarring starts the disease process which produces severe shortness of breath.

Most dust particles are too large to pass through the walls of the alveoli, but gases, vapours, mists, and fumes can all enter the bloodstream through the lungs. In addition, welding fumes or truck exhausts can stimulate the lung's defences to produce large amounts of phlegm, causing the condition known as chronic bronchitis. These same substances can destroy the delicate air sacs of the lungs, causing emphysema.

Because the lungs are in such intimate contact with so many pollutants in workplace air, they are the prime target for occupational carcinogens.

ASPHYXIANTS

Chemicals that interfere with the transfer of oxygen to the tissues are called asphyxiants. The exposed individual literally suffocates because the bloodstream cannot supply enough oxygen for life.

There are two main classes of asphyxiants—simple and chemical. **Simple asphyxiants** displace oxygen in the air, thereby leaving less or none for breathing. **Chemical asphyxiants** cause the same effect by interfering with the body's ability to take up, transport, or use oxygen.

Simple asphyxiants are a major hazard in confined spaces, where breathable air can be displaced by gas from sewage, for instance.

When the normal oxygen level of 21% drops to 16%, breathing and other problems begin, such as lightheadedness, buzzing in the ears, and rapid heartbeat. Simple asphyxiants in construction include argon, propane, and methane. These chemicals usually have no other toxic properties.

Carbon monoxide is one example of a chemical asphyxiant. It combines with the oxygen-carrying compound in the blood and reduces its ability to pick up "new" oxygen. Hydrogen sulphide, on the other hand, interferes with the chemical pathways which transfer the oxygen, while hydrogen cyanide paralyzes the respiratory centre of the brain.

ABSORPTION

Absorption through the skin is another common form of entry for toxic substances (e.g., organic solvents). The skin is the largest organ of the body and has the largest surface area that can come into contact with harmful substances. Some chemicals can penetrate through the skin, reach the bloodstream, and get to other parts of the body where they can cause harm. Toluene and Cellosolve are examples of chemicals which are absorbed through the skin. Mineral spirits and other solvents used in the manufacturing of paint can easily penetrate the skin.

THE SKIN

The skin protects the internal organs of the body from the outside environment. Its outer layer is composed of hardened, dead cells which make the skin resistant to daily wear and tear. Sweat glands cool the body when the environment is hot. Sebaceous glands produce oils which repel water. A network of small blood vessels, or capillaries, plays a key role in controlling body temperature. These capillaries open when it is hot, radiating heat outward into the air, and constrict when it is cold, conserving heat in the body. The skin also has a protective layer of oils and proteins which helps to prevent injury or penetration by harmful substances.

A substance may be absorbed and travel to another part of the body, or it may cause damage at the point of entry (the skin), and start the disease process. Such substances are usually identified in an MSDS with a notation "skin" along with their exposure limits, indicating that the exposure can occur through the skin, mucous membranes, or eyes, or may damage the skin itself.

THE SKIN

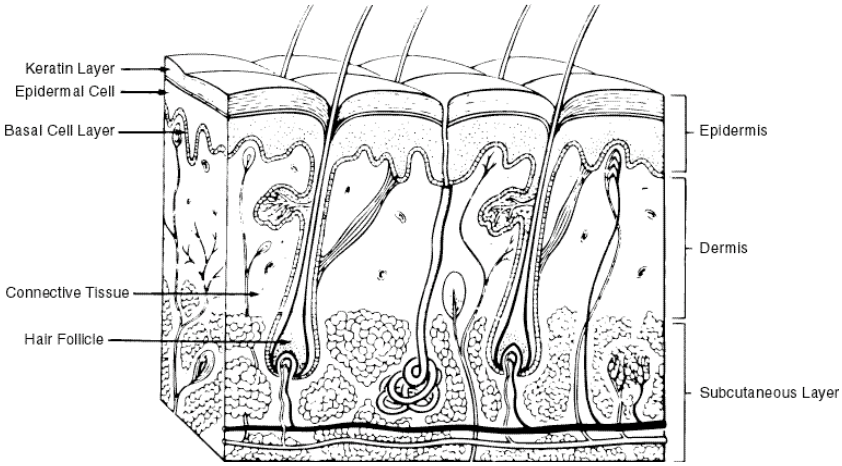


TABLE 1
MAJOR DERMATITIS HAZARDS IN CONSTRUCTION

MATERIAL	TYPE	OCCUPATION/ACTIVITY	CONTROLS
Wet Concrete	Allergic/Corrosive	- Concrete Workers	- Rubber boots, rain pants, rubber gloves if necessary.
Epoxy Materials	Allergic/Defatting (solvents may aggravate allergy)	- Cement Finishers - Seamless Floor Installers - Painters - Tile/Terrazzo Installers	- Barrier creams - Gloves resistant to specific solvents (see Glove Selection Chart, page 68) - Good personal hygiene
Coal Tar	Allergic	- Roofers - Waterproofers	- Change work clothing daily if doing dusty work - Barrier creams usually work well - Good personal hygiene
Solvents/Degreasers	Defatting	- Mechanics - Painters - Service Trades - Millwrights	- Appropriate gloves (see Glove Selection Chart, page 68) - Minimize skin contact - Good personal hygiene
Cleaners	Corrosive/Defatting	- Labourers - Service Trades	- Usually rubber gloves, boots and maybe rain pants - Good personal hygiene

SKIN IRRITATION

DERMATITIS is an inflammation of the skin which can be caused by hundreds of workplaces substances like solvents (paints), epoxy resins, acids, caustic substances, and metals. Dermatitis appears as redness, itchiness, or scaling of the skin. There are two types of dermatitis:

- primary irritation dermatitis (contact dermatitis), and
- sensitization dermatitis (allergic dermatitis).

Major dermatitis hazards in construction are listed in Table 1.

CONTACT DERMATITIS is caused by friction, heat or cold, acids, alkalis, irritant gases, and vapours. Skin in contact with the chemical turns red, becomes itchy, and may develop eczema (collection of fluid droplets under the skin's surface). Typical hazards in construction include caustics, acids, many chlorinated solvents, wet concrete, chromic acid, and calcium hydroxide.

ALLERGIC CONTACT DERMATITIS, on the other hand, is the result of an allergic reaction to a given substance. Sensitization may be the result of prolonged or repeated contact and becomes established usually within 10 to 30 days.

Once sensitized, even a minute exposure can produce a severe reaction. Substances like organic solvents (paints), chromic acid, and epoxy resins can produce both primary and contact dermatitis. Sensitizers include epoxy materials (especially the hardener), nickel, and chromium.

Certain agents such as coal tar and creosote can have a strong sensitizing effect when combined with exposure to sunlight—they are known as photosensitizers.

SOLVENTS

Keratin Solvents: These injure or dissolve the outer layer of the skin producing dry, cracked skin. All the alkalis such as ammonium hydroxide, sodium hydroxide, and calcium chloride are keratin solvents.

Fat and Oil Solvents: These remove the surface oils of the skin so that it can no longer hold water efficiently. Dry, cracked skin results. Organic solvents such as toluene and xylene will cause this condition.

Keratin Stimulants: On contact these primary irritants cause a change in the skin so that unusual growth appears, as with exposure to coal tar pitch and arsenic.

Some hazardous materials used in the workplace have been linked with skin cancer. A number of them are listed in Table 2.

TABLE 2

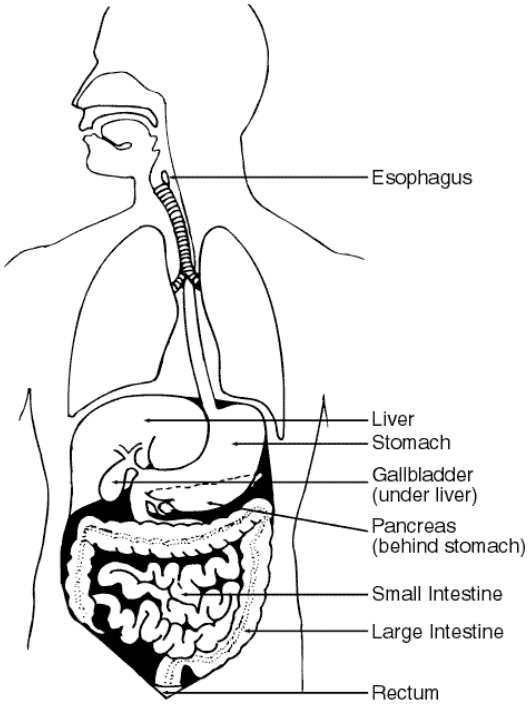
Some Suspected Workplace Causes of Skin Cancer

Pitch	Arsenic	Ultraviolet Light
Asphalt	Tar	X-Rays
Benzo(a)pyrene	Creosote	Anthracene
Shale Oil	Cutting Oils	Soot

INGESTION

A third major route of entry for toxic substances is through the mouth and digestive tract. Toxic materials may reach the stomach when food or drink is consumed, when cigarettes are smoked in a dusty work area, when clean lunchrooms are not provided, when workers fail to wash their hands before eating or smoking, or when food is left unwrapped in a dusty place. Lead dust, for example, is easily ingested in this way and can have serious health effects. Once swallowed, the substances enter the digestive tract and may enter the bloodstream.

The digestive tract is a continuous tube that extends from the mouth to the rectum. The organs of the digestive system provide the means of ingestion, digestion, and absorption of food. Almost all digestion and absorption of food and water take place in the small intestine. The large intestine generally absorbs vitamins and salts.



THE DIGESTIVE SYSTEM

Once swallowed, the toxic substances enter the digestive tract, where they may enter the bloodstream and move on to the liver. The liver and kidneys try to remove the poisons and make the substances less harmful to the body, but they are not always successful.

INJECTION

In rare cases the chemical may enter the body by injection. Skin can be punctured by paint from a high-pressure spray gun or oil from a high-pressure hydraulic hose. This is very serious and requires prompt medical attention. Chemicals in the paint or oil can damage the immediate area and be transported by the blood to a target organ. Chemicals can also be injected into the body by means of puncture wounds from nails or staples, for example.

HAZARDOUS SUBSTANCES IN THE BODY

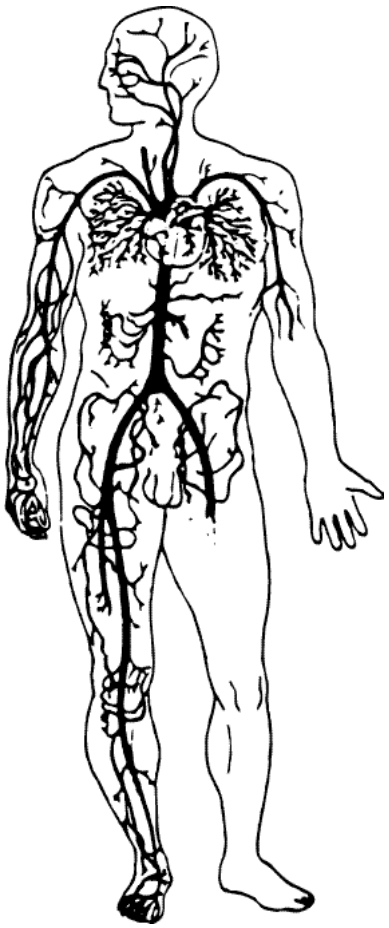
THE CIRCULATORY SYSTEM

The circulatory system is not usually in direct contact with hazardous materials. Once in the bloodstream, however, harmful substances can be transported to any part of the body.

The centre of the circulatory system is the heart. It pumps blood outward through a vast network of blood vessels which branch like a tree, becoming smaller and smaller as they go. The vessels branch so extensively that no cell is more than a few millimeters from a blood vessel or capillary.

Table 3

Some Substances Which May Cause Anemia	
Arsine Gas	Cadmium
Selenium	Copper
Lead	Gallium
Stibine	Mercury Compounds
Beryllium	Benzene
	Toluene



Hazards to the Circulatory System

Food and oxygen reach every cell in the body through capillaries, but so do toxic substances from the workplace. Oxygen is carried by a protein called hemoglobin, which is contained in the red blood cells. Oxygen binds strongly to hemoglobin, but unfortunately, so does carbon monoxide, a common workplace hazard produced by combustion engines in trucks, machinery, etc. In fact, carbon monoxide binds or attaches to hemoglobin about 200-300 times more readily than oxygen.

In high concentration, carbon monoxide can kill because it overloads the hemoglobin in the red cells and replaces the oxygen which the body needs to survive. But even low levels of repeated carbon monoxide exposure may have

serious effects on the heart and the central nervous system.

Many toxic substances attack the blood cells directly. The body forms blood cells continually in the marrow cavity inside the bones. Hazardous materials like benzene can interfere with this formative process and cause anemia, a shortage of red blood cells. Table 3 lists some of the materials which may cause anemia.

THE LIVER

The liver is the chemical factory of the body. The cells which make up the liver contain enzymes which can convert certain toxic substances into forms that are more easily handled by the body. But the liver itself may be damaged if it is overwhelmed by toxic substances.

The liver may become inflamed, producing the condition known as **hepatitis**. This disease may be caused by a virus or by chemicals like alcohol, carbon tetrachloride, and other chlorinated hydrocarbons. Repeated bouts of hepatitis may lead to liver scarring and a disease called **cirrhosis** of the liver. Generally speaking, it means that there are not enough normal liver cells remaining to detoxify body chemicals.

Overexposure to chemicals like acrylonitrile, benzene, carbon tetrachloride, DDT, chloroform, phenol, styrene, tetrachloroethane, and tetrachloroethylene may also cause liver damage. Vinyl chloride, a substance used in the production of plastics, has been linked to a rare and deadly form of liver cancer called angiosarcoma.

Table 4

Some Substances Suspected of Causing Liver Damage		
Antimony	Acrylonitrile	Ethylidene Dichloride
Arsine	Benzene	Hydrazine
Beryllium	Carbon Tetrabromide	Methyl Alcohol
Bismuth	Carbon Tetrachloride	Methyl Chloride
Cadmium	Chlorinated Benzenes	Methylene Dianiline
Copper	Chloroform	Naphthalene
Indium	Cresol	Phenol
Manganese	DDT	Pyridine
Nickel	Dimethyl Sulfate	Styrene
Phosphorus	Dioxane	Terachloroethylene
Selenium	Epichlorohydrin	Toluene
	Ethyl Alcohol	Trichloroethane
	Ethylene Chlorohydrin	Trichloroethylene

THE KIDNEYS AND BLADDER

The kidneys act as a filter for substances in the blood. Each kidney contains over a million small filters. These filters clean the blood, removing a number of impurities which they deposit in the urine. The urine then passes to little tubes which monitor the levels of acid and the amount of water in the body, and keep them balanced. From these tubes, the urine moves to the bladder, which stores it until it is released from the body.

Since the kidneys act as filters, they can be seriously injured by toxic substances passing through the body. Kidney disorders may result in high or low blood pressure, which in turn may cause heart strain or heart failure. Kidney malfunction may also upset the body's delicate chemical balance, resulting in further harm to the body.

Just as the lungs are vulnerable to hazardous materials because they are a major route of entry, the kidneys and bladder are vulnerable because they are a major route of exit.

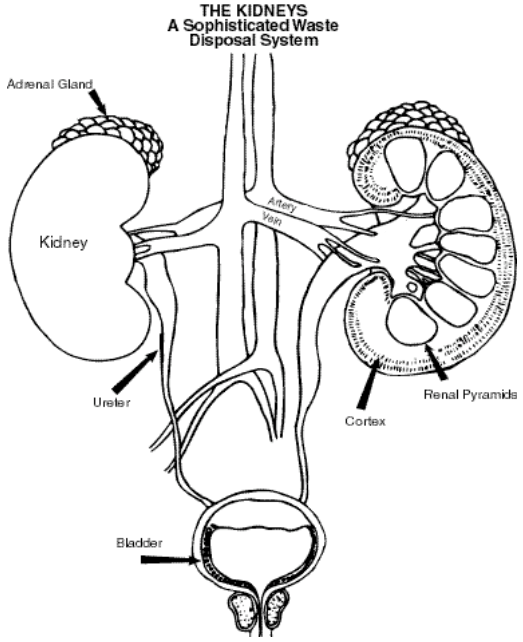


Table 5 shows some of the suspected causes of kidney damage.

Table 5

Suspected of Causing Kidney Damage	
Lead	Naphthalene
Mercury	Carbon Tetrachloride
Cadmium	Tetrachloroethane
Chromates	Carbon Monoxide
Copper	Gasoline Vapours
Uranium	Turpentine
Beryllium	Bismuth
Arsenic	Oxalic Acid
Arsine	Intense Heat
Sodium Fluoride	Vibration
Iodine	High Voltage Shocks
Carbon Disulfide	Blood Loss

THE NERVOUS SYSTEM

To stay alive, we must breathe continuously, our heart must pump constantly, and all the other organs must function. We also think and respond to emotions and sensations. All these functions performed by the mind and body are controlled by the nervous system.

Table 6

Some Chemicals That May Affect the Nervous System			
Depression of Central Nervous System	**Brain Poisoning**	**Brain Damage by Oxygen Deprivation**	**Nerve Function Disorders**
Acetates Alcohols Brominated chemicals Chlorinated chemicals Ethers Ketones	Carbon disulfide Hydrogen cyanide Hydrogen sulfide Stibine Arsine	Asphyxiating gases Carbon monoxide	Organo-phosphate pesticides Organo-phosphate plasticizers Heavy Metals Mercury Lead Manganese Arsenic

The central nervous system is the control centre. The spinal cord connects the brain to the nervous system. Part of the nervous system reaches the outer areas and is called the peripheral nervous system.

Most injuries of the central nervous system are permanent, although damage to the peripheral nervous system can sometimes be reversed. Exposure to metals like lead and mercury may interfere with nerve impulses and result in tremors and loss of reflexes or feeling.

Central Nervous System Depression covers effects such as headache, lightheadedness, drowsiness, and unconsciousness. The organ affected is the brain and the result is depressed performance. Many solvents such as toluene, xylene, ether, and acetone produce this effect if the vapour concentration is high enough. Workers exposed to these chemicals in cleaning solvents, paints, thinners, and degreasers may have experienced these effects.

The brain needs a constant supply of oxygen. Some toxic chemicals interfere with the functioning of the central nervous system and disrupt the oxygen supply. The first warning signs are dizziness and drowsiness. Warning signs should be heeded immediately and appropriate action taken. For example, you should immediately leave the area and seek medical assistance.

The operations of the nervous system are very complicated. It is a delicately balanced system and several chemicals can damage it, such as those shown in Table 6.

THE REPRODUCTIVE SYSTEM

Workplace hazards affect the worker, but the problem reaches into the worker's home as well.

The reproductive organs—the testes in men and the ovaries in women—produce the cells that allow us to reproduce. Any damage to these cells can have disastrous consequences. Deformities in children may result or the developing embryo may be so severely damaged that it is unable to survive and is miscarried.

Some chemicals cause miscarriages or birth defects by attacking the genetic material of cells or the systems which control its functions. Similar damage may also be involved in cancer—cancer-causing substances are often the cause of birth defects and miscarriages.

Factors	Reduced fertility	Miscarriages	Chromosomal damage	Malformations	Sperm damage
Anaesthetic gases	♂	♂♀		♀	
Benzene	♂		♂♀		
Mercury		♀		♀	
Epichlorohydrin			♂♀		
Ethylene dibromide	♂				
Ethylene oxide		♀	♂♀		
Glutaraldehyde		♀			
Ionizing radiation	♀	♀	♂♀	♀	
Chloroprene	♂	♂			♂
Lead	♂♀	♀			♂
Organic solvents	♂	♀	♀	♀	
Carbon disulphide	♂	♀			
Vinyl chloride		♂	♂		

Legend:

♂ = Male exposure

♀ = Female exposure

Source: Finland's Institute for Occupational Health, Helsinki.

EFFECTS OF HAZARDOUS SUBSTANCES

The effects of exposure to workplace safety hazards are sometimes immediate, painful, and obviously damaging, but it is not always easy to observe when and how the body's cells are attacked by hazardous materials in the workplace. Many of the most serious diseases do not occur until 10 to 30 years after exposure.

LATENCY OF WORKPLACE DISEASE

Latency refers to the time lag between exposure to a hazardous material and the eventual development of a disease. The latency period does not refer to the total duration of exposure to a substance, but to the time that has elapsed since the first exposure. For many occupational hazards, the latency period is from ten to twenty years. It may even be as long as thirty or forty years.

Latency has a number of important implications for the worker. An individual exposed to a highly dangerous substance may feel no ill effects at the time of exposure. The effects may only show up many years later. For instance, exposure to ionizing radiation or asbestos causes very little in the way of symptoms at the time of actual exposure, but the long-term effects can be deadly.

Past scientific studies have often failed to address the problem of latency in evaluating the incidence of disease (such as asbestosis). In order to develop a clear picture of diseases which appear many years after exposure, researchers must study not only the current workforce (including many workers who have worked in a particular environment for less than twenty years), but also those workers who had exposure in the past.

Finally, a workplace free of disease is not necessarily a workplace free of hazards. The diseases of today generally reflect the working conditions of several decades ago. Similarly, the workplace hazards of today may produce the health problems of the future.

ACUTE AND CHRONIC EFFECTS OF WORKPLACE HAZARDS

Workplace hazards may have both immediate and long-term effects on the body. These are termed acute and chronic effects. The sudden collapse of a worker who has been exposed to massive doses of carbon monoxide, or the headaches of a backhoe operator working in a poorly ventilated cab, are examples of acute effects.

The acute effects of toxic substances occur immediately or very soon after the worker's exposure, and are generally caused by high levels of exposure. They may cause death, but are often treatable if caught quickly. Sudden and dramatic, they result from the direct action of the hazardous material on the cells of the body.

Often more serious, however, are the chronic effects of toxic substances. Chronic effects become apparent only after many years. By and large, they are not treatable. They often result from the body's attempts to repair itself or to compensate for the acute effects of a substance. For example, cancer is a chronic effect, as is the lung scarring caused by silica dust or the hearing damage caused by excessive noise. Chronic disease becomes evident only after severe damage has occurred.

The acute effects of hazardous material are usually very different from the chronic effects. Table 7 illustrates the difference between the acute and chronic effects of some of the hazards discussed earlier.

Table 7

Acute and Chronic Effects of Some Common Workplace Hazards

	Acute	Chronic
Acid Mists	Irritation of the eyes and throat, watering of the eyes, cough, sore throat, chest pain	Chronic bronchitis and emphysema
Asbestos	Mild respiratory irritation, cough, sneezing	Asbestosis; cancer of the lung, pleura, larynx, stomach, and intestines
Carbon Monoxide	Drowsiness, headache, confusion; in very high amounts, unconsciousness and death	May contribute to heart attacks and strokes
Trichloroethylene	Lightheadedness, euphoria, "drunken" feeling, numbness	Liver and kidney damage; possibly liver cancer
Vibration	Tingling and stiffness in the joints	Arthritis, tendonitis

Exposure limits have been developed for various hazardous materials to protect workers, but they should not be treated as a fine line between safe and unsafe workplaces. Not all individuals react in the same manner to the same amount of a harmful material. The levels of workers' exposures should be reduced to the lowest practical level achievable. Efforts to reduce workers' exposures should start at half the exposure limit. This is known as the "action level."

FACTORS INFLUENCING TOXIC EFFECT

Factors Related to the Substance

a) Chemical Composition

Different chemicals produce different effects, but changes in composition may influence the toxic effect. For example, pressure-treated wood presents very little problem when dry. However, when the wood is burned the preservative decomposes, producing more toxic chemicals.

In some instances exposure to more than one chemical may change the toxic effect. For example, a person who works with solvents and then has a drink after work will get drunk faster and may have an increased risk of liver damage than from either factor alone.

b) Physical Properties

With respiratory hazards, the two main concerns are particle size and vapour pressure.

Particles greater than 10 micrometers in diameter are

removed from inhaled air in the nose and upper respiratory system. As particle size decreases, the system's ability to remove particles also decreases until it is unable to filter out the substance.

Vapour pressure measures the potential of a liquid to vaporize. The higher the vapour pressure, the greater the hazard. If, for example, two solvents of equal toxicity are available for use, the one with the lower vapour pressure will present less of a vapour hazard and will therefore be the safer choice.

c) Solubility in Body Fluids

Certain chemicals are more soluble in body fluids than others. Chemicals termed lipid soluble are soluble in cell membranes. They can very easily penetrate the body and are more mobile once inside. By being lipid soluble they may also remain longer in the body before being excreted. Organic solvents such as toluene, xylene, acetone, and methanol are considered lipid soluble.

Factors Related to Exposure Situation

a) Dose

With most chemicals, the frequency and severity of toxic effect is directly related to **how much** of the hazard the individual is exposed to and for **how long**. This is commonly referred to as the dose/effect or dose/response relationship. With ethyl alcohol, for example, there is no adverse effect if the dose is within the body's ability to control it. However, if the dose exceeds that capacity, the effect increases with the amount consumed.

By examining the past use of toxic materials in the workplace, by conducting animal studies, and by comparison with other substances, it is possible to assign "safe working levels" of exposure for many materials. The "threshold" is the level up to which no significant adverse effect is likely to occur in most people.

With some substances, mainly carcinogens, the safe working levels are difficult to define or may not exist. For this reason, exposures to known or suspected cancer-causing substances must be very closely controlled.

b) Co-Factors

Most of the standards that are set for "safe working levels" are based upon exposure to one chemical at a time. In many cases this does not occur. For example, exposure to asbestos increases the risk of lung cancer five times, while smoking increases the risk 10 times. A smoker exposed to asbestos, however, is 50 times more likely to develop lung cancer than a person who does not smoke and is not exposed to asbestos. The concept of multiple exposures has not been extensively studied. As a result, exposures to complex mixtures should be kept as low as possible.

Factors Related to the Individual

Certain individuals are more susceptible to chemical exposure than others. These are some factors which may influence toxic effect.

a) Genetic Status

Individual susceptibility may be explained by genetic make-up. It is suspected that the sites where toxic agents react is determined by genes that differ from person to person. This theory may help to explain why only some people exposed to a particular substance develop an illness while others do not.

b) Allergic Status

In people allergic to certain substances, antibodies cause the body to overproduce its own chemical defences, leading to symptoms such as asthma and dermatitis.

For example, when a person is first exposed to epoxies or isocyanates a number of antibodies are produced. On subsequent exposure, the reaction is much more severe because of this store of antibodies. With repeated exposure, the allergic reaction can be triggered by smaller and smaller doses. This process is called "sensitization."

c) Presence of Predisposing Disease

Disease may make a person more susceptible to certain toxic agents as the body is already in a weakened condition.

For example, a person with a heart ailment such as angina may have a heart attack if exposed to levels of carbon monoxide which would have little effect on normal healthy people. Similarly, people who suffer from a lung ailment such as emphysema will have a much more severe reaction to lung irritants than a healthy person.

d) Age

Be aware that chemicals may have a greater effect on both older and younger workers.

2 FIRST AID

Regulation 1101 under the *Workplace Safety and Insurance Act* details the obligations of employers regarding first aid equipment, facilities, and trained personnel in all workplaces. Section 91/4 of the Act authorizes the WSIB to penalize employers who do not comply with these requirements.

Basic first aid concentrates on **breathing**, **bleeding**, and **burns**.

Breathing

If the casualty is unconscious, check for breathing. Listen at the mouth and nose. Watch and feel for chest movement.

If the casualty is not breathing, start artificial respiration immediately. The most efficient method is mouth-to-mouth (Figure 1).

First Aid – Breathing

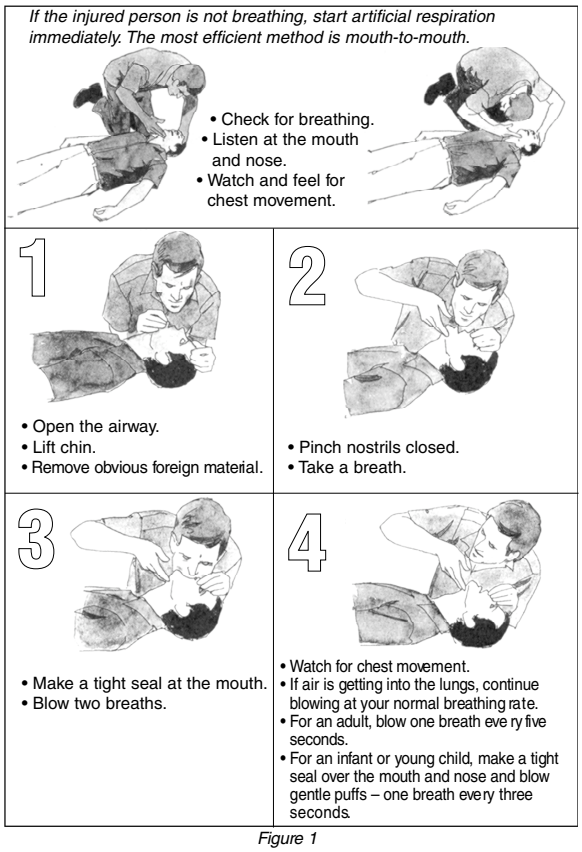


Figure 1

Bleeding

Control external bleeding immediately.

- Apply direct pressure to stop blood flow.
- Place casualty in comfortable position and elevate affected part.
- Get the casualty to rest to slow circulation.
- Apply direct pressure with hand over dressing.
- Do not remove blood-soaked dressing. Add another dressing and continue pressing.
- When bleeding is controlled, secure bandage and maintain elevation.

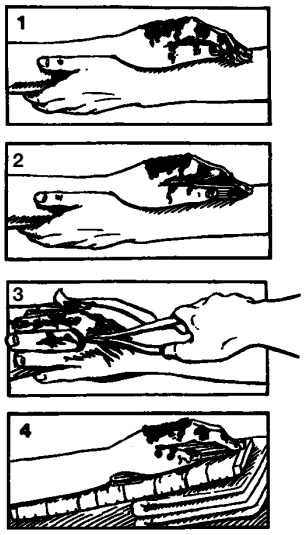
The simple formula for the control of bleeding is Rest, Elevate, Direct Pressure – R.E.D.

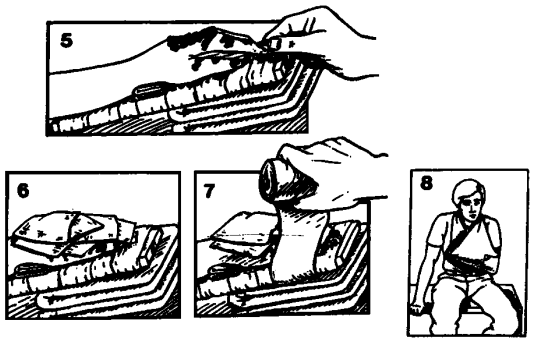
A deep wound in the palm of the hand usually results in severe bleeding. You should control bleeding from a wound across the palm of the hand with **direct pressure, elevation**, and **rest.**

- Make a fist and apply pressure to the wound; at the same time, elevate the hand.
- Seat the casualty.
- Place a wad of gauze dressings over the wound and close the fingers around the wad to maintain pressure.
- Elevate the hand again to a higher position.

For a crushed hand, the treatment is different.

1. Steady and support the injured hand.
2. Place a pad of dressings in the palm of the hand to keep it in the position of function.
3. Remove any jewellery before swelling occurs.
4. Transfer the hand to a padded splint extending from mid-forearm to fingertips and elevate slightly.
5. Place non-stick dressings between the fingers and between the index finger and thumb.
6. Cover the injured hand with sterile dressings or a clean cloth.
7. Starting at the fingertips, apply a roller bandage to secure the hand to the splint.
8. Apply an arm sling. Transport the casualty to medical aid.





Courtesy St. John Ambulance

Burns

Immediately immerse the burned part in ice water or immediately apply ice or clean cloths soaked in cold water.

Cold will
- reduce the temperature of the burned area and prevent further damage
- reduce swelling and blistering
- relieve pain.

Medical Alert

Valuable information about the history of a casualty can often be found on a **Medical Alert** device – a bracelet, necklace, or pocket card. This warning alerts first aiders and medical personnel to the fact that the casualty

- has a medical condition requiring special treatment, or
- is allergic to certain substances.

Severed Tissue

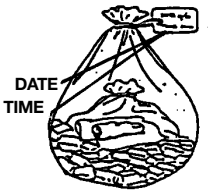
Completely or partially severed parts must be preserved, regardless of their condition, and taken to the medical facility with the casualty.

A partially severed part should be

- kept as near as possible to its normal position
- covered with sterile gauze dressing, bandaged, and supported
- kept cool with an ice bag or cold compress outside the bandage.

A completely severed part should be

- wrapped in sterile gauze moistened with clean water, placed in a clean watertight plastic bag and sealed, and a record made of the time this was done
- placed in another plastic bag or container partially filled with crushed ice
- transported with the casualty to a medical facility.



Bagging of completely severed part

Do not attempt to clean severed parts and do not use antiseptic solutions.

If possible, notify medical facility that casualty is being transported with partially or completely severed parts.

Heat and Cold Exposures

Workers required to work in high temperatures or cold environments must take precautions against exposure.

A healthy worker acclimatizes to this exposure and can maintain a normal temperature by conserving heat in the cold and by dissipating heat when it is hot.

When a body sweats excessively to dissipate heat, the resulting loss of body salts and fluids causes a muscular reaction called heat cramps. Prolonged exposure to a hot environment causes heat exhaustion. When the temperature control mechanisms of the body fail, heat stroke results and the person may die.

Heat Exhaustion

Symptoms
- Pulse weak and rapid
- Breathing rapid and shallow
- Vision blurred
- Skin cold and clammy
- Nausea and vomiting.

Treatment
- Move out of the heat.
- Place at rest.
- Loosen tight clothing.
- Keep head low, raise legs and feet slightly.
- For cramps, give a glass of slightly salted water (add 1/4 teaspoon salt). Give as much as the casualty will take.
- Watch breathing; get medical help.

Heat Stroke

Symptoms
- Temperature of 42°C to 44°C
- Pulse rapid and progressively weaker
- Breathing noisy
- Often no perspiration in cases of non-exhaustion heat stroke
- Nausea and vomiting.

Treatment
- Sponge with cold water.
- Cover with wet sheets.
- Direct current of air around casualty by hand or electric fan.
- Obtain prompt medical aid.

See the chapter on heat stress, page 18.

Cold Exposure

Exposure to cold can injure the surface of the body causing local tissue damage (frostbite). It can also cause general body cooling that can be fatal (hypothermia). Contributing factors include

- temperature
- wind velocity
- worker's age and physical condition
- degree of protection given by outer clothing or covering
- exposure to cold or icy water.

Stay Warm
- Wear clothing that will maintain body heat without sweating. Several layers of light, loose-fitting clothing trap air and have greater protective value than one layer of heavy clothing.
- Cover your head. A warm hat liner is ideal for keeping your head and ears warm.
- Avoid tight-fitting boots. When practical, change boots regularly to allow each pair to dry completely. This will keep your feet a lot drier and warmer.
- Wear mittens instead of gloves when practical. This will keep your hands a lot warmer.

Stay Dry

Avoid wetness due to sweating, rain, or snow. Wetness contributes to heat loss.

Stay Safe

- Limit the length of time you spend in extreme cold conditions.
- Have someone check you for signs of frostbite.

Avoid Fatigue

Rest periodically in a sheltered location.

Avoid Tobacco

Nicotine decreases blood flow and increases the possibility of cold injury.

Avoid Alcohol

Because it dilates the blood vessels, alcohol causes additional heat loss.

Frostbite – Skin looks white, waxy, and feels numb. Freezing causes hardening.

- Warm frostbitten area gradually with body heat. Do not rub.
- Do not thaw hands or feet unless medical aid is far away and there is no chance of refreezing. Parts are better thawed in a hospital.
- If there are blisters, apply sterile dressings and bandage lightly to prevent breaking. Get medical attention.

Hypothermia

Caused when body temperature falls below normal during prolonged exposure to cold, it can develop quickly and be fatal.

Danger signs are shivering, slurred speech, stumbling, and drowsiness.

Condition is severe when shivering stops. Unconsciousness and stopped breathing may follow.

First aid for hypothermia must

– stop further cooling of the body
– provide heat to begin rewarming.

Treatment

- Remove casualty carefully to shelter. Movement or rough handling can upset heart rhythm.
- Keep the casualty awake.
- Remove wet clothing and wrap casualty in warm covers.
- Rewarm neck, chest, abdomen, and groin – but not extremities.
- Apply direct body heat or safe heating devices.
- Give warm, sweet drinks if casualty is conscious.
- Monitor breathing, give artificial respiration if needed.
- Call for medical aid or transport carefully to nearest facility.

Immersion Foot – Caused by wet cooling of the feet, over an extended period, at temperatures above freezing. It is most prevalent in persons who spend long periods with their feet in cold water or mud.

Immersion foot can be prevented by keeping the feet dry. Carry spare socks in a warm place, such as inside the jacket, and change them often to help prevent this condition.

Initially the feet are cold, swollen, and waxy, and may be numb. After warming, they may become red, swollen, and hot, and blisters may occur.

In advanced stages of immersion foot, gangrene may develop.

- Remove wet footwear and warm cold areas.
- Get medical aid.

Embedded Object

Do not attempt to pull out objects embedded in a wound. Pulling nails, splinters, or pieces of glass from wounds will cause more damage and will increase bleeding.

- Cover lightly with dressing without pressure on the object.
- Apply pressure around the wound and away from the embedded object.
- Get medical help as soon as possible.

Eye Injuries

Do not attempt to remove particles on the pupil or stuck to the eyeball.

- Remove loose particles with care using the moistened corner of a tissue.
- If that fails, cover the eye lightly with a dressing to prevent movement and transport casualty to a medical facility.
- Avoid rubbing the injured eye and causing further injury.

Unconsciousness

Loss of consciousness may threaten life if the casualty is face-up and the tongue has dropped to the back of the throat, blocking the airway.

- Make certain that the person is breathing before looking for the cause of unconsciousness.
- If injuries permit, place the casualty in the recovery position (Figure 2) with the neck extended.
- Never give anything by mouth to an unconscious casualty.

Fractures

A fracture is a break or a crack in a bone.

- Steady and support the injury. **Do not move the victim.**
- Dress the wound and control any bleeding.
- If casualty must be moved for safety, secure the limb with padded splints.
- Check for pulse. If none, get medical aid immediately.
- Reassure and keep casualty warm to prevent shock until help arrives.

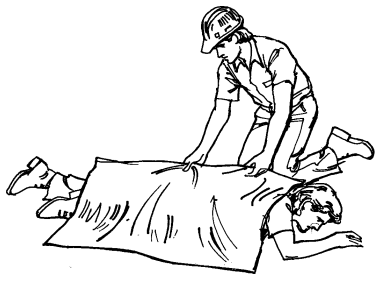


Figure 2

3 HEAT STRESS

The Construction Safety Association of Ontario thanks the following for their help in developing this chapter:

- American Conference of Governmental Industrial Hygienists (ACGIH)
- Sarnia Regional Labour-Management Health and Safety Committee.

WHERE DOES HEAT STRESS OCCUR IN CONSTRUCTION?

Construction operations involving heavy physical work in hot, humid environments can put considerable heat stress on workers. Hot and humid conditions can occur either indoors or outdoors.

Indoors

- steel mills and foundries
- boiler rooms
- pulp and paper mills
- electrical utilities
- petrochemical plants
- smelters
- furnace operations
- oil and chemical refineries
- electrical vaults
- interior construction and renovation.

Outdoors

- roadbuilding
- homebuilding
- work on bridges
- trenching
- pouring and spreading tar or asphalt
- working on flat or shingle roofs
- excavation and grading.

Asbestos removal, work with hazardous wastes, and other operations that require workers to wear semi-permeable or impermeable protective clothing can contribute significantly to heat stress. Heat stress causes the body's core temperature to rise.

WHAT HAPPENS WHEN THE BODY'S CORE TEMPERATURE RISES?

The human body functions best within a narrow range of internal temperature. This "core" temperature varies from 36°C to 38°C. A construction worker performing heavy work in a hot environment builds up body heat. To get rid of excess heat and keep internal temperature below 38°C, the body uses two cooling mechanisms:

1) The heart rate increases to move blood—and heat—from heart, lungs, and other vital organs to the skin.
2) Sweating increases to help cool blood and body. Evaporation of sweat is the most important way the body gets rid of excess heat.

When the body's cooling mechanisms work well, core temperature drops or stabilizes at a safe level (around 37°C). But when too much sweat is lost through heavy labour or working under hot, humid conditions, the body doesn't have enough water left to cool itself. The result is dehydration. Core temperature rises above 38°C. A series of heat-related illnesses, or heat stress disorders, can then develop.

HOW CAN WE RECOGNIZE HEAT STRESS DISORDERS?

Heat stress disorders range from minor discomforts to life-threatening conditions:

- heat rash
- heat cramps
- heat exhaustion
- heat stroke.

Heat rash

Heat rash—also known as prickly heat—is the most common problem in hot work environments. Symptoms include

- red blotches and extreme itchiness in areas persistently damp with sweat
- prickling sensation on the skin where sweating occurs.

Treatment—cool environment, cool shower, thorough drying. In most cases, heat rashes disappear a few days after heat exposure ceases. If the skin is not cleaned frequently enough the rash may become infected.

Heat cramps

Under extreme conditions, such as removing asbestos from hot water pipes for several hours in heavy protective gear, the body may lose salt through excessive sweating. Heat cramps can result. These are spasms in larger muscles—usually back, leg, and arm. Cramping creates hard painful lumps within the muscles.

Treatment—stretch and massage muscles; replace salt by drinking commercially available carbohydrate/electrolyte replacement fluids.

Heat exhaustion

Heat exhaustion occurs when the body can no longer keep blood flowing to supply vital organs and send blood to the skin to reduce body temperature at the same time. Signs and symptoms of heat exhaustion include

- weakness
- difficulty continuing work
- headache
- breathlessness
- nausea or vomiting
- feeling faint or actually fainting.

Workers fainting from heat exhaustion while operating machinery, vehicles, or equipment can injure themselves and others. Here's one example from an injury description filed with the Workplace Safety and Insurance Board:

High temperature and humidity in the building contributed to employee collapsing. When he fell, his head struck the concrete floor, causing him to receive stitches above the right eye.

Treatment—heat exhaustion casualties respond quickly to prompt first aid. If not treated promptly, however, heat

exhaustion can lead to heat stroke—a medical emergency.

- Call 911.
- Help the casualty to cool off by
  - resting in a cool place
  - drinking cool water
  - removing unnecessary clothing
  - loosening clothing
  - showering or sponging with cool water.

It takes 30 minutes at least to cool the body down once a worker becomes overheated and suffers heat exhaustion.

Heat stroke

Heat stroke occurs when the body can no longer cool itself and body temperature rises to critical levels.

WARNING: **Heat stroke requires immediate medical attention.**

The following case is taken from a coroner's report.

On June 17, 1994, a rodworker was part of a crew installing rebar on a new bridge. During the lunch break, his co-workers observed him in the hot sun on the bulkhead of the bridge; the recorded temperature by Environment Canada for that day was 31ºC with 51% humidity. Shortly thereafter the rodworker was found lying unconscious on the scaffold, apparently overcome by the intense heat. He was taken to a local hospital, then transferred to a Toronto hospital. However, despite aggressive treatment by numerous specialists, he died. Cause of death: heat stroke.

The primary signs and symptoms of heat stroke are

- confusion
- irrational behaviour
- loss of consciousness
- convulsions
- lack of sweating
- hot, dry skin
- abnormally high body temperature—for example, 41°C.

Treatment

For any worker showing signs or symptoms of heat stroke,

- Call 911.
- Provide immediate, aggressive, general cooling.
  - Immerse casualty in tub of cool water or
  - place in cool shower or
  - spray with cool water from a hose.
  - Wrap casualty in cool, wet sheets and fan rapidly.
- Transport casualty to hospital.
- Do not give anything by mouth to an unconscious casualty.

WARNING

- Heat stroke can be fatal even after first aid is administered. Anyone suspected of suffering from heat stroke should not be sent home or left unattended unless that action has been approved by a physician.
- If in doubt as to what type of heat-related disorder the worker is suffering from, call for medical assistance.

WHAT FACTORS ARE USED TO ASSESS HEAT STRESS RISK?

Factors that should be considered in assessing heat stress include

- personal risk factors
- environmental factors
- job factors.

Personal risk factors

It is difficult to predict just who will be affected by heat stress and when, because individual susceptibility varies. There are, however, certain physical conditions that can reduce the body's natural ability to withstand high temperatures:

- **Weight**
  Workers who are overweight are less efficient at losing heat.
- **Poor physical condition**
  Being physically fit aids your ability to cope with the increased demands that heat places on your body.
- **Previous heat illnesses**
  Workers are more sensitive to heat if they have experienced a previous heat-related illness.
- **Age**
  As the body ages, its sweat glands become less efficient. Workers over the age of 40 may therefore have trouble with hot environments. Acclimatization to the heat and physical fitness can offset some age-related problems.
- **Heart disease or high blood pressure**
  In order to pump blood to the skin and cool the body, the heart rate increases. This can cause stress on the heart.
- **Recent illness**
  Workers with recent illnesses involving diarrhea, vomiting, or fever have an increased risk of dehydration and heat stress because their bodies have lost salt and water.
- **Alcohol consumption**
  Alcohol consumption during the previous 24 hours leads to dehydration and increased risk of heat stress.
- **Medication**
  Certain drugs may cause heat intolerance by reducing sweating or increasing urination. People who work in a hot environment should consult their physician or pharmacist before taking medications.
- **Lack of acclimatization**
  When exposed to heat for a few days, the body will adapt and become more efficient in dealing with raised environmental temperatures. This process is called acclimatization. Acclimatization usually takes 6 to 7 days. Benefits include
  - lower pulse rate and more stable blood pressure
  - more efficient sweating (causing better evaporative cooling)
  - improved ability to maintain normal body temperatures.

  Acclimatization may be lost in as little as three days away from work. People returning to work after a holiday or long weekend—and their supervisors—should understand this. Workers should be allowed to gradually re-acclimatize to work conditions.

Environmental factors

Environmental factors such as ambient air temperature, air movement, and relative humidity can all affect an individual's response to heat. The body exchanges heat with its surroundings mainly through radiation and sweat evaporation. The rate of evaporation is influenced by humidity and air movement.

Radiant Heat

Radiation is the transfer of heat from hot objects through air to the body. Working around heat sources such as kilns or furnaces will increase heat stress. Additionally, working in direct sunlight can substantially increase heat stress. A worker is far more comfortable working at 24°C under cloudy skies than working at 24°C under sunny skies.

Humidity

Humidity is the amount of moisture in the air. Heat loss by evaporation is hindered by high humidity but helped by low humidity. As humidity rises, sweat tends to evaporate less. As a result, body cooling decreases and body temperature increases.

Air Movement

Air movement affects the exchange of heat between the body and the environment. As long as the air temperature is less than the worker's skin temperature, increasing air speed can help workers stay cooler by increasing both the rate of evaporation and the heat exchange between the skin surface and the surrounding air.

Job factors

Clothing and Personal Protective Equipment (PPE)

Heat stress can be caused or aggravated by wearing PPE such as fire- or chemical-retardant clothing. Coated and non-woven materials used in protective garments block the evaporation of sweat and can lead to substantial heat stress. The more clothing worn or the heavier the clothing, the longer it takes evaporation to cool the skin. Remember too that darker-coloured clothing absorbs more radiant heat than lighter-coloured clothing.

Workload

The body generates more heat during heavy physical work. For example, construction workers shoveling sand or laying brick in hot weather generate a tremendous amount of heat and are at risk of developing heat stress without proper precautions. Heavy physical work requires careful evaluation even at temperatures as low as 23°C to prevent heat disorders. This is especially true for workers who are not acclimatized to the heat.

ARE THERE MEASURES FOR EVALUATING HEAT STRESS RISK?

To prevent heat stress, scientists from the World Health Organization (WHO) have determined that workers should not be exposed to environments that would cause their internal body temperature to exceed 38°C. The only true way of measuring internal body temperature is rectally (oral or inner ear measurements are not as accurate). As an alternative, the American Conference of Governmental Industrial Hygienists (ACGIH) has developed a method of assessing heat stress risk based on a wet bulb globe temperature (WBGT) threshold (Table 2, page 22).

This method of assessment involves the three main components of the heat burden experienced by workers:

1) thermal environment
2) type of work
3) type of clothing.

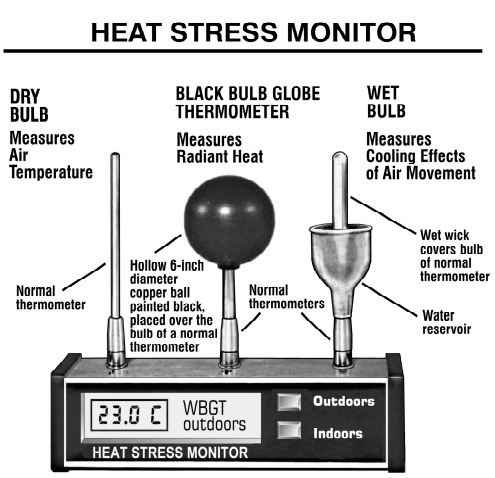
Thermal environment

The first factor in assessing heat stress is the thermal environment as measured by WBGT index. WBGT is calculated in degrees Celsius using a formula which incorporates the following three environmental factors:

- air temperature
- radiant heat (heat transmitted to the body through the air from hot objects such as boilers or shingles heated by the sun)
- cooling effects of evaporation caused by air movement (humidity).

To measure WBGT, a heat stress monitor consisting of three types of thermometers is required:

1) A normal thermometer called a **dry bulb thermometer** is used to measure air temperature.
2) Radiant heat is measured by a **black bulb globe thermometer**. This consists of a hollow, 6-inch diameter copper ball painted flat black and placed over the bulb of a normal thermometer.
3) A **wet bulb thermometer** measures the cooling effect of evaporation caused by air movement (wind or fan). It consists of a normal thermometer wrapped in a wick kept moist at all times. As air moves through the wet wick, water evaporates and cools the thermometer in much the same way that sweat evaporates and cools the body.



Heat stress monitors currently available calculate WBGT automatically. The equipment required and the method of measuring WBGT can be found in the ACGIH booklet *TLVs® and BEIs®: Threshold Limit Values…Biological Exposure Indices*. The booklet also outlines permissible exposure limits for heat stress. Older instruments, however, require calculation by the operator.

Calculation depends on whether sunlight is direct (outdoors) or not (indoors).

Working outdoors in direct sunlight

For work in direct sunlight WBGT is calculated by taking 70% of the wet bulb temperature, adding 20% of the black bulb temperature, and 10% of the dry bulb temperature.

WBGT (out) = 70% (0.7) x wet bulb temperature + 20% (0.2) x black bulb globe temperature + 10% (0.1) x dry bulb temperature

Working indoors (no sunlight)

For work indoors or without direct sunlight, WBGT is calculated by taking 70% of the wet bulb temperature and adding 30% of the black bulb temperature.

WBGT (in)= 70% (0.7) x wet bulb temperature + 30% (0.3) x black bulb globe temperature

Example

Suppose it's a bright sunny day and a crew of roofers is working 20 feet above ground. Our assessment yields the following readings:

Wet bulb temperature (cooling effects of evaporation) = 20°C

Black bulb globe temperature (radiant heat) = 36°C

Dry bulb temperature (air temperature) = 33°C

Using the formula for work in direct sunlight, we calculate as follows:

WBGT = 0.7 x wet bulb temperature + 0.2 x black bulb globe temperature + 0.1 x dry bulb temperature
= 0.7 x 20 + 0.2 x 36 + 0.1 x 33
= 14 + 7.2 + 3.3
WBGT (outdoors) = 24.5 °C

Type of work

The second factor in assessing heat stress is the type of work being performed. Following are the four categories, with some examples of each:

Light work	• Using a table saw • Some walking about • Operating a crane, truck, or other vehicle • Welding
Moderate work	• Laying brick • Walking with moderate lifting or pushing • Hammering nails • Tying rebar • Raking asphalt • Sanding drywall
Heavy work	• Carpenter sawing by hand • Shoveling dry sand • Laying block • Ripping out asbestos • Scraping asbestos fireproofing material
Very Heavy Work	• Shoveling wet sand • Lifting heavy objects

Type of clothing

Free movement of cool, dry air over the skin maximizes heat removal. Evaporation of sweat from the skin is usually the major method of heat removal. WBGT-based heat exposure assessments are based on a traditional summer work uniform of long-sleeved shirt and long pants. With regard to clothing, the measured WBGT value can be adjusted according to Table 1.

TABLE 1: Additions to measured WBGT values for some types of clothing

Clothing Type	**Addition to WBGT**
Summer work uniform	0
Cloth (woven material) overalls	+3.5
Double-cloth overalls	+5

Note: These additions do not apply to encapsulating suits, thermal-insulated clothing, or clothing impermeable or highly resistant to water vapour or air movement. Special garments such as these, and multiple layers of clothing, severely restrict sweat evaporation and heat removal. As a result, body heat may produce life-threatening heat stress even when environmental conditions are considered cool.

Determine work/rest schedules

The WGBT can be used to determine work/rest schedules for personnel under various conditions. Knowing that the WGBT is 24.5°C in the example above, you can refer to Table 2 and determine that workers accustomed to the heat ("acclimatized"), wearing summer clothes, and doing "heavy" work can perform continuous work (100% work).

Suppose work is being performed indoors at a pulp and paper mill under the following conditions:

- Workers are wearing cloth coveralls.
- Boilers are operational.

- Work load is moderate.
- General ventilation is present.

Our assessment yields the following readings:

Wet bulb temperature
(cooling effects of evaporation) = 23°C
Black bulb globe temperature (radiant heat) = 37°C
Dry bulb temperature (air temperature) = 34°C

Using the formula for work indoors, we calculate as follows:

WBGT = 0.7 x wet bulb temperature
+ 0.3 x black bulb globe temperature
= 0.7 x 23 + 0.3 x 37 = 27.2°C
Addition for cloth overalls
(Table 1) = 3.5
WBGT (indoors) = 30.7°C

Referring to Table 2, we determine that workers accustomed to the heat (acclimatized), wearing cloth overalls, and performing "moderate" work can work 15 minutes per hour (25% work; 75% rest).

The WBGT must never be used as an indicator of safe or unsafe conditions. It is only an aid in recognizing heat stress. The ultimate assessment and determination of heat stress must lie with the individual worker or co-worker trained to detect its symptoms. Supervisors must allow individual workers to determine if they are capable of working in heat.

Table 2 is intended for use as a screening step only. Detailed methods of analysis are fully described in various technical and reference works. Contact CSAO for further information.

TABLE 2: Screening Criteria for Heat Stress Exposure using WBGT
(Values are WBGTs in °C. These are **NOT** air temperatures.)

	Acclimatized				Unacclimatized			
Work Demands	Light	Moderate	Heavy	Very Heavy	Light	Moderate	Heavy	Very Heavy
100% Work	29.5	27.5	26		27.5	25	22.5	
75% Work; 25% Rest	30.5	28.5	27.5		29	26.5	24.5	
50% Work; 50% Rest	31.5	29.5	28.5	27.5	30	28	26.5	25
25% Work; 75% Rest	32.5	31	30	29.5	31	29	28	26.5

Notes

- WBGT values are expressed in °C. WBGT is NOT air temperature.
- WBGT-based heat exposure assessments are based on a traditional summer work uniform of long-sleeved shirt and long pants.
- If work and rest environments are different, hourly time-weighted averages (TWA) should be calculated and used. TWAs for work rates should also be used when the demands of work vary within the hour.
- Because of the physiological strain produced by very heavy work among less fit workers, the table does not provide WBGT values for very heavy work in the categories *100% Work* and *75% Work; 25% Rest*. Use of the WGBT is not recommended in these cases. Detailed and/or physiological monitoring should be used instead.
- Consult the latest issue of *TLVs® and BEIs®*: Threshold Limit Values® and Biological Exposure Indices®, published by the American Conference of Governmental Industrial Hygienists, for guidance on how to properly measure, interpret, and apply the WBGT.

Because of the variable and transient nature of construction sites it may not be practical to measure the WBGT. It's therefore reasonable to ask if there are other ways to evaluate heat stress risk.

IS IT POSSIBLE TO USE THE HUMIDEX TO EVALUATE HEAT STRESS RISK?

The humidex is a measure of discomfort based on the combined effect of excessive humidity and high temperature. As noted already, heat-related disorders involve more than air temperature and humidity. **Other factors—air movement, workload, radiant heat sources, acclimatization—must also be considered in assessing heat stress.** But humidex readings can signal the need to implement procedures for controlling heat stress in the workplace.

Environment Canada provides the following humidex guidelines.

- Where humidex levels are less than 29°C, most people are comfortable.
- Where humidex levels range from 30°C to 39°C, people experience some discomfort.
- Where humidex levels range from 40°C to 45°C, people are uncomfortable.
- Where humidex levels are over 45°C, many types of labour must be restricted.

In the hazard alert *Heat Stress and Heat Stroke in Outdoor Work*, the Ontario Ministry of Labour recommends using the WBGT to evaluate heat stress. However, the humidex can be permissible instead if equivalency is demonstrated.

In the absence of any heat-related incidents, a Ministry of Labour inspector is not likely to issue orders against any employer with a comprehensive heat stress program based on the humidex.

If the humidex rather than the WBGT is being used to monitor conditions, the employer should have

- documentation describing the heat stress policy
- training that emphasizes recognition of heat stress symptoms
- thorough investigation of any heat stress incidents to determine whether the heat stress policy is deficient.

Because humidex readings can vary substantially from point to point it is important that a reading be taken at the actual workplace.

See the Appendix (page 24) for an example of one company's heat stress policy using the humidex.

HOW CAN HEAT STRESS BE CONTROLLED?

Heat stress can be controlled through education, engineering, and work procedures. Controls will

- **Protect health**
  Illness can be prevented or treated while symptoms are still mild.
- **Improve safety**
  Workers are less liable to develop a heat-related illness and have an accident. Heat stress often creeps up without warning. Many heat-induced accidents are caused by sudden loss of consciousness.
- **Increase productivity**
  Workers feel more comfortable and are likely to be more productive as a result.

Training and education

According to the National Institute of Occupational Safety and Health (NIOSH), heat stress training should cover the following components:

- knowledge of heat stress hazards
- recognition of risk factors, danger signs, and symptoms
- awareness of first-aid procedures for, and potential health effects of, heat stroke
- employee responsibilities in avoiding heat stress
- dangers of using alcohol and/or drugs (including prescription drugs) in hot work environments.

Engineering controls

Engineering controls are the most effective means of preventing heat stress disorders and should be the first method of control. Engineering controls seek to provide a more comfortable workplace by using

- reflective shields to reduce radiant heat
- fans and other means to increase airflow in work areas
- mechanical devices to reduce the amount of physical work.

Given the constantly changing nature of construction sites, engineering controls are not usually feasible. Proper work procedures are therefore required to prevent heat stress disorders.

Work procedures

The risks of working in hot construction environments can be diminished if labour and management cooperate to help control heat stress.

Management

- Give workers frequent breaks in a cool area away from heat. The area should not be so cool that it causes cold shock—around 25°C is ideal.
- Increase air movement by using fans where possible. This encourages body cooling through the evaporation of sweat.
- Provide unlimited amounts of cool (not cold) drinking water conveniently located.
- Allow sufficient time for workers to become acclimatized. A properly designed and applied acclimatization program decreases the risk of heat-related illnesses. Such a program exposes employees to work in a hot environment for progressively longer periods. NIOSH recommends that for workers who have had previous experience in hot jobs, the regimen should be
  - 50% exposure on day one
  - 60% on day two
  - 80% on day three
  - 100% on day four.
  For new workers in a hot environment, the regimen should be 20% on day one, with a 20% increase in exposure each additional day.
- Make allowances for workers who must wear personal protective clothing and equipment that retains heat and restricts the evaporation of sweat.
- Schedule hot jobs for the cooler part of the day; schedule routine maintenance and repair work in hot areas for the cooler seasons of the year.
- Consider the use of cooling vests containing ice packs or ice water to help rid bodies of excess heat.

Labour

- Wear light, loose clothing that permits the evaporation of sweat.
- Drink small amounts of water—8 ounces (250 ml)—every half hour or so. Don't wait until you're thirsty.
- Avoid beverages such as tea, coffee, or beer that make you pass urine more frequently.
- Where personal PPE must be worn,
  - use the lightest weight clothing and respirators available
  - wear light-colored garments that absorb less heat from the sun
  - use PPE that allows sweat to evaporate.
- Avoid eating hot, heavy meals. They tend to increase internal body temperature by redirecting blood flow away from the skin to the digestive system.
- Don't take salt tablets unless a physician prescribes them. Natural body salts lost through sweating are easily replaced by a normal diet.

WHAT ARE THE RESPONSIBILITIES OF WORKPLACE PARTIES REGARDING HEAT STRESS?

Employers

The *Occupational Health and Safety Act* and its regulations do not specifically cover worker exposure to heat. However, under the *Occupational Health and Safety Act* employers have a general obligation to protect workers exposed to hot environments. Employers should develop a written health and safety policy outlining how workers in hot environments will be protected from heat stress. As a minimum, the following points should be addressed.

- Adjust work practices as necessary when workers complain of heat stress.
- Make controlling exposures through engineering controls the primary means of control wherever possible.
- Oversee heat stress training and acclimatization for new workers and for workers who have been off the job for a while.
- Provide worker education and training, including periodic safety talks on heat stress during hot weather or during work in hot environments.
- Monitor the workplace to determine when hot conditions arise.
- Determine whether workers are drinking enough water.
- Determine a proper work/rest regime for workers.
- Arrange first-aid training for workers.

When working in a manufacturing plant, for instance, a contractor may wish to adopt the plant's heat stress program if one exists.

Workers

- Follow instructions and training for controlling heat stress.
- Be alert to symptoms in yourself and others.
- Avoid consumption of alcohol, illegal drugs, and excessive caffeine.
- Find out whether any prescription medications you're required to take can increase heat stress.
- Get adequate rest and sleep.
- Drink small amounts of water regularly to maintain fluid levels and avoid dehydration.

APPENDIX

WBGT is the most common and useful index for setting heat stress limits, especially when sources of radiant heat are present. It has proven to be adequate when used as part of a program to prevent adverse health effects in most hot environments.

The following procedure uses the simpler humidex (which does not take into account radiant heat) as the measure to evaluate heat stress risk. It does note, however, that if radiant heat is present, WBGT monitoring should be carried out. If humidex is being used as an initial criterion, in lieu of WBGT, then it is best to err on the side of caution.

Company X

HEAT STRESS MANAGEMENT PROCEDURE

Heat stress at its simplest is the stress placed on the body by heat. Heat stress can be as minor as a heat rash or as critical as heat stroke. Procedures and actions have been established to manage activities under hot, humid conditions.

To determine safe workload and the possibility of heat stress under various humidex conditions, we will use the chart *Guidelines for Work/Rest Regimen* (page 25). The chart will be used by supervision as a guideline in determining workload. This guideline is not a substitute for the judgment of a competent supervisor who shall consider worker acclimatization, worker fitness, air movement, radiant heat, special clothing, etc.

If the general humidex measurement is not representative of heat load—for example, when someone is working on top of a furnace or in a confined space—the supervisor shall ask the Safety Advisor to conduct Wet Bulb Globe Temperature (WBGT) measurements, help to assess environmental factors, and determine the appropriate work/rest regimen under the circumstances.

Prevention

When the Safety Advisor (via radio communication) issues a humidex advisory or when work is to be done in special high heat load conditions, supervision shall take the following actions.

- Present a morning toolbox talk emphasizing heat stress management both on and off the job. Individual actions off the job are listed on pages 23-24.
- Initiate buddy system so that no worker is out of view of workmate(s).
- Emphasize water intake and rest periods, in accordance with the chart *Guidelines for Work/Rest Regimen*. Recognize individual tolerances to heat and allow rest breaks accordingly.
- Arrange for a rest area that is significantly cooler (ventilated or air-conditioned) than the work area.

Supervision should consider other preventive measures.

- Emphasize the use of mechanical power when necessary to reduce physical demands.
- Increase air movement to allow evaporation.
- Provide shade for personnel working in direct sunlight; provide shielding from radiant heat.
- Schedule physically demanding or hot jobs for cooler times of day.
- Wearing fire-retardant clothing or chemical suits can increase the possibility of heat stress. Extra caution is necessary when assessing risk and determining workload.
- Increase the number of workers or have workers work at slower pace.
- Allow unacclimatized workers to become acclimatized gradually over a period of several days.

In addition to action by supervision, workers should take individual action on humid days.

- Consult with doctor if medical condition is hampered by hot environments.
- Ensure good nutrition and proper rest at night.
- Avoid using alcohol or tobacco on humid days.
- Salt food well (workers on reduced-salt diets should consult their doctors).

GUIDELINES FOR WORK/REST REGIMEN

Based on United States Environmental Protection Agency guidelines for heat stress in agriculture and the American Conference of Governmental Industrial Hygienists WBGT-TLV (assumes acclimatization, fully clothed in lightweight pants and shirt, adequate water consumption, and perceptible air movement).

HUMIDEX	LIGHT WORK			MODERATE WORK			HEAVY WORK			WATER
°Celsius	Full sun	Partly cloudy	Shade or no shadow	Full sun	Partly Cloudy	Shade or no shadow	Full sun	Partly cloudy	Shade or no shadow	
28	C	C	C	C	C	C	15	C	C	16 oz. every 30 minutes
30	C	C	C	C	C	C	25	C	C	
32	C	C	C	15	C	C	A	C	C	
34	C	C	C	25	C	C	A	C	C	16 oz. every 15 minutes
36	15	C	C	A	C	C	A	15	C	
38	25	C	C	A	15	C	A	25	C	
40	A	C	C	A	25	C	A	A	C	
42	A	15	C	A	A	C	A	A	15	16 oz. every 10 minutes
44	A	25	C	A	A	15	A	A	25	
46	A	A	C	A	A	25	A	A	A	
48	A	A	15	A	A	A	A	A	A	
50	A	A	25	A	A	A	A	A	A	

C = continuous work permitted
15 or 25 = minutes of rest per hour (including rests, pauses, and operational waiting periods during work, or equivalent slowing of pace of work)
A = adjust the work (e.g. delay work until cooler or implement other controls)

Examples of Work

Light Work	Flat welding, instrument fitting, pipe fitting, bench grinding, bench fabrication, drilling at grade, light rigging, etc.
Moderate Work	Position welding, position grinding with large grinder, impact guns on small bolts, heavy rigging, etc.
Heavy Work	Lifting, pulling, pushing heavy material without mechanical equipment, using large hand equipment such as large impact guns or sledgehammers, prolonged overhead grinding, etc.

Symptoms and First Aid Requirements

The following table indicates symptoms and treatment for the six different types of heat stress. These are general guidelines only.

TYPE OF HEAT STRESS	SYMPTOMS	TREATMENT
Heat Rash	Red bumpy rash with severe itching	Change into dry clothes and avoid hot environments. Rinse skin with cool water.
Sunburn	Red, painful, or blistering and peeling skin	If the skin blisters, seek medical aid. Use skin lotions (avoid anaesthetics) and work in shade if possible.
Heat Cramps	Painful cramps in legs, stomach, or arms. Cramps may be an indication of more serious condition.	Move to cool area, loosen tight or restrictive clothing. Drink fluid replacement to replenish vital nutrients. If cramps continue, seek medical attention.
Fainting	Sudden loss of consciousness after at least two hours of work; cool moist skin and a weak pulse.	***Get medical aid immediately.*** Assess breathing and heart rate. Loosen tight or restrictive clothing. If person regains consciousness, offer sips of cool water.
Heat Exhaustion	Heavy sweating, cool moist skin, weak pulse; person is tired, weak, or confused and complains of thirst; vision may be blurred.	***Get medical aid immediately.*** This condition can progress quickly to heat stroke. Move person to cool shaded area. Remove excess clothing, spray with cool water, and fan to increase cooling. Deliver ongoing care until medical aid is provided.
Heat Stroke	Person may be confused, weak, clumsy, tired, or acting strangely. Skin is flushed, red, and dry; pulse fast; headache or dizziness. Person may lose consciousness.	***Get medical aid immediately.*** Time is very important. Remove excess clothing, spray with cool water, and fan to increase cooling. If person loses consciousness, monitor breathing and heart rate. Place person in recovery position. Deliver ongoing care until medical aid is provided.

Remember: Workers feeling ill, regardless of temperature or humidity, should consult their supervisor.

4 BACK CARE

Nearly 25% of the lost-time injuries in construction are related to the back. More than half of these injuries result from lifting excessive weight or lifting incorrectly.

To prevent injuries, you need

1. proper posture
2. correct lifting techniques
3. regular exercise.

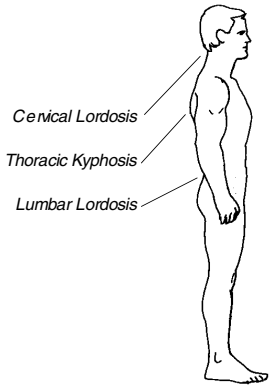
Posture

Correct posture is not an erect, military pose. It means maintaining the naturally occurring curves in your spine.

You have two inward curves – at the neck and low back – and one outward curve – at the upper back.

Keeping your spine aligned in this manner reduces everyday stresses on your back and minimizes the effects of the normal aging process on the spine.

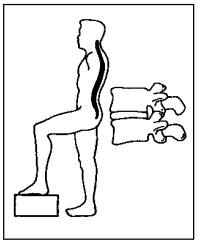
When working in a crouched, bent, or stooping position for a prolonged period, take regular breaks by standing up and bending backwards three times.



Correct Posture

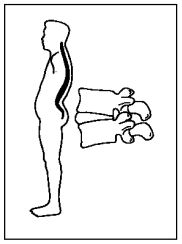
You have two inward curves (lordosis), one each at the neck and low back, and one outward curve (kyphosis) at the upper back.

Common Posture



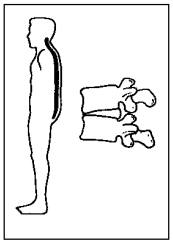
Normal

Prolonged standing often causes an increased curve in your back. Elevating one foot on a stool or any other object (a phone book or brick will do) will take stress off the lower spine.



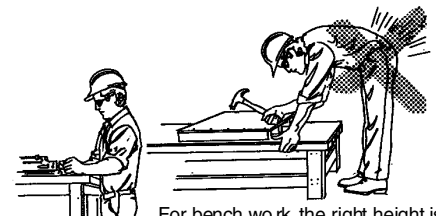
Sway Back

An increased curve in your lower back will jam the vertabrae together (sway back). If held too long, the position will cause lower back muscles and ligaments to tighten and lead to lower back pain.



Flat Back

Too little curve (flat back) will put extra pressure on the front of your discs. This may contribute to disc problems and pain.

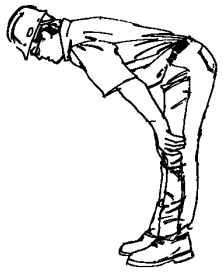


For bench work, the right height is vital.

Precision work

Light work

Heavy work



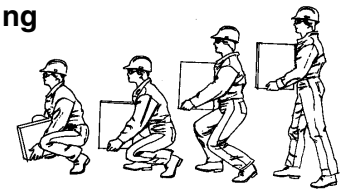
Work Overhead

When working overhead in an arched position for prolonged periods, take regular breaks by returning to stable footing and bending forward three times.

If possible avoid working on ladders. Use scaffolds instead, especially for long term tasks or for jobs where you must handle heavy materials.

Materials Handling

Proper Lifting



1. Plan your move.
   - Size up the load and make sure pathway is clear.
   - Get help as needed.
   - Use a dolly or other device if necessary.
2. Use a wide-balanced stance with one foot slightly ahead of the other.
3. Get as close to the load as possible.
4. Tighten your stomach muscles as the lift begins.
5. When lifting, keep your lower back in its normal arched position and use your legs to lift.
6. Pick up your feet and pivot to turn – don't twist your back.
7. Lower the load slowly, maintaining the curve in your lower back.

Your back can manage most lifts – if you lift correctly.

Avoid lifting above shoulder height. This causes the back to arch, placing heavy stress on the small joints of the spine.

Do not catch falling objects. Your muscles may not have time to coordinate properly to protect the spine.

Push rather than pull. Pushing allows you to maintain the normal curves in your back.

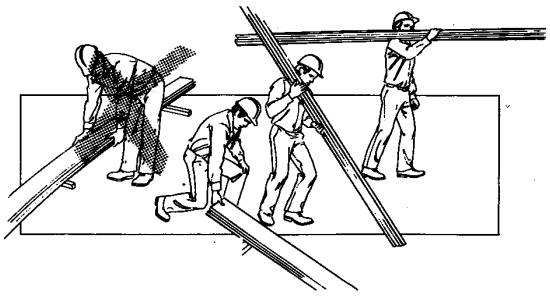
Weight Transfer

Pull the object toward you while transferring your weight to the lift side.

Lift only to the level required.

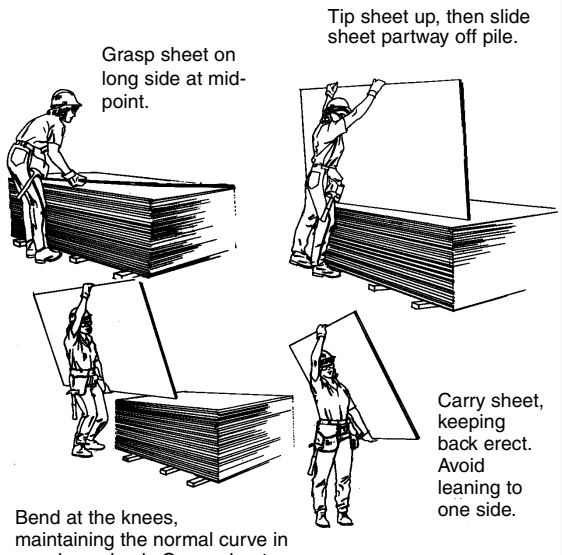
Shift your weight to your other leg while pushing the object into position.

Sheet Materials

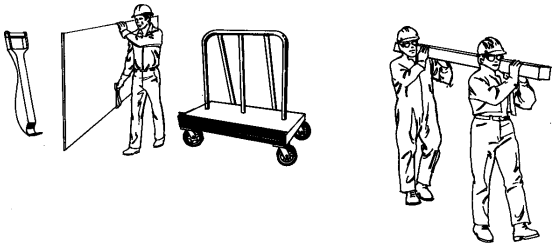


If sheets are on the floor, use the same technique as for lifting long lumber. Lift one end first.

When you handle sheet materials, use proper techniques to protect your back. Where possible, store sheets at a convenient height and above ground on timbers or trestles.



For long carries, use carrying handles. Better yet, if surface is smooth and hard use a drywall cart.



Two-Person Lift

Lifters should be of similar height. Before starting they should decide on lifting strategy and who will take charge.

For a two-person lift of a long load, the lifter who takes charge must see that the load is carried on the same side, with a clear line of vision. Begin by lifting load from ground to waist height. Then lift the load from waist to shoulder.

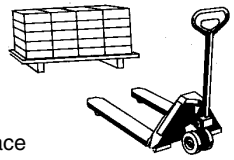
Carrying on Stairs

Use your stomach muscles to help support and protect your back. If possible, the tallest and/or strongest person should be at the bottom of the load.

Balance

Avoid one-handed carrying if possible. Try to distribute the weight evenly on each side. If you can't avoid one-handed carrying, such as with a single pail, hold the free arm either straight out or on your hip as a counterbalance.

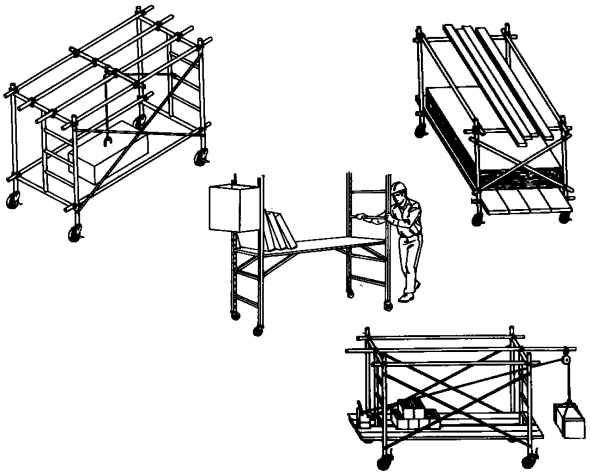
Mechanical Help



Use a cart or dolly for transporting tools and equipment wherever possible.

Consider using pallets where surface conditions allow.

Rolling frame scaffolds with a few tube-and-clamp components may be useful for moving heavy objects such as motors or drives where other devices such as forklifts are not available.



Wheelbarrows with dual wheels are a great improvement over single wheels. Better balance and increased flotation over soft ground make wheeling easier on the back.

Lift tables with casters for heavy components can be helpful. These tables are light, carry loads of several hundred pounds, and have adjustable heights from one to several feet.

Exercise

Construction work strengthens some muscles while others become shorter and weaker, creating a muscle imbalance. A regular exercise program can help to prevent this from happening.

A good exercise program should consist of four basic parts:
1. warm-up
2. main workout
3. strength and stretch
4. cool-down.

Warm-Up

This is a general exercise program only. Before starting any exercise program, consult your doctor first.

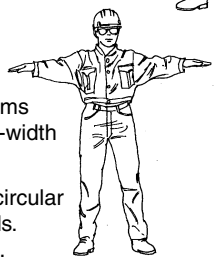
If you have any concerns or experience any pain while doing the exercises, stop and consult your doctor.

1. March in Place

Start: Stand in position.

Action: Pump arms and legs in opposite directions. Make sure heels contact ground. Continue 3 to 5 minutes.

2. Arm Circles



Start: Stand with arms raised horizontally and slightly in front of shoulders, palms down, and feet shoulder-width apart.

Action: Rotate arms in forward circular motion for 15-30 seconds. Relax. Repeat 3-5 times.

Stretching Program

The following stretching exercises are of greatest value before work starts. They may, however, be done at any convenient time. Whenever they are done, a brief warm-up (walking briskly or jogging on the spot) is most beneficial.

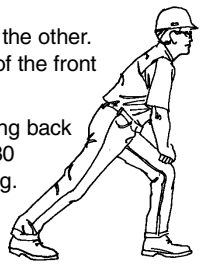
The exercises should be performed in a slow, controlled manner and held in a sustained stretch. Avoid bouncy, jerky movements which may tear muscle fibres.

3. Knees to Chest

Start: Support yourself securely with one hand.

Action: Pull your knee toward your chest and grasp around your knee with your free hand. Hold the stretch for 30 seconds. Lower your leg to the ground and repeat with the other leg. Repeat three times for each leg.

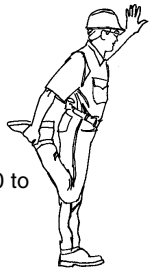
4. Hip Stretch



Start: Stand with one foot in front of the other. Place hands above the knee of the front leg.

Action: Gently bend front knee, keeping back foot flat on the floor. Hold 20-30 seconds. Repeat with other leg. Repeat three times for each leg.

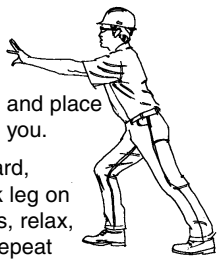
5. Thigh Stretch



Start: Support yourself with one hand on something secure.

Action: Bend your leg back and grasp your ankle with your free hand. Gently pull your ankle toward your body, keeping your trunk straight. Hold 20 to 30 seconds; repeat with other leg. Repeat three times for each leg.

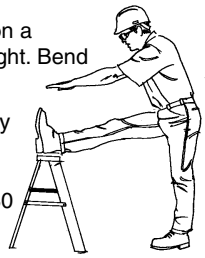
6. Calf Stretch



Start: Stand slightly away from a solid support and lean on it with your outstretched hands. Bend the forward leg and place the other leg straight behind you.

Action: Slowly move your hips forward, keeping the heel of the back leg on the ground. Hold 30 seconds, relax, and repeat with other leg. Repeat three times for each leg.

7. Hamstring Stretch



Start: Place the back of your heel on a platform at a comfortable height. Bend your supporting leg slightly.

Action: Looking straight ahead, slowly bend forward at the hips until you feel a good stretch at the back of the raised leg. Hold 30 seconds and repeat with other leg. Repeat three times for each leg.

5 MOULDS

More and more construction firms are involved in removing toxic moulds from contaminated buildings. This section explains

- what moulds are
- where they are found
- why they are of concern
- what health effects they may cause
- how they can be identified
- how they can be safely removed.

This section also covers the obligations of employers and others under Ontario's *Occupational Health and Safety Act.*

What are moulds?

Moulds are microorganisms that produce thousands of tiny particles called spores as part of their reproductive cycle. Mould colonies are usually visible as colourful, woolly growths. They can be virtually any colour – red, blue, brown, green, white, or black. When disturbed by air movement or handling, moulds release their spores into the air. Given the right environmental conditions, these spores can go on to form other mould colonies.

Where are moulds found?

Moulds can be found almost anywhere outdoors and indoors. Indoor moulds usually originate from outside sources such as soil and vegetation. Moulds love dark, moist environments and can grow at room temperature on various construction materials including wallpaper, particleboard, ceiling tiles, drywall, and plywood.

Construction workers can be exposed to toxic spores when working on buildings with some sort of water damage from flooding, plumbing leaks, or leaks in the structure itself.

Why are moulds of concern?

In buildings with water damage or ongoing moisture problems, certain types of “water-loving” moulds may reproduce to higher than normal levels and potentially cause adverse health effects. *Stachybotrys chartarum* (formerly known as *Stachybotrys atra*) is of particular concern because it can be found in large colonies and can cause adverse health effects.

Stachybotrys has gained special attention because it has been discovered in portable classrooms with ongoing moisture problems. It appears as small black patches and grows well on water-soaked cellulose material such as wallpaper, ceiling tiles, drywall, and insulation containing paper.

In addition to *Stachybotrys*, construction personnel working in water-damaged buildings may be exposed to other types of toxic moulds such as *Fusarium, Aspergillus,* and *Penicillium*.

What health effects can moulds cause?

Air movement and the handling of contaminated material can release toxic spores into the atmosphere. These spores cause adverse health effects by producing toxic substances known as mycotoxins. Once released, toxic spores must come into contact with the skin or be inhaled before symptoms can develop. Not all exposed construction workers will develop symptoms.

- Exposure to toxic moulds may irritate skin, eyes, nose, and throat, resulting in allergy-like symptoms such as difficulty in breathing, runny nose, and watery eyes.
- Other symptoms such as fatigue and headache have also been reported.
- Workers who are allergic to moulds could experience asthmatic attacks.
- Workers exposed to *Stachybotrys* have also experienced burning in the nose, nose bleeds, severe coughing, and impairment of the immune system. *Stachybotrys* does not cause infection and is not spread from person to person.
- People with weakened immune systems are particularly susceptible to mould-related illness and should not work in mould-contaminated areas.

How are moulds identified?

Owners of buildings that may be mould-contaminated should conduct, at their own expense, an assessment to determine whether or not the buildings are indeed contaminated. The assessment should include building inspection and analysis of bulk samples.

Mould on visible surfaces may be just the tip of the iceberg. Since they thrive in dark, moist environments, moulds may be hidden from view. Thorough inspections of water-damaged areas must be conducted. This involves looking into wall cavities, behind drywall, under carpets, and above ceiling tiles.

Not all mounds are toxic. The type of mould identified and the extent of the contamination will determine the precautions to be taken.

Bulk sampling and laboratory analysis are used to document the type of mould growing on surfaces. The procedure involves scraping surface material into a sealable plastic bag and sending it by overnight delivery to an accredited laboratory.

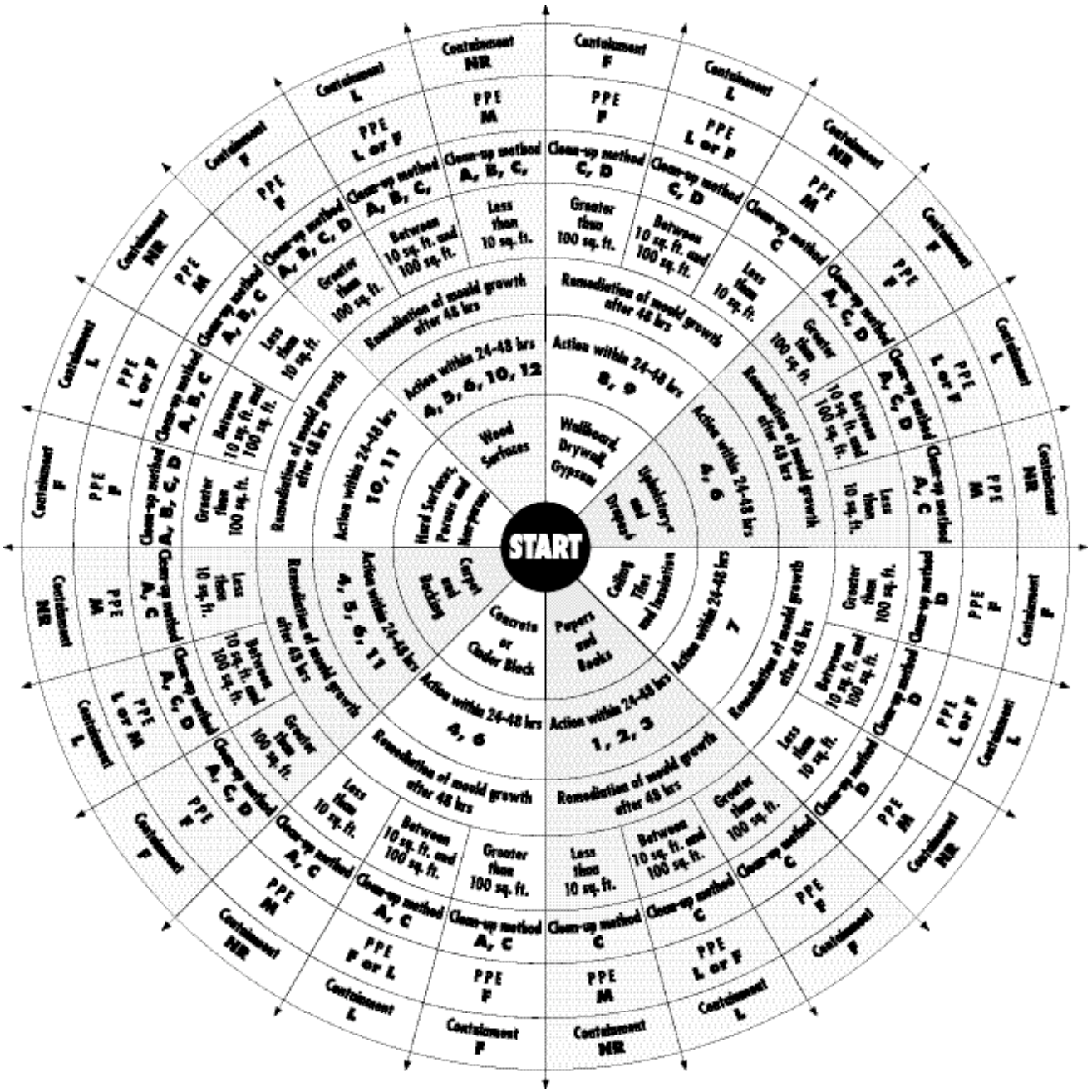
An accredited laboratory is one that participates in the American Industrial Hygiene Association's Environmental Microbiology Proficiency Analytical Testing Program. The chosen laboratory should have a competent mycologist (a person that studies moulds) who can analyze the sample and determine whether the mould is likely to pose a health risk.

Based on the presence of visible mould, evidence of water damage, and symptoms that are consistent with allergic or toxic response to mould, it may be justified to skip bulk sampling and go straight to remediation (removal).

The person taking bulk samples or performing inspections must be suitably protected for Level 1 work (see chart below) and must be careful not to unduly disturb the mould.

How can moulds be safely removed?

Toxic moulds must be removed. However, special control measures must first be implemented to prevent worker exposure and the spread of moulds from the construction area to adjacent areas. This is especially true for


START
Wood Surfaces
Hard Surfaces: Pavers and Non-porous
Carpet and Backing
Concrete or Cinder Block
Papers and Books
Ceiling Tiles and Insulation
Upholstery and Drapes
Wallboard, Drywall, Gypsum
Action within 24-48 hrs
4, 5, 6, 10, 12
Action within 24-48 hrs
10, 11
Action within 24-48 hrs
4, 5, 6, 11
Action within 24-48 hrs
4, 6
Action within 24-48 hrs
1, 2, 3
Action within 24-48 hrs
7
Action within 24-48 hrs
8, 9
Action within 24-48 hrs
4, 6
Remediation of mould growth after 48 hrs
Less than 10 sq. ft.
Between 10 sq. ft. and 100 sq. ft.
Greater than 100 sq. ft.
Clean-up method A, B, C, D
Clean-up method A, B, C
Clean-up method A, C
Clean-up method C
Clean-up method C, D
Clean-up method D
PPE M
PPE L or F
PPE F
PPE F or L
Containment NR
Containment L
Containment F

Stachybotrys because of its potentially severe health effects.

The extent of contamination governs what remediation measures need to be taken in order to prevent the spread of toxic moulds.

Note: The cause of moisture problems should be corrected before any mould remediation takes place.

A follow-up inspection should be conducted 3-6 months after remediation to ensure that the mould has not returned.

Obligations under the Act

Although there are no Ontario regulations specifically addressing moulds, an employer must, under the *Occupational Health and Safety Act,* take every precaution reasonable in the circumtances for the protection of a worker. Work practices set out by Health Canada in *Fungal Contamination of Public Buildings: A Guide to Recognition and Management* provide a reasonable standard.

Employers have a duty to instruct workers in the safe removal and handling of mould-contaminated material. Workers in turn have the duty to follow these instructions. Building owners must ensure that trade contractors follow proper remediation procedures.

Mould remediation chart

The chart on page 30 summarizes mould control procedures recommended by the Environmental Protection Agency in the United States.

For various kinds of material, the chart indicates how mould growth can be prevented within 24-48 hours of water damage and also provides general advice on remediation. This information is intended only as a summary of basic procedures and is not intended, nor should it be used, as a detailed guide to mould remediation.

Although the chart may look complicated, it becomes clear and useful when taken one step, or one ring, at a time.

1) Start at the centre.
2) In the first ring, identify the material you are concerned about.
3) In the next ring, find out what actions to take within the first 24-48 hours of CLEAN water damage. Actions are numbered 1, 2, 3, 4 and so on. Each is spelled out under the **Action within 24-48 hrs** column at right.
4) Proceed to the next ring if mould growth is apparent and more than 48 hours have elapsed since water damage. Determine whether the contaminated area is less than 10 square feet, between 10 and 100 square feet, or greater than 100 square feet.
5) Proceed to the next ring and follow the clean-up method indicated for the size of the contaminated area. Methods are lettered A, B, C, and D. Each is spelled out under the **Clean-up Methods** column.
6) In the next ring, determine the level of personal protective equipment required. This is indicated by M, L, or F under the **PPE** column.
7) Finally, in the outermost ring, determine whether containment is necessary and, if so, whether it must be L (limited) or F (full). These requirements are explained in the **Containment** column.

Action within 24-48 hrs

Actions are for damage caused by clean water. If you know or suspect that water is contaminated by sewage or chemical or biological pollutants, consult a professional. Do not use fans unless the water is clean or sanitary. If mould has grown or materials have been wet for more than 48 hours, consult **Clean-up Method** in the chart.

1. Discard non-valuable items.
2. Photocopy valuable items, then discard.
3. Freeze (in frost-free freezer or meat locker) or freeze-dry.
4. Remove water with water-extraction vacuum.
5. Reduce humidity levels with dehumidifiers.
6. Accelerate drying process with fans and/or heaters.
   - Don't use heat to dry carpet.
   - Use caution applying heat to hardwood floors.
7. Discard and replace.
8. May be dried in place, if there is no swelling and the seams are intact. If not, then discard and replace.
9. Ventilate wall cavity.
10. For all treated or finished woods, porous (linoleum, ceramic tile, vinyl) and non-porous (metal, plastic) hard surfaces, vacuum or damp-wipe with water or water and mild detergent and allow to dry; scrub if necessary.
11. For porous flooring and carpets, make sure that subfloor is dry. If necessary clean and dry subfloor material according to chart.
12. Wet paneling should be pried away from walls for drying.

Clean-up Methods

Methods are for damage caused by clean water. If you know or suspect that water is contaminated by sewage or chemical or biological pollutants, consult a professional. These are guidelines only. Other cleaning methods may be preferred by some professionals. Consult **Action within 24-48 hrs** in the chart if materials have been wet for less than 48 hours and mould growth is not apparent. If mould growth is not addressed promptly, some items may be damaged beyond repair. If necessary, consult a restoration specialist.

A. Wet-vacuum the material. (In porous material, some mould spores/fragments will remain but will not grow if material is completely dried.) Steam cleaning may be an alternative for carpets and some upholstered furniture.
B. Damp-wipe surfaces with water or with water and detergent solution (except wood – use wood floor cleaner); scrub as needed.
C. Use a high-efficiency particulate air (HEPA) vacuum once the material has been thoroughly dried. Dispose of HEPA-vacuum contents in well-sealed plastic bags.
D. Remove water-damaged materials and seal in plastic bags inside containment area, if there is one. Dispose of as normal waste. HEPA-vacuum area once it is dried.

PPE (Personal Protective Equipment)

Use professional judgment to determine PPE for each situation, particularly as the size of the remediation site and the potential for exposure and health effects increase. Be prepared to raise PPE requirements if contamination is more extensive than expected.

M Minimum – Gloves, N-95 respirator, goggles/eye protection.
L Limited – Gloves, N-95 respirator or half-face respirator with HEPA filter, disposable overalls, goggles/eye protection.
F Full – Gloves, disposable full-body clothing, head gear, foot coverings, full-face respirator with HEPA filter.

Containment

Use professional judgment to determine containment for each situation, particularly as the size of the remediation site, and the potential for exposure and health effects, increase.

NR None Required
L Limited – From floor to ceiling, enclose affected area in polyethylene sheeting with slit entry and covering flap. Maintain area under negative pressure with HEPA-filtered fan. Block supply and return air vents in containment area.
F Full – Use two layers of fire-retardant polyethylene sheeting with one airlock chamber. Maintain area under negative pressure with HEPA-filtered fan exhausted outside of building. Block supply and return air vents in containment area.

Endnotes

a) Upholstery may be difficult to dry within 48 hours. For items with monetary or sentimental value, consult a restoration specialist.
b) Follow manufacturer's laundering instructions.

Equipment

1 PERSONAL PROTECTIVE EQUIPMENT

INTRODUCTION

Personal protective equipment (PPE) is something all construction workers have in common.

PPE is designed to protect against safety and/or health hazards. Hard hats, safety glasses, and safety boots, for instance, are designed to prevent or reduce the severity of injury if an accident occurs.

Other PPE, such as hearing and respiratory protection, is designed to prevent illnesses and unwanted health effects.

It is important to remember that PPE only provides protection. It reduces the risk but does not eliminate the hazard.

This chapter will enable PPE users to

- assess hazards and select a suitable control method
- locate and interpret legislation related to PPE
- effectively use and maintain PPE.

Legal Requirements

While common to all trades, PPE varies according to individual, job, and site conditions.

Legal requirements for personal protective equipment also vary and the appropriate sections of the construction regulation (O. Reg. 213/91) under the *Occupational Health and Safety Act* should be consulted.

The *Occupational Health and Safety Act* makes employers and supervisors responsible for ensuring that required PPE is worn. This does not mean that the employer must provide PPE but only ensure that it is provided by someone.

Workers, meanwhile, have a duty under the Act to wear or use PPE required by the employer. This addresses situations where the regulations may not require PPE but the employer has set additional health and safety standards, such as mandatory eye protection.

The construction regulation (O. Reg. 213/91) broadly requires that such protective clothing, equipment, or devices be worn "as are necessary to protect the worker against the hazards to which the worker may be exposed." It also requires that the worker be trained in the use and care of this equipment.

Control Strategies

Personal protective equipment should be the last resort in defence. Better alternatives lie in engineering controls that eliminate as much of the risk as possible. Engineering controls fall into five categories:

- substitution
- alternative work methods
- isolation
- enclosure
- ventilation.

Substitution

This control substitutes a less toxic chemical that can do the same job. A common example is the substitution of calcium silicate or fibreglass insulation for asbestos insulation. Substitution is an effective control as long as the substitute is less hazardous.

Alternative Work Methods

This simply means doing the job in a way which is less hazardous. For example, brushing or rolling paint produces much lower vapour levels than spray painting. Similarly, wet removal of asbestos releases up to 100 times less dust than dry removal. The change should be checked to ensure that it is safer.

Isolation

Isolation isolates the worker from the hazard. In a quarry, for example, the operator of a crusher can be isolated from dust by a filtered, air-conditioned cab.

Enclosure

A substance or procedure may be enclosed to contain toxic emissions. It may be as simple as putting a lid on an open solvent tank or enclosing asbestos removal projects with polyethylene sheeting (Figure 1). Enclosures have also been built around compressors to reduce the noise level. Enclosures must not restrict access when maintenance is required.

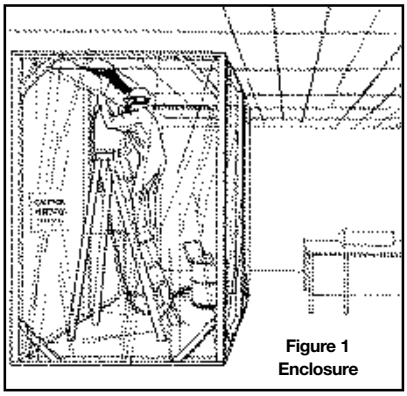


Figure 1
Enclosure

Ventilation

A common engineering control is to dilute the contaminant in the air by using general ventilation. Local ventilation is better because it removes the contaminant. General ventilation may employ fans to move large volumes of air and increase air exchange. This is not suitable, however, for highly toxic materials.

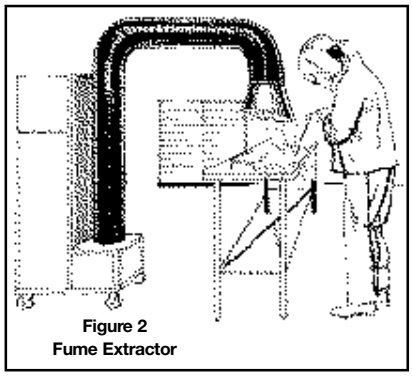


Figure 2
Fume Extractor

Local ventilation captures and removes contaminants at their source. At a shop bench, a fume hood can be constructed to remove dusts and fumes. On sites, portable fume extractors (Figure 2) can be used.

Remember: many filtering systems can only remove fumes—not gases or vapours.

Personal Protective Equipment

When it is not possible to apply any of the five engineering controls, personal protective equipment may be the last resort.

Regulations often refer to Canadian Standards Association (CSA) or other equipment standards as a convenient way to identify equipment which meets requirements and is acceptable. CSA-certified equipment can be identified by the CSA logo (Figure 3). For instance, there are CSA standards for

Figure 3
CSA logo

- Head Protection - CSAZ94.1M1992
- Eye Protection - CSAZ94.3-99
- Foot Protection - CSAZ195-M1992

For respiratory protection, National Institute for Occupational Safety and Health (NIOSH) standards and approvals are usually referenced throughout North America.

For life jackets, Transport Canada certification is the standard reference.

EYE PROTECTION

With the permission of the Canadian Standards Association, some information in this chapter is reproduced from CSA Standard CAN/CSA-Z94.3-99, Industrial Eye and Face Protectors, *which is copyrighted by Canadian Standards Association, 178 Rexdale Boulevard, Toronto, Ontario M9W 1R3. While use of this material has been authorized, CSA shall not be responsible for the manner in which the information is presented, nor for any interpretations thereof.*

Introduction

Eye protection is not the total answer to preventing eye injuries. Education regarding proper tools, work procedures, hazard awareness, and the limitations of eye protection is also very important. Like any other manufactured product, eye protection has material, engineering, and design limitations. But proper eye protection, selected to match the specific construction hazard, combined with safe work procedures, can help to minimize the number and severity of eye injuries.

When we consider that one out of every two construction workers may suffer a serious eye injury during their career, the importance of wearing proper eye protection cannot be over-emphasized. In the hazardous environment of the construction industry, wearing proper eye protection should be considered a labour-management policy, not a matter of individual preference.

Classes of Eye Protectors

Before outlining the type(s) of eye protectors recommended for a particular work hazard, it is necessary to explain the various types of eye protectors available. Eye protectors are designed to provide protection against three types of hazards — impact, splash, and radiation (visible and invisible light rays) — and, for purposes of this manual, are grouped into seven classifications based on the CSA Standard Z94.3-99, *Industrial Eye and Face Protectors.*

The seven basic classes of eye protectors are: spectacles, goggles, welding helmets, welding hand shields, hoods, face shields, and respirator facepieces.

Class 1 – Spectacles (Figure 1)

CSA Standard Z94.3-99 requires that Class 1 spectacles incorporate side protection. Most side shields are permanently attached to the eyewear, but some may be detachable.

Examples of Class 1 - Spectacles

Class 1A
Spectacles with side protection

Class 1B
Spectacles with side and radiation protection

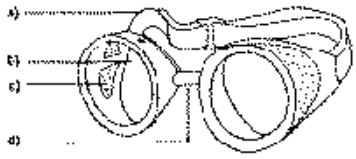
Figure 1

Class 2 – Goggles

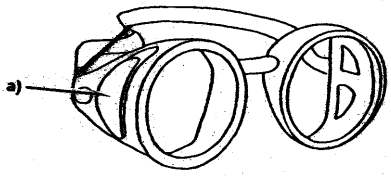
There are two types of goggles — eyecup and cover. Both must meet the CSA Z94.3-99 Standard.

Eyecup goggles (Figure 2) completely cover the eye socket to give all-round protection. They have adjustable or elasticized headbands and are equipped with ventilation ports to allow passage of air and prevent fogging. Some have direct ventilation ports which prevent the direct passage of large particles, but do not exclude dust or liquids. Others have indirect ventilation ports which prevent the passage of particles, dust, and liquids. There are also models available with an adjustable chain bridge.

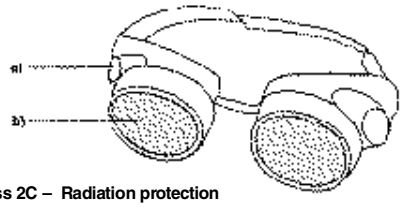
Figure 2 – Eyecup Goggles



Class 2A – Direct ventilated goggles for impact protection
Eyecup goggles with direct ventilation openings or ports. These openings exclude direct passage of large particles. They do not exclude dust and splash. a) headband; b) lens; c) direct ventilation port; d) bridge.



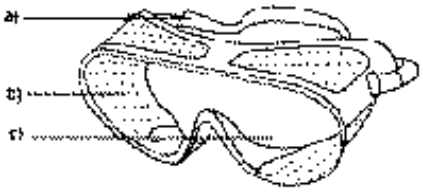
Class 2B – Non-ventilated and indirect ventilated goggles for impact, dust, and splash protection
Eyecup goggles with indirect ventilation ports to exclude direct passage of dust or liquids. These goggles are identical to class 2A except for the type of ventilation ports. a) indirect ventilation port



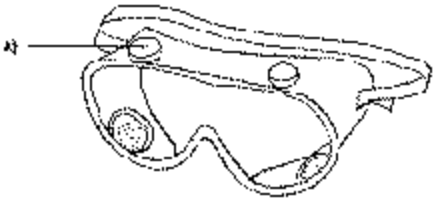
Class 2C – Radiation protection
Eyecup goggles for radiation protection with indirect ventilation ports not only to allow passage of air and prevent fogging, but also to exclude light. The lenses in these goggles are filter lenses. a) indirect ventilation port; b) filter lens.

Cover goggles (Figure 3) are designed to be worn over spectacles. They have adjustable or elasticized headbands and are equipped with direct or indirect ventilation ports to allow passage of air and prevent fogging.

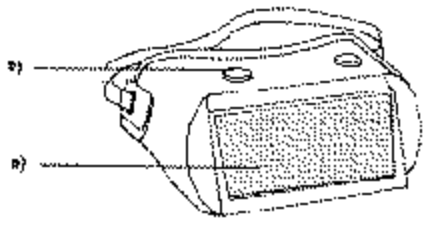
Figure 3 – Cover Goggles



Class 2A – Direct ventilated goggles for impact protection
Cover goggles with direct ventilation ports. (This type normally incorporates a soft-frame goggle.) As in class 2A eyecup goggles, these openings or ports exclude direct passage of large particles. They do not exclude dust and splash. a) headband; b) direct ventilation port; c) lens.



Class 2B – Non-ventilated and indirect ventilated goggles for impact, dust, and splash protection
Cover goggles for dust and splash with indirect ventilation ports to exclude direct passage of dust or liquid. a) indirect ventilation port.

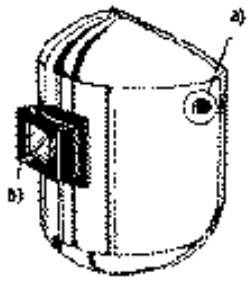


Class 2C – Radiation Protection
Cover goggles for radiation protection. a) filter lens; b) indirect ventilation port.

Class 3 – Welding Helmets (Figure 4)

This class provides radiation and impact protection for face and eyes. There are two types of welding helmets available — the stationary plate helmet and the lift-front or flip-up plate helmet. There are also special models incorporating earmuff sound arrestors and air purification systems. Special magnifying lens plates manufactured to fixed powers are available for workers requiring corrective lenses.

Figure 4 – Welding Helmets



Lift-front helmets or shields have three plates or lenses – a filter or shaded plate made of glass or plastic in the flip-up cover, along with a clear thin glass or plastic outer lens to keep it clean, and a clear, impact-resistant plastic or glass lens mounted in the helmet itself. a) hard hat attachment; b) flip-up lens holder.

Stationary plate helmets are similar to lift-front helmets except for the fact that they have a single filter lens plate, normally 51mm x 108mm (2" x 4-1/4") in size, or a larger plate 114mm x 113mm (4-1/2" x 5-1/4") in size which is more suitable for spectacle wearers.

The filter or shaded plate is the radiation barrier. Arc welding produces both visible light intensity and invisible ultraviolet and infra-red radiation. These ultraviolet rays are the same type of invisible rays that cause skin burning and eye damage from overexposure to the sun. However, ultraviolet rays from arc welding are considerably more severe because of the closeness of the eyes to the arc and lack of atmospheric protection. In arc welding, therefore, it is necessary to use a filter plate of the proper lens shade number to act as a barrier to these dangerous light rays and to reduce them to the required safe degree of intensity. For proper welding shade numbers, see Table 2, page 40.

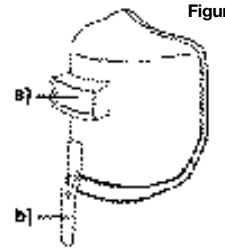
In addition to common green filters, many special filters are also available. Some improve visibility by reducing yellow or red flare; others make the colour judgment of temperature easier. A special gold coating on the filter lens provides additional protection by reflecting radiation.

Class 4 – Welding Hand Shields (Figure 5)

Welding hand shields are designed to give radiation and impact protection for the face and eyes.

NOTE: With welding helmets and hand shields, the user is continually lifting and lowering the visor. To protect the eyes when the visor is lifted, Class 1 spectacles should be worn underneath.

Figure 5 – Hand Shields



Hand-held shields or inspectors' shields are similar to Class 3 welding helmets except that there are no lift-front type models. a) stationary plate; b) handle.

Class 5 – Hoods (Figure 6)

Non-rigid helmets or hoods come with impact-resistant windows usually made of plastic. An air-supply system may also be incorporated. Hoods may be made of non-rigid material for use in confined spaces and of collapsible construction for convenience in carrying and storing.

Hood types include
5A with impact-resistant window
5B for dust, splash, and abrasive materials protection
5C with radiation protection
5D for high-heat applications.

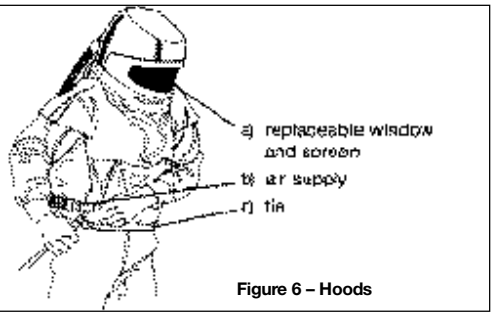


Figure 6 – Hoods

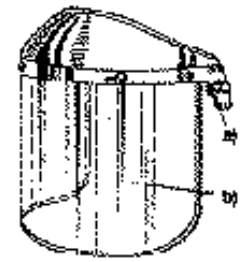
Class 6 – Face Shields (Figure 7)

Face shields are just what the name implies—a device that includes a transparent window or visor to shield the face and eyes from impact, splash, heat, or glare. With face shields, as with welding helmets and hand shields, the user is continually lifting and lowering the visor. To protect the eyes when the visor is lifted, Class 1 spectacles should be worn underneath. Face shields may also be equipped with an adjustable spark deflector or brow guard that fits on the worker's hard hat. Shaded windows are also available to provide various degrees of glare reduction; however, they do not meet the requirements of CSA Standard Z94.3-99 *Industrial Eye and Face Protectors* for ultraviolet and total heat protection and should not be used in situations where any hazard is present from ultraviolet or infra-red radiation.

Class 6

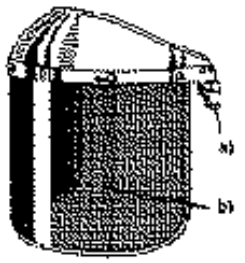
This class includes
6A for impact and splash protection
6B for radiation protection
6C for high-heat applications.

Figure 7 – Face Shields



Class 6A
Face shield for impact, piercing, splash, head, and glare protection.
a) hard hat attachment; b) face shield (window).

Class 6B
Face shield for light non-piercing impact, splash, low heat, and glare protection. The major difference between 6A and 6B is the degree of thickness in the shield.



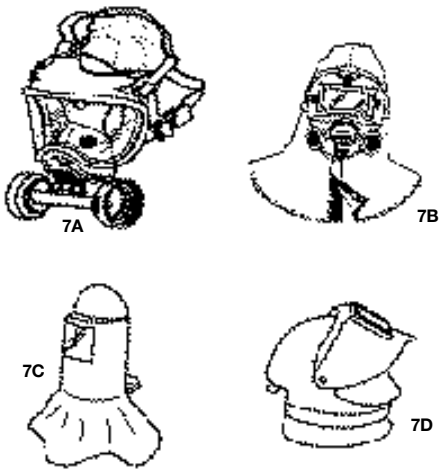
Class 6C
Face shield for light non-piercing impact and high heat protection only (usually wire screen windows). a) hard hat attachment; b) wire screen.

Figure 7 – Face Shields

Class 7 – Respirator Facepieces (Figure 8)

This class includes
7A for impact and splash protection
7B for radiation protection
7C with loose-fitting hoods or helmets
7D with loose-fitting hoods or helmets for radiation protection.

Figure 8 – Respirator Facepieces



Hazards and Recommended Protectors

Reprinted from CSA Standard Z94.3-99 *Industrial Eye and Face Protectors*, Table 1 classifies the main eye hazards and outlines the types of protectors recommended for each. Each situation requires that all hazards be considered in selecting the appropriate protector or combination of protectors.

The practice of requiring all personnel to wear spectacles is strongly recommended. Spectacles should be worn underneath Classes 3, 4, 5, 6, or 7 protectors, where the hazard necessitates the use of spectacles.

The following classifications provide a general overview of eye protectors for each hazard group. For specific hazards, refer to Table 1. Note that the best eye protection results from a combination of different classes of eye protectors.

Group A: Flying Objects (Figure 9)

Minimum eye protection recommended:
Class 1 spectacles

Optimum eye protection recommended:
Goggles worn with face shields to provide eye and face protection.

Group B: Flying Particles, Dust, Wind, etc. (Figure 10)

Minimum eye protection recommended:
Class 1 spectacles

Optimum eye protection recommended:
Goggles (for dust and splash) worn with face shields to provide eye and face protection.

Group C: Heat, Glare, Sparks, and Splash from Molten Metal (Figure 11)

Minimum eye protection recommended:
Class 1 spectacles with filter lenses for radiation protection. Side shields must have filtering capability equal to or greater than the front lenses.

Optimum eye protection recommended:
Eyecup or cover goggles with filter lenses for radiation protection, worn with face shields to provide eye and face protection.

Table 1

Hazards and Recommended Protectors

Hazard groups	Nature of hazard	Hazardous activities involving but not limited to	Spectacles Class 1		Goggles Class 2			Welding helmet Class 3	Welding hand shield Class 4	Face shields Class 6			Non-rigid hoods Class 5			
			A	B	A	B	C			A	B	C	A	B	C	D
A	Flying objects	Chipping, scaling, stonework, drilling; grinding, buffing, polishing, etc.; hammer mills, crushing; heavy sawing, planing; wire and strip handling; hammering, unpacking, nailing; punch press, lathework, etc.	■		■	■				■			■	■		
B	Flying particles, dust, wind, etc.	Woodworking, sanding; light metal working and machining; exposure to dust and wind; resistance welding (no radiation exposure); sand, cement, aggregate handling; painting; concrete work, plastering; material batching and mixing	■		■	■				■			■	■		
C	Heat, sparks, and splash from molten materials	Babbiting, casting, pouring molten metal; brazing, soldering; spot welding, stud welding; hot dipping operations		■			■				■	■			■	■
D	Acid splash; chemical burns	Acid and alkali handling; degreasing, pickling and plating operations; glass breakage; chemical spray; liquid bitumen handling				■				■				■		
E	Abrasive blasting materials	Sand blasting; shot blasting; shotcreting				■				■				■		
F	Glare, stray light (where reduction of visible radiation is required)	Reflection, bright sun and lights; reflected welding flash; photographic copying	■		■	■				■			■	■		
G	Injurious optical radiation (where moderate reduction of optical radiation is required)	Torch cutting, welding, brazing, furnace work; metal pouring, spot welding, photographic copying		■			■				■				■	
H	Injurious optical radiation (where large reduction of optical radiation is required)	Electric arc welding; heavy gas cutting; plasma spraying and cutting; inert gas shielded arc welding; atomic hydrogen welding						■	■							

*Note: **Shaded areas are recommendations for protectors.** Class 1 and Class 2 protectors shall be used in conjunction with recommendations for Class 3, 4, 5, and 6 protectors. The possibility of multiple and simultaneous exposure to a variety of hazards shall be considered in assessing the needed protection. Adequate protection against the highest level of each of the hazards should be provided. This Table cannot encompass all of the various hazards that may be encountered. In each particular situation, thorough consideration should be given to the severity of all the hazards in selecting the appropriate protector or combination of protectors. The practice of wearing protective spectacles (Class 1B) with filter lenses under welding helmets or hand shields is strongly recommended to ensure impact and flash protection to the wearer when the helmet or lift front is raised or the shield is not in use. Protectors that meet the requirements for ignition and flame resistance are not intended to provide protection in environments that expose the user to open flames or high-energy arcs.* Courtesy Canadian Standards Association

Table 2

Recommended Shade Numbers for Arc Welding and Cutting

Operation	Current in amperes																		
	0.5	1.0	2.5	5.0	10	15	20	30	40	60	80	100	125	150	175	200	225	250	275	300	350	400	450	500
SMAW (covered electrodes)										7				8		10				11				
GMAW (MIG)										7				10		10				10				
GTAW (TIG)										8				8				10						
Air carbon arc cutting														10										
Plasma arc cutting																8				9		10		
Plasma arc welding						6						8						10					11	
		1.0		5.0		15		30		60		100		150		200		250		300		400		500

Notes:

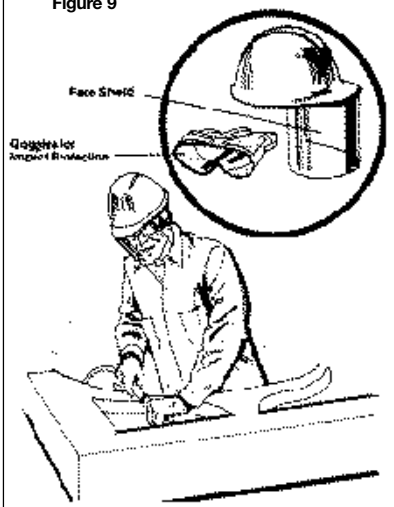
(1) *For other welding processes (e.g., laser, electron beam welding), consult the manufacturer for eye protection recommendations.*

(2) *For pulsed GMAW (MIG), use peak current for selecting the appropriate shade number.*

(3) *For underwater welding, the minimum shade number shown may not necessarily apply.*

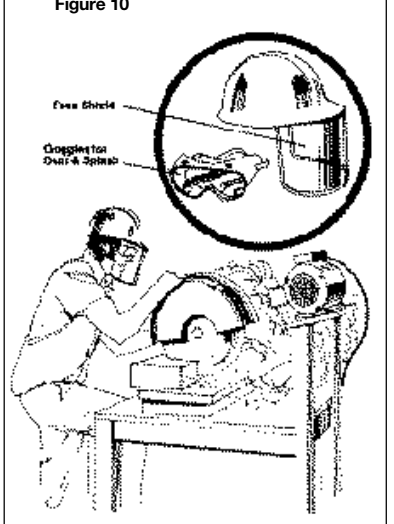
Courtesy Canadian Standards Association

Figure 9



Group A: Flying Objects (Chipping)

Figure 10



Group B: Flying Particles, Dust, Wind, etc. (Sawing)

Figure 11

Group C: Heat, Glare, Sparks, and Splash (Brazing)

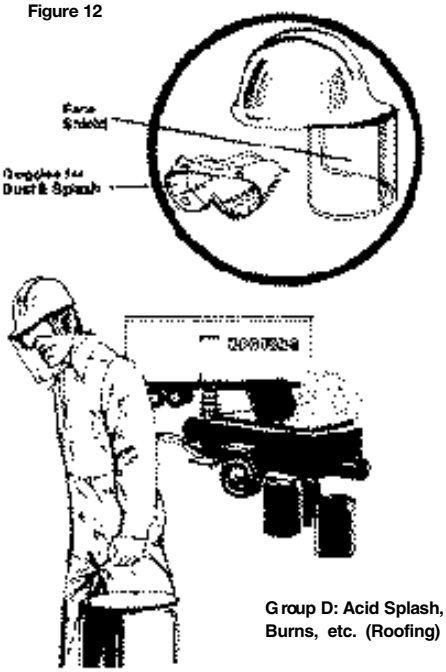
Group D: Acid Splash, Chemical Burns, etc. (Figure 12)

Only eye protection recommended:

Eyecup or cover goggles (for dust and splash) worn with face shields to provide eye and face protection.

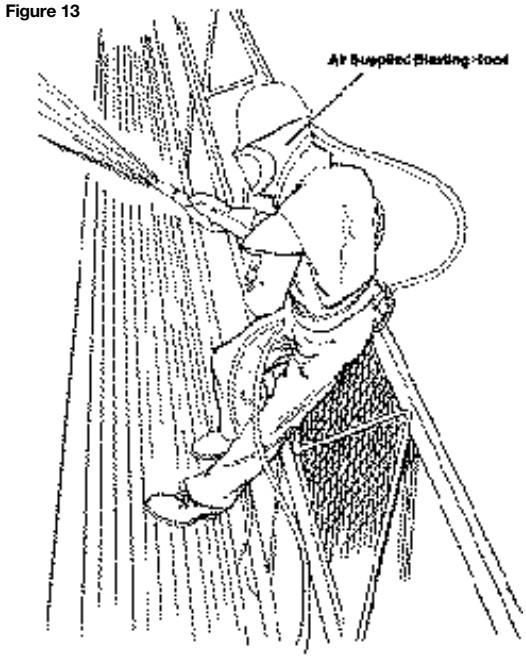
Hoods may also be required for certain hazardous activities such as chemical spraying.

Figure 12



Group D: Acid Splash, Chemical Burns, etc. (Roofing)

Figure 13



Group E: Abrasive Blasting

Group E: Abrasive Blasting Materials (Figure 13)

Minimum eye protection recommended:

Eyecup or cover goggles for dust and splash.

Optimum eye protection recommended:

Hoods with an air line.

Group F: Glare, Stray Light (Figure 14)

These are situations where only slight reduction of visible light is required, e.g., against reflected welding flash. Stray light would result from passing by a welding operation and receiving a flash from the side without looking directly at the operation.

Minimum eye protection recommended:

Filter lenses for radiation protection. Side shields must have filtering capability equal to or greater than the front lenses.

Optimum eye protection recommended:

Goggles with filter lenses for radiation protection. See Table 2 for recommended shade numbers.

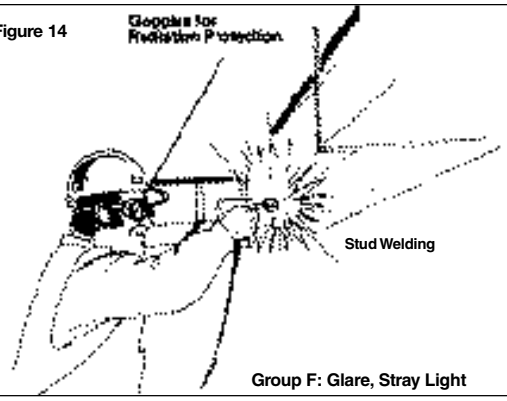
Group G: Injurious Radiation (Figure 15)

These are situations where only moderate reduction of visible light is required: for example, gas welding. Injurious radiation would result from looking directly at the welding operation.

Only eye protection recommended:

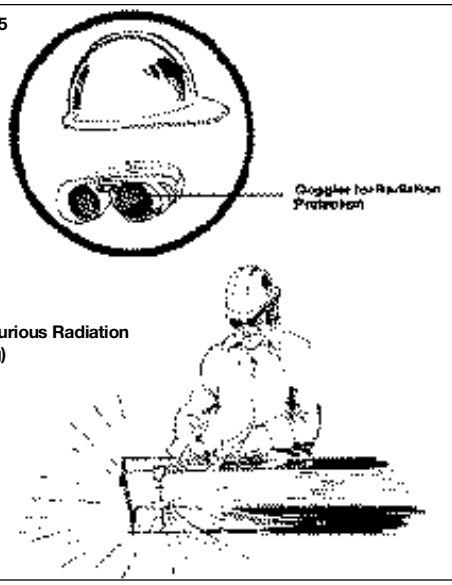
Goggles with filter lenses for radiation protection.

Figure 14



Group F: Glare, Stray Light

Figure 15



Group G: Injurious Radiation (Gas Cutting)

Note: The intensity of the flame and arc is lower in Group G than in Group H. For this reason, required filter shade numbers for this group are also lower. See Table 2.

Group H: Injurious Radiation (Figure 16)

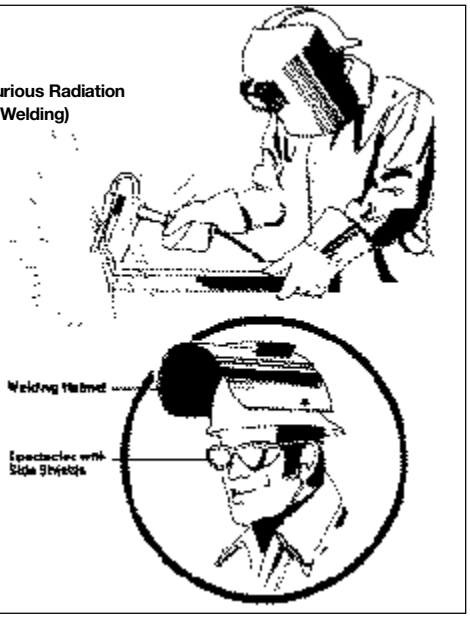
These are situations where a large reduction in visible light is essential, e.g., in electric arc welding.

Only eye protection recommended:

Class 1 spectacles worn with full welding helmets or welding hand shields. These spectacles should incorporate suitable filter lenses if additional protection is required when the welding helmet is in the raised position: for example, when working near other welding operations. See Table 2.

Figure 16

Group H: Injurious Radiation (Electric Arc Welding)



Injuries Associated with Construction Hazards

The cornea is the front layer of the eye and the first point at which light enters the eye; if light rays cannot pass through the cornea, vision is prevented. Injuries to the cornea that cause scarring, scratching, or inflammation can impair sight.

1. **Flying Objects**
   A piece of metal can pierce the cornea and eyeball and possibly cause the loss of an eye.
2. **Dust**
   Dust, sawdust, etc. can cause irritation resulting in a corneal ulcer which is a breakdown of corneal tissue causing a red, watery, or pussy eye.
3. **Heat**
   Heat can burn and severely damage the cornea.
4. **Acid Splash**
   Acid splash and chemicals can burn the cornea, conjunctiva (white coat on the eye), and eyelid and possibly cause loss of sight.
5. **Abrasive**
   Sand can cause a corneal abrasion which can result in loss of sight.
6. **Glare**
   Glare can make it difficult to see and can cause extreme fatigue to the eye.
7. **Radiation**
   Ultraviolet light from a welding arc can damage the cornea.

Correct eye protection, when matched to the hazard, can prevent or reduce the degree of any eye injury. However, once an eye injury has occurred, it is critical that the injury, no matter how small, be given immediate attention and first aid.

Eye protection can only protect against injury if it is worn continuously on-site.

It is often the time when a worker removes eye protection while working near or passing by other hazardous activities on the job that an eye injury results. When it is necessary to remove eye protection, do so only in a location that is completely away from hazardous work areas.
The inconvenience of wearing eye protection is far outweighed by the risk of being blinded in one or both eyes.

Purchase of Protective Spectacles

Protective spectacles are available with “plano” or non-prescription lenses and with prescription lenses.

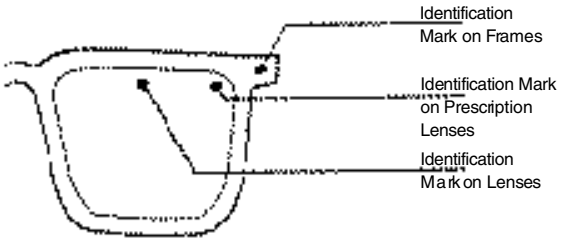
The polycarbonate materials used in safety glasses provide the best protection, while regular plastic CR-39 lenses in industrial thickness provide a substitute where polycarbonate is not available. Anti-scratch coatings are applied to the lens surface to extend useful lens life.

Glass lenses, even when thermally or chemically hardened, are not acceptable for the workplace. Current glass lenses do not meet the impact requirements of CSA Standard Z94.3-99.

When purchasing safety glasses, specify **industrial protection** lenses and frames. This term indicates that the eye protection meets specific test requirements.

Industrial protection safety glasses can be identified by the manufacturer’s or supplier’s logo or monogram which is located on the lens and frame (Figure 17).

Figure 17 – Where to Locate Identification Marks or Symbols



On non-prescription eye protectors, look also for the CSA logo.

This mark must appear on both the frame **and** the lens. It distinguishes industrial quality lenses and frames from streetwear lenses and frames.

The Canadian Standards Association (CSA)

certification program for non-prescription (plano) industrial eye and face protection covers complete protectors only. It does not cover separate components such as lenses, frames, or shields.

In addition to the manufacturer's logo or I.D. mark which appears on the eye protector, the CSA logo will appear to indicate the eye protection meets the requirements of the CSA Z94.3-99 standard. Certification of industrial prescription safety glasses is not yet available.

Until such a program is available, the user should look for the manufacturer's or supplier's logo or I.D. mark on the frame and lens which indicates adherence to the American National Standards Institute (ANSI) Standard Z87.1-1989.

Fitting

Improper fit is the most common reason for resistance to wearing eye protection. A worker who wears non-prescription (plano) lenses and continues to complain about blurred vision after the fit has been checked by a competent person may require prescription lenses. Prescription lenses must be fitted by an optician or optometrist. Plano eye protection should be fitted individually by a trained person.

Here are some general guidelines to follow when fitting the various classes of eye protectors.

Class 1 – Spectacles require that the proper eye size, bridge size, and temple length be measured for each individual. The wearer should be able to lower his head without the spectacles slipping.

Class 2 – Goggles with adjustable headbands should fit snugly over the wearer's spectacles when worn.

Class 3 – Welding helmets are equipped with adjustable attachments to provide a comfortable fit over the head and face. Attachments are also available to fit on hard hats.

Class 4 – Hand-held shields require no adjustment.

Class 5 – Hoods Adjustments are located on the top inside of the hood. A tie is located around the neck to secure the hood and to prevent the entry of dust.

Class 6 – Face shields are equipped with adjustable attachments to provide a comfortable fit over the head and face. Attachments are also available to fit on hard hats.

Class 7 – Respirator facepieces should fit snugly without gaps to make an effective seal against airborne contaminants.

Care

Eye protectors in construction are subjected to many damage-causing hazards. Therefore, care is very important.

1. Lenses should be inspected regularly for pitting and scratches that can impair visibility.
2. Scratched or pitted lenses and loose frames or temples should be replaced or repaired as soon as possible with components from the original manufacturer.
3. Lenses should be cleaned with clear water to remove abrasive dust—cleaning dry lenses can scratch the surface.
4. Anti-fog solutions can be used on glass or plastic lenses.
5. Frames should be handled with care and checked daily for cracks and scratches.
6. Eye protectors should never be thrown into tool boxes where they can become scratched or damaged.
7. Cases should be provided and used to protect spectacle lenses when not being worn.

Contact Lenses

In the construction industry, contact lenses are not a substitute for protective eyewear. Dust and dirt can get behind the contact lenses causing sudden discomfort and impairment of vision.

Contact lenses are also difficult to keep clean when they have to be removed or inserted since there are seldom suitable washing-up facilities on a jobsite.

It is recommended that contact lenses not be worn on construction sites.

However, in cases where contact lenses must be worn to correct certain eye defects, workers should obtain from their ophthalmologist or optometrist written permission indicating the necessity of wearing contact lenses in order to function safely at work. In these cases eye protection, preferably cover goggles, must be worn with the contact lenses.

HEAD PROTECTION

Standards

Requirements for head protection are specified in the current edition of the construction regulation (O. Reg. 213/91).

Under this regulation, hard hats are mandatory for all construction workers on the job in Ontario. The hard hat must protect the wearer's head against impact and against small flying or falling objects, and must be able to withstand an electrical contact equal to 20,000 volts phase to ground.

At the present time, the Ministry of Labour (MOL) considers the following classes of hard hats to be in compliance with the regulation.

Class B
– manufactured and tested in accordance with CSA Standard Z94.1-1977

Class B
– manufactured and tested in accordance with ANSI Z89.1-1986

Type I, Class E
– manufactured and tested in accordance with ANSI Z89.1-1997.

Class E
– manufactured and tested in accordance with CSA Standard Z94.1-1992

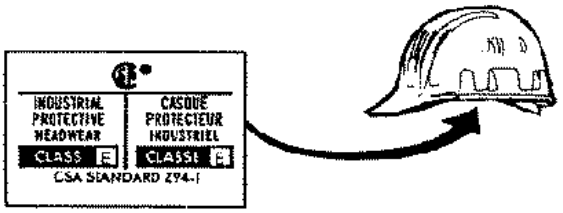
Type II, Class E
– manufactured and tested in accordance with ANSI Z89.1-1997.

"Type" and "Class" of hard hat can be identified by the CSA or ANSI label. Some manufacturers also stamp the CSA or ANSI classification into the shell of the hard hat under the brim.

Styles

New Class E hard hats come in three basic styles:

1) standard design with front brim, rain gutter, and attachment points for accessories such as hearing protection
2) standard design with front brim and attachment points for accessories but without a rain gutter
3) full-brim design with attachment points for accessories and brim that extends completely around the hat for greater protection from the sun.



CSA label, stamped into the shell, indicating Class E hard hat

FOOT PROTECTION

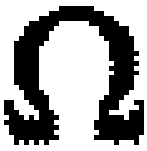
Ankle injuries represent 50% of all foot injuries in Ontario construction. Properly worn, a CSA-certified Grade 1 workboot meets the requirements of the current construction regulation (O. Reg. 213/91) and helps protect against ankle and other injuries.

One of three CSA grades, Grade 1 offers the highest protection and is the only one allowed in construction. In a Grade 1 boot, a steel toe protects against falling objects while a steel insole prevents punctures to the bottom of the foot.

Grade 1 boots can be identified by

- a green triangular patch imprinted with the CSA logo on the outside of the boot and
- a green label indicating Grade 1 protection on the inside of the boot.

Grade 1 boots are also available with metatarsal and dielectric protection. A white label with the Greek letter Omega in orange indicates protection against electric shock under dry conditions.



Greek Omega Label

Selection and Fit

Grade 1 boots are available in various styles and sole materials for different types of work. For example, Grade 1 rubber boots may be better suited than leather boots for sewer and watermain or concrete work.

Boots should provide ample “toe room” (toes about 1/2 inch back from the front of steel box toe cap when standing with boots laced).

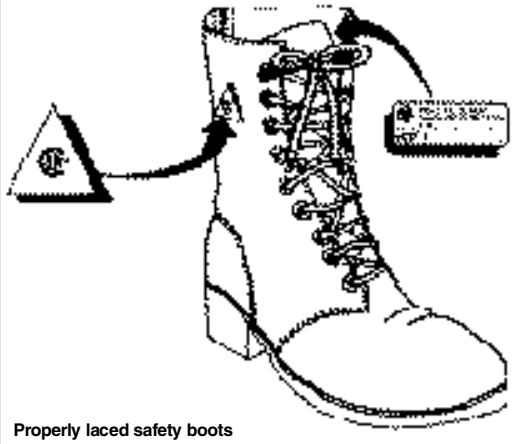
When fitting boots, allow for heavy work socks. If extra sock liners or special arch supports are to be worn in the boots, insert these when fitting boots.

Care and Use

Lacing boots military style permits rapid removal. In an emergency, the surface lace points can be cut, quickly releasing the boot.

In winter, feet can be kept warm by wearing a pair of light socks covered by a pair of wool socks. Feet should be checked periodically for frostbite.

Use high-cut (260 mm or 9 in) or medium-cut (150 mm or 6 in) CSA Grade 1 workboots. The higher cut helps support the ankle and provides protection from cuts or punctures to the ankle.



Properly laced safety boots with CSA labels

HEARING PROTECTION

Introduction

Construction generally produces noise. Typical construction work may involve equipment driven by large and small engines, metal fabrication, power drilling and sawing, air hammering, and blasting – all of which can produce noise at harmful levels.

Depending on the noise level, duration of exposure, and other factors, a temporary or permanent hearing loss may result. Temporary hearing losses will usually be restored by the body within a few hours after the exposure has ceased. Hearing losses which cannot be restored by the body over any length of time are termed permanent.

A person suffering a hearing loss will frequently not realize it. Noise may be harmful at levels that an exposed person does not consider irritating or annoying. Therefore, despite **individual** preferences, prevention and control procedures must be based on the **general** potential for hearing loss.

Waiting for personal discomfort before taking preventive measures may be too late to avoid a permanent noise-induced hearing loss.

Noise Measurement

Measuring sound levels can determine

- whether or not a noise hazard is present
- noise exposures of workers
- which workers require hearing protection, hearing tests, education, and training.

Measurements are performed with a sound level meter (SLM). The unit used to measure the intensity of sound is the decibel (dB). Intensity is perceived as loudness.

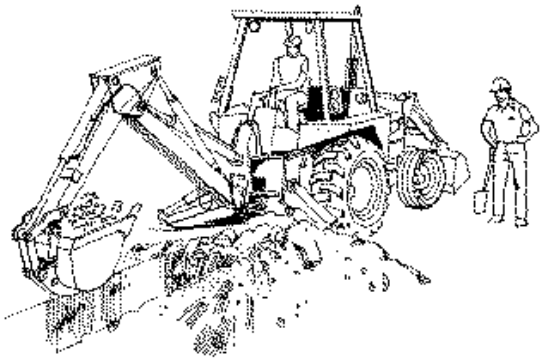
Noise levels can't be added directly like other numbers. For example, two noise sources producing 90 dB each would have a combined output of 93 dB, not 180 dB. The combined output of 93 dB is actually a *doubling* of intensity.

In many construction situations several different sources each contribute to the overall noise. This means that a worker's exposure may be much higher than it would be if only one of the sources was present (Figure 1).

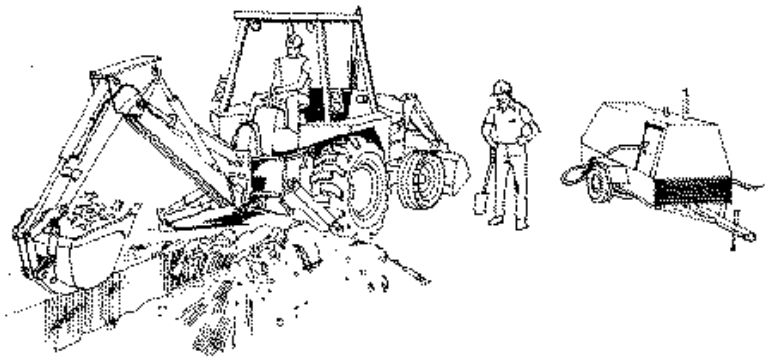
In addition to intensity, the SLM can detect a wide range of frequencies. Since the human ear tends to filter out the lower frequencies and slightly accentuate the higher ones, SLMs are engineered to do the same. They feature an internal mechanism called "A-weighting." The resulting noise level is expressed as decibels (dB) on the "A" scale or dBA.

Two types of noise measurements can be performed: area and personal.

Figure 1



The backhoe is producing 90 dB of noise. The worker standing nearby is therefore exposed to 90 dB.



The backhoe is producing 90 dB. The compressor is also producing 90 dB. The worker standing between the two pieces of equipment is therefore exposed to their combined output. This double intensity is 93 dB.

An **area noise measurement** is taken in a specific work area. The measurement is generally used as a preliminary step to determine whether more detailed evaluation involving personal noise measurement is necessary. Area noise readings should not be used to determine what hearing protection is required or who needs a hearing test. Personal exposure measurement should be used for these purposes.

Personal noise measurement involves a small device called a noise dosimeter. Workers can wear the device to determine their average noise exposure over a whole shift. Usually worn around the waist, the dosimeter has a microphone that is placed as close to the worker's ear as possible.

Noise measurements should be carried out in accordance with acceptable standards. Canadian Standards Association (CSA) Standard Z107, *Procedures for the Measurements of Occupational Noise Exposure*, provides guidance on the type of equipment to use, which workers to test, and how to test.

Noise evaluation must be done by a knowledgeable person trained and experienced in conducting noise surveys.

Hearing Process

The hearing process begins when the outer ear directs sound waves into the ear canal (Figure 2). The eardrum vibrates as sound waves strike it. This vibration is then transmitted through the middle ear where it is amplified on a membrane called the oval window. The oval window separates the middle ear from the inner ear where the sensitive hearing organs are located. Attached to the other side of the oval window is a tiny, snail-shaped structure called the cochlea. The cochlea contains fluid and hair cells. These thousands of small but highly sensitive hair cells feel the vibration. Responding to the cells are microscopic nerve endings that send messages to the brain, where the signals are interpreted as varieties of sound.

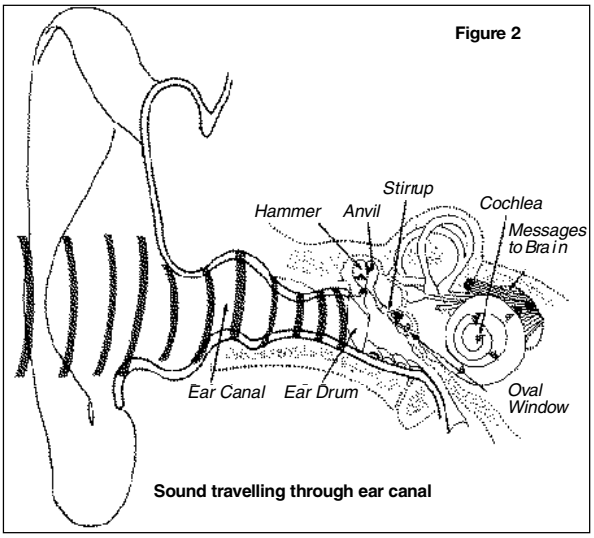
Hearing Loss

Any reduction in the normal ability to hear is referred to as a loss of hearing. A hearing loss can be either temporary or permanent.

Temporary Threshold Shift

With a temporary hearing loss, normal hearing will usually return after a rest period away from all sources of intense or loud noise. The recovery period may be minutes, hours, a day or perhaps even longer. It is believed that a temporary hearing loss occurs when hair cells in the inner ear have been bent by vibrations and need time to bounce back.

Most of the temporary hearing loss occurs during the first two hours of exposure and recovery takes place usually within the first two hours after exposure stops.



However, the length of time needed for recovery depends primarily on how great the initial loss was. The greater the initial loss the longer the time needed to recuperate. This temporary decrease in hearing ability is called a temporary threshold shift (TTS) because the threshold or level at which sound can be heard has been raised.

For instance, to listen to your favourite music at the volume you like, you would have to turn it up a few more notches than usual. This phenomenon explains why some people, particularly those who suffer from some form of hearing loss, claim that they "get used to the noise."

If these previous exposures are allowed to continue under the same conditions and without the proper interval of rest, then a certain degree of permanent hearing loss is possible.

Permanent Threshold Shift

Permanent hearing loss is the result of hair cell or nerve destruction within the cochlea. Once these important parts of the hearing process are destroyed, they can never be restored or regenerated. The resulting permanent hearing loss, also referred to as permanent threshold shift (PTS), can range from slight impairment to nearly total deafness.

A symptom of PTS is the inability to pick up sounds with higher frequencies. As damage increases, the reception of speech becomes more difficult.

Unfortunately, the damage builds up gradually. Workers may not notice changes from one day to another. But once the damage is done there is no cure. Effects may include the following.

- Sounds and speech become muffled so that it's hard to tell similar-sounding words apart or to pick out a voice in a crowd.
- Sufferers ask people to speak up, then complain that they are shouting.
- There's a permanent ringing in the ears (tinnitus).
- Sufferers need to turn the volume on the radio or television way up or find it hard to use the telephone.

Determining Factors

The following factors determine the degree and extent of hearing loss:

- **Type of Noise**
  (continuous, intermittent, impact, high or low frequency)
- **Intensity of Noise**
  (level of loudness)
- **Duration of Exposure**
  (length of time worker subjected to noise – for example, during day, on specific shifts)
- **Employment Duration**
  (years worker subjected to noise)
- **Type of Noise Environment**
  (character of surroundings – for example, enclosed, open, reflective surfaces)
- **Source Distance(s)**
  (distance of worker from noise source)
- **Worker's Position**
  (position of worker relative to noise source)
- **Worker's Age**
  (for instance, a 20-year-old apprentice versus a 50-year-old journeyperson)
- **Individual Susceptibility**
  (sensitivity difference, physical impairments)
- **Worker's Present Health**
  (whether a worker has any detectable losses or ear diseases)
- **Worker's Home and Leisure Activities**
  (exposures to noise other than occupational, such as hunting, skeet shooting, earphone music, snowmobiling, etc.)

Other prime causes of permanent hearing loss are age, traumatic injuries (such as from explosions or gunfire), and infection.

Noise, however, is the major identifiable cause of hearing loss. Therefore, it is important that controls are exercised wherever possible so that such losses can be prevented.

Hearing Protection

One form of controlling noise hazards is through the proper use of hearing protection devices (HPDs). Hearing protectors should be provided when engineering controls cannot be implemented or while such controls are being initiated.

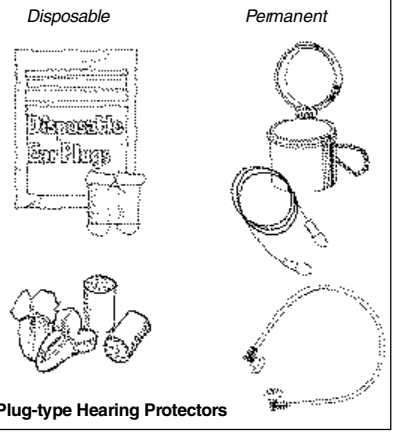
Hearing protective devices are barriers that reduce the amount of noise reaching the sensitive inner ear. Fit, comfort, and sound reduction or "attenuation" are important considerations in choosing HPDs.

Commonly used hearing protection devices are either earplugs or earmuffs. Earplugs attenuate noise by plugging the ear canal (Figure 3). The muff-type protector is designed to cover the external part of the ear providing an "acoustical seal" (Figure 4). Table 1 describes some of the characteristics of these different types of hearing protectors.

Effectiveness

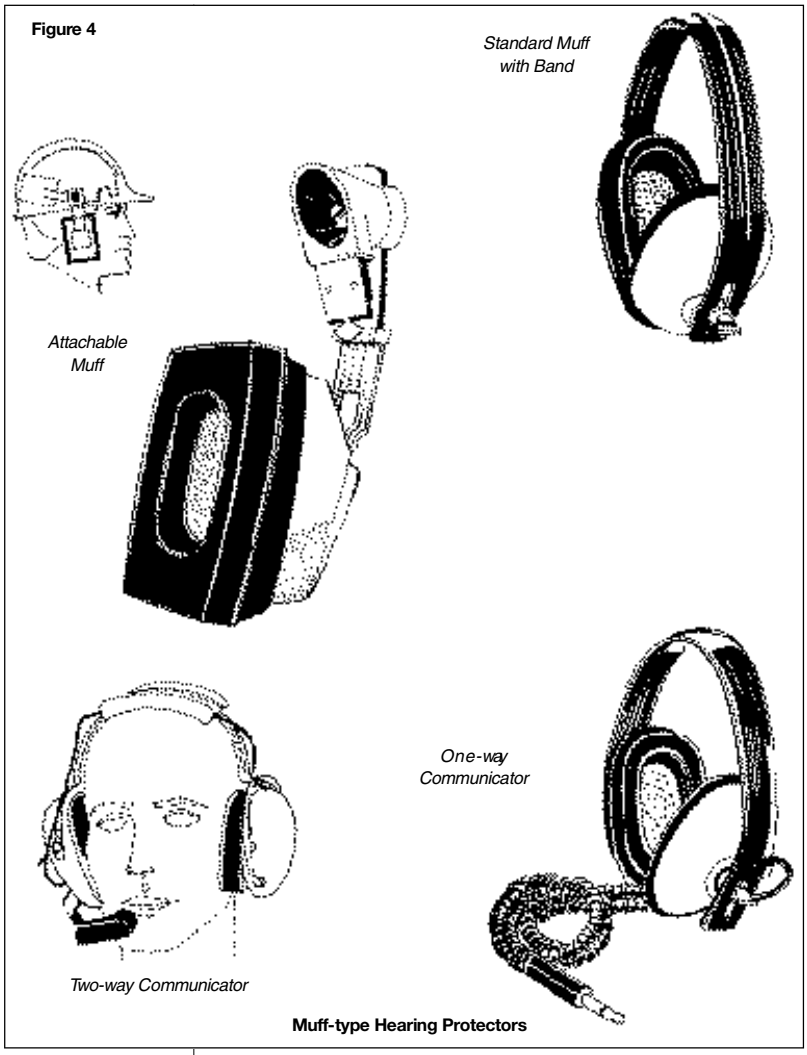
Obviously, the effectiveness of an HPD depends on the amount of time it is worn. What is not obvious to most wearers is the drastic reduction in protection if HPDs are not worn in noisy environments even for short periods of time.

Figure 3



Plug-type Hearing Protectors

Figure 4



Muff-type Hearing Protectors

The reduction in effectiveness can be as great as 95% or more if the protectors are not worn for as little as three or four minutes. It is therefore important to wear HPDs during the entire noise exposure period in order to achieve the maximum protection available.

The effectiveness of HPDs also depends on the manner in which noise is transmitted through or around the protector. The following points should be noted.

- Even relatively small openings or air leaks in the seal between the hearing protector and the skin can typically reduce attenuation by 5 to 15 dB or more.
- Constant movement of the head or body vibration can lead to air leaks, therefore making periodic adjustments necessary to ensure a proper seal.
- Hair, especially long hair and facial hair, can cause a poor fit.
- Proper fitting is crucial to obtaining a reasonable degree of protection from an HPD.
- Earmuff effectiveness is greatly influenced by headband tension. If tension decreases through routine usage or alteration by the user, earmuff effectiveness is reduced.
- Modifying the earmuff by drilling holes in the earcups renders the protection useless.
- Anatomical differences such as ear canal size, jaw size, and heads of different shape and size may affect the fit of earmuffs and earplugs. To accommodate these differences, HPDs should be made available to users in various shapes and sizes.
- Recreational headsets such as those used with radios and CD players are **not** to be used as hearing protection.

Selection Criteria

In addition to attenuation characteristics, the following factors should be considered when selecting hearing protectors:

– noise exposure levels and standards
– comfort
– appearance
– communication requirements
– work environment or work procedures
– overprotection.

Noise Exposure Levels and Standards

Identifying the noise level(s) to which an individual may be exposed throughout an entire working day determines the class of hearing protector needed.

Evaluation is based on eight-hour noise exposure, not a spot or area measurement. For example, a quick-cut saw operated by a mason may produce a noise level of 110 dBA. But the mason may only be exposed to an average of 92 dBA over the full eight-hour shift. The reason is that the saw is not operated continuously during that period. There will be times when the worker is laying brick, taking a coffee break, or eating lunch.

CSA Standard Z94.2, *Hearing Protectors*, identifies classes of hearing protectors as A, B, and C. Protectors are classed by attenuation ability under laboratory

Table 1: Types of Hearing Protectors

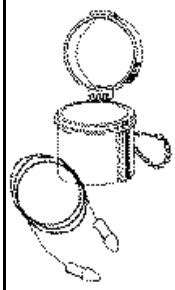
	FOAM EARPLUGS	PREMOULDED EARPLUGS	EARMUFFS	FORMABLE EARPLUGS	CUSTOM-MOULDED EARPLUGS	SEMI-INSERT EARPLUGS
						
STYLE and COMFORT	Consist of compressible plastic foam. Come in many shapes. Often described as "disposable plugs." Elasticity lets them adapt easily to changes in ear canal.	Usually made of plastic or silicone rubber attached to a flexible stem for handling and insertion. Come in many shapes and sizes to suit different ear canals.	Consist of two insulated plastic cups attached to metal or plastic band. Cups equipped with soft cushions for seal and comfort. Head band tension ensures good seal.	Made from pliable material such as cotton/wax mixture, silicone putty, and mineral wool.	Custom made to fit a particular ear by taking an impression of the ear, making a mould, and casting a plug.	Commonly known as banded earplugs or canal caps. They consist of small caps or pods that are held in place over the ear canal by spring-loaded bands.
INTENDED USE	Most brands can be reused a few times before being discarded.	To be used more than once.	To be used regularly. Can be worn with or without plugs. Easily attached to hard hats.	• Single-use for mineral wool products. • Multi-use for cotton/wax products. • Semi-permanent for silicone putty products.	Permanent use	To be used more than once.
HYGIENE PRACTICES	Clean hands required each time fresh plugs inserted.	Plugs should be cleaned regularly with warm soapy water, preferably after each removal from ear.	General maintenance required. Head band must be maintained. Cushions must be replaced when soiled or brittle.	Clean hands required for shaping and insertion.	Wash with hot water and soap, preferably after removal.	Wash with hot water and soap, preferably after removal.
ADVANTAGES	Low risk of irritation. One size fits most workers.	Reusable.	Less likely to cause irritation. When attached to hard hat, always available for use.	Relatively cheap	Good fit only if a proper impression of the ear is taken.	Good for when frequent removal is required.
DISADVANTAGES	Use requires clean hands. Large supply required for frequent removals and usage.	Plugs must be kept clean to prevent irritation. May produce some discomfort with pressure. Though reusable, plugs degrade over time. Inspect and replace as necessary.	Bands may wear out and tension decrease. Eyewear and hair may interfere with fit and reduce protection.	Not recommended for the noise levels found on construction projects.	If the wearer's weight changes drastically, new plugs should be made. Plugs can be lost, shrink, harden, or crack over time, and must be replaced.	Proper seal is necessary for good attenuation.

Table 2

MAXIMUM NOISE LEVEL (dBA)	RECOMMENDED CLASS OF HEARING PROTECTOR
Less than 85 dbA	No protection required
Up to 89 dBA	Class C
Up to 95 dBA	Class B
Up to 105 dBA	Class A
Up to 110 dBA	Class A plug + Class A or Class B muff
More than 110 dBA	Class A plug + Class A or Class B muff and limited exposure

Recommended criteria for selecting a class of hearing protector, based on a daily 8-hour exposure to noise levels in dBA. Adapted from CSA Standard Z94.2-M1984.

conditions modified by certain practical field considerations. Class A protectors offer the highest ability to attenuate, followed by B and C.

Table 2 provides guidelines for proper selection. Table 3 lists typical noise levels for various kinds of construction equipment. The upper limits of the noise levels can be used as a guide in selecting a specific class of hearing protectors.

Comfort

Comfort is an important consideration in selection. An HPD that isn't comfortable will simply not be worn or will be worn improperly.

With earplugs several factors affect comfort. Since some plugs are relatively non-porous they can often create a pressure build-up within the ear and cause discomfort. Dirty plugs may irritate the ear canal. The shape of an individual's ear canals may not allow certain plugs to fit properly.

Earmuffs should be made of materials which do not absorb sweat and which are easy to maintain and clean. The earmuff cup should be adjustable to conform to various head sizes and shapes. Headband tension and earcup pressure should be adjusted so that they are effective without being uncomfortable. Weight may also be a factor.

Workers should be allowed to try out various HPDs to determine which are most comfortable.

Appearance

HPD appearance may influence selection. Those that look bulky or uncomfortable may discourage potential users. Allowing workers to select from various HPDs, or various makes of the same HPD, can help overcome this problem.

Speech Requirements

Consider the level of the noise hazard and the risks of impaired communication (Table 4). The potential for speech interference is greatest when background noise – meaning all noises generated in the surrounding area – is

Table 3

TYPICAL NOISE LEVEL MEASUREMENTS FOR CONSTRUCTION	
* EQUIPMENT	NOISE LEVEL (DBA) AT OPERATOR'S POSITION
Cranes	78 – 103
Backhoes	85 – 104
Loaders	77 – 106
Dozers	86 – 106
Scrapers	97 – 112
Trenchers	95 – 99
+ PIle drivers	119 – 125
Compactors	90 – 112
+ Explosive-actuated tools	120 – 140
Grinders	106 – 110
Chainsaws	100 – 115
Concrete saw	97 – 103
Sand blasting nozzle	111 – 117
Jackhammers	100 – 115
Compressors	85 – 104

* Generally, newer equipment is quieter than older equipment. (For noise levels of specific equipment, contact the Construction Safety Association of Ontario.)

\+ Pile drivers and explosive-actuated tools generate intermittent or "impulse" sound.

low. In this case HPD wearers with impaired hearing may have difficulty understanding speech because they must contend not only with their hearing loss but with the attenuation of their protector as well. In other cases, the use of HPDs by workers with normal hearing may actually *improve* their understanding of speech in noisy environments.

In other words, wearing HPDs doesn't always reduce the ability to communicate. Factors to consider include the user's hearing ability, noise levels, and the type of HPD. Where two-way communication is vital, radio-equipped hearing protectors can be worn (Figure 4).

Work Environment/Procedures

Choosing an HPD is sometimes dictated by the constraints of the work area or work procedures. For example, large volume earmuffs may not be practical in confined work situations with little head room or clearance.

In this case, flat-cup muffs or earplugs may be more practical. Where work is necessary near electrical hazards, it may be desirable to use non-conductive suspension-type muffs. The type of protector may also be determined by the nature of work, as in welding where certain types of earmuffs may interfere with the welder's helmet.

The attenuation of the muff-type hearing protector may be considerably reduced when worn with spectacle-type safety glasses. (The head configuration of the wearer and the type of glasses worn will determine the reduction in attenuation.) Where safety glasses must be worn, cable-type temples should be used in order to allow the smallest possible opening

Table 4

Effects of Hearing Protectors on Understanding Speech

HEARING ABILITY OF WEARER	BACKGROUND / SURROUNDING NOISE LEVELS IN dBA		
	Less than 75	75 to 85	Greater than 85
Normal hearing	Little effect	No effect	Improves communication
Impaired hearing	Moderate effect	Little effect	No effect

between the seal of the protector and the head. Otherwise earplugs should be worn, provided they are adequate.

Consideration should be given to hearing protectors which can be attached to hard hats where exposures to noise may be high but intermittent and where hard hats must be worn at all times. Periodic adjustments may be necessary because movement of the hard hat may break the seal of the HPD.

Consideration should also be given to work involving oils, grease, and other products which may soil hands. Ear infections may occur when earplugs are inserted by soiled hands.

Overprotection

Workers wearing HPDs that provide too much attenuation may feel isolated from their surroundings. Sounds may be heard as muffled. Speech or warning sounds may be unrecognizable. Overprotection can lead workers to resist wearing HPDs. Protectors should be chosen to provide sufficient, but not excessive, attenuation. The objective should be to reduce noise levels to or below the recommended maximum eight-hour exposure of 85 dBA, but not below 70 dBA.

Fit, Care, and Use

Workers should be instructed in the proper fitting of HPDs as recommended by the manufacturer. Training should include a demonstration. Workers should then practice using the HPDs under close supervision. Checks are needed to ensure the best possible protection. Many of these checks relate to fit.

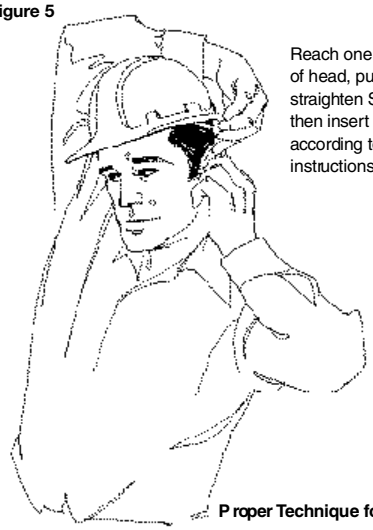
Earmuffs

1) Earmuffs should conform to the latest issue of CSA Standard Z94.2.
2) The cup part of the earmuff should fit snugly over the entire ear and be held firmly in place by a tension band.
3) The cup and band should not be so tight as to cause discomfort.
4) Cup, cushion, and band should be checked for possible defects such as cracks, holes, or leaking seals before each use of the HPD.
5) Because band tension can be reduced over a period of time, the band may require repair or replacement.
6) Defective or damaged parts should be repaired or replaced as needed. Tension band, cushions, and cups are readily replaceable.

Earplugs

1) Earplugs should conform to the latest issue of CSA Standard Z94.2.
2) For maximum attenuation the method of insertion illustrated in Figure 5 should be used. Because the ear canal is slightly S-shaped, the ear must be pulled back to straighten the canal for the plug to fit properly.

Figure 5



Reach one hand around back of head, pull ear upwards to straighten S-shaped ear canal, then insert plug with other hand according to manufacturer's instructions.

Proper Technique for Inserting Earplugs

3) Earplugs must be fitted snugly in the ear canal. This will cause some discomfort initially. However, in time (usually a period of two weeks) the discomfort vanishes. Should there be severe discomfort initially or mild discomfort for more than a few weeks, seek professional advice. In most instances it will only be a matter of re-sizing, although some ear canals cannot be fitted with plugs because of obstructions, unique shapes, or deformities. In fact, the shape of one ear canal may be entirely different from the other.
4) Reusable earplugs should be washed with warm soapy water daily to prevent the remote possibility of infection or other discomfort. When not in use, they should be kept in a clean container.
5) Earplugs with torn or otherwise damaged flanges should be replaced.

WARNING: Cotton batten does not provide adequate protection from construction noise.

Training

Workers who wear HPDs should be trained to fit, use, and maintain the protectors properly. Workers should understand

- that there is risk of hearing loss if HPDs are not worn in noisy environments (eight-hour exposure of 85 dBA)
- that wearing HPDs is required in all situations where noise exposure may damage hearing
- that to be effective an HPD must not be removed even for short periods
- that various HPDs are available to accommodate differences in ear canal size, jaw size, head size and shape, comfort level, compatibility with other forms of PPE, etc.
- that proper fit is essential to achieve maximum protection.

Audiometry

Anyone who works with noisy equipment on a regular basis should take a periodic audiometric or hearing capability test for the following reasons:

1) **To determine whether or not a hearing loss exists.** Even if no hearing loss is detected, workers exposed to noise levels in excess of 90 dBA should wear hearing protectors. Workers who have some hearing loss should wear HPDs to minimize any further loss.
2) **To determine the type of hearing loss.** Certain hearing losses can be reversed. Some individuals have suffered for years only to find out that their hearing problem could have been corrected surgically. These situations usually occur as a result of birth defects and are known as "conductive losses."
3) **To determine the effectiveness of programs for noise control and hearing protection.** Early identification is important so that prevention practices can be implemented, maintained, and revised when necessary.

Summary

Control of noise in construction is of growing importance as a result of increasing hearing loss claims.

Most noise problems can be analyzed in terms of source, transmission path, and receiver. This allows a convenient understanding of the overall problem and a useful approach to remedial measures. The three components can usually be treated in isolation, although sometimes all three must be considered together in order to control unacceptable noise levels.

At source, remedial measures are aimed at reducing the noise being generated.

Along the transmission path, barriers can be introduced to reduce or eliminate noise reaching the ears.

For the receiver, remedial measures involve personal protective equipment properly selected, fitted, and worn. The equipment must be used in high noise environments **all the time.**

Failure to provide preventive or control measures will result in temporary and ultimately permanent hearing losses.

The Construction Safety Association of Ontario can assist management and labour in the industry by providing useful information, research, and training.

RESPIRATORY PROTECTION

Introduction

In the course of their work, construction personnel are often exposed to respiratory hazards in the form of dangerous dusts, gases, fumes, mists, and vapours.

In some cases careful selection of materials and work practices can virtually eliminate respiratory hazards. Where that is not possible, the next best choice is engineering controls such as fume exhaust systems that deal with the hazard at the source.

Respirators are the least preferred method of protection from respiratory hazards because they

- do not deal with the hazard at the source
- can be unreliable if not properly fitted and maintained
- may be uncomfortable to wear.

In spite of these drawbacks, in many construction operations respiratory protective equipment is the only practical control.

Respiratory Hazards

Respiratory hazards may be present as

- gases
- vapours
- fumes
- mist
- dusts.

Gases — consist of individual molecules of substances, and at room temperature and pressure, they are always in the gaseous state. Common toxic gases found in construction are carbon monoxide from engine exhaust and hydrogen sulphide produced by decaying matter found in sewers and other places.

Vapours — are similar to gases except that they are formed by the evaporation of liquids (e.g., water vapour). Common vapours found in construction are produced by solvents such as xylene, toluene, and mineral spirits used in paints, coatings, and degreasers.

Fumes — are quite different from gases or vapours, although the terms are often used interchangeably. Technically, fumes consist of small particles formed by the condensation of materials which have been subjected to high temperatures. Welding fume is the most common type of fume in construction. Other examples include pitch fume from coal tar used in built-up roofing and fume from diesel engines.

Mists — are small droplets of liquid suspended in air. The spraying of paint, form oils, and other materials generates mists of varying composition.

Dusts — are particles which are usually many times larger than fume particles. Dusts are generated by crushing, grinding, sanding, or cutting and by work such as demolition. Two kinds of hazardous dust common in construction are fibrous dust from insulation materials (such as asbestos, mineral wool, and glass fibre) and non-fibrous silica dust from sandblasting, concrete cutting, or rock drilling.

In construction settings, respiratory hazards may be compounded, depending on the number and variety of jobs under way. For example, both mist and vapours may be present from paint spraying or both gases and fumes from welding.

Health Effects

Respiratory hazards can be divided into the following classes based on the type of effects they cause.

Irritants are materials that irritate the eyes, nose, throat, or lungs. This group includes fibreglass dust, hydrogen chloride gas, ozone, and many solvent vapours. With some materials (e.g., cadmium fume produced by welding or oxyacetylene cutting of metals coated with cadmium) the irritation leads to a pneumonia-like condition called pulmonary edema. **This effect may not be apparent**

until several hours after exposure has stopped.

Asphyxiants are substances which result in inadequate oxygen in the body. They can be classified as either **simple asphyxiants** or **chemical asphyxiants.**

Simple asphyxiants are other gases or vapours which cause oxygen to be displaced, creating an **oxygen-deficient atmosphere**. Oxygen content of 18% may lead to some fatigue during exertion. Oxygen concentrations lower than 15% can cause loss of consciousness and may be fatal. For example, nitrogen used to purge tanks can displace oxygen, resulting in unconsciousness and even death for those who enter. Oxygen may also be consumed by chemical or biological activity such as rusting or bacteria digesting sewage.

Chemical asphyxiants interfere with the body's ability to transport or use oxygen. Two examples are carbon monoxide and hydrogen sulphide.

Central nervous system depressants interfere with nerve function and cause symptoms such as headache, drowsiness, nausea, and fatigue. Most solvents are central nervous system depressants.

Fibrotic materials cause "fibrosis" or scarring of lung tissue in the air sacs. Common fibrotic materials found in construction include asbestos and silica.

Carcinogens cause or promote cancer in specific body organs. Asbestos is the most common carcinogen in construction.

Nuisance dusts do not cause significant effects unless exposure is of high concentration and/or long duration. Excessive exposure to these substances can be adverse in itself or can aggravate existing conditions such as emphysema, asthma, or bronchitis. Examples include plaster dust, cellulose from some insulation, and limestone dust.

Respiratory Protective Equipment

A wide variety of equipment can be used to protect workers from respiratory hazards. Devices range from simple, inexpensive dust masks to sophisticated self-contained breathing apparatus. Generally, the equipment can be divided into two distinct classes — air-purifying respirators and supplied-air respirators.

Air-Purifying Respirators

As their name indicates, these devices purify the air drawn through them. There are two main types of air-purifying respirators:

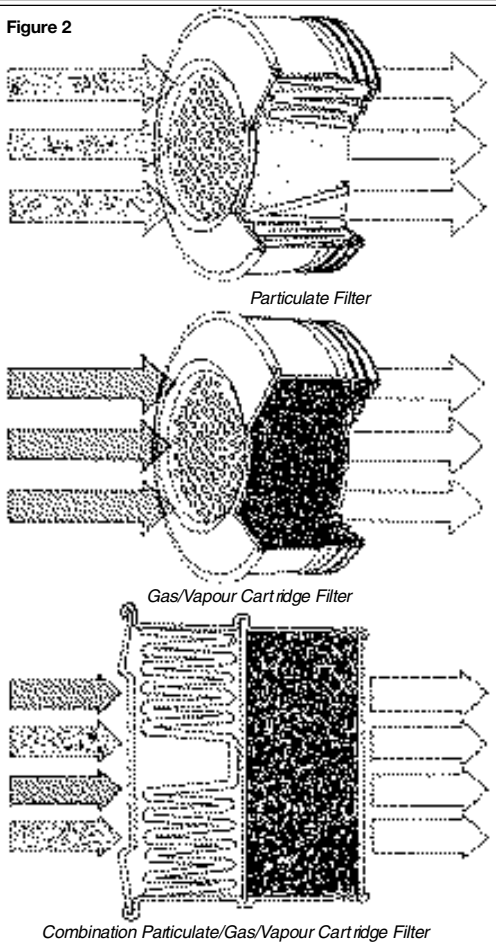
1) **Non-powered**
   Air is drawn through the air-purifying filter by the wearer breathing in and creating a negative pressure in the facepiece. Non-powered respirators depend entirely on the wearer breathing in (inhaling) and breathing out (exhaling) to deliver an adequate supply of purified breathing air.
2) **Powered**
   These respirators have a blower that blows purified air into the facepiece. (Figure 6, page 55).

Air-purifying respirators have limitations and should not be used where

- there is insufficient oxygen
- very high concentrations of contaminant are present
- the contaminant cannot be detected by odour or taste at safe levels.

Warning: Air-purifying respirators simply remove certain airborne hazards. They do not increase or replenish the oxygen content of the air and should never be worn in atmospheres containing less than 19.5% oxygen.

Figure 2



Filter Types

Although many different filters have been designed for specific hazards, there are three basic types used with air-purifying respirators:

- particulate filters
- gas/vapour cartridge filters
- combination particulate/gas/vapour filters. See Figure 2.

Particulate Filter

This type removes solid particles such as dusts, fumes, or mists and operates like the air filter in a car engine. The devices may be filtering facepiece respirators or respirators with replaceable filters. Different grades of filters are available, depending on the size of particles to be removed.

When particulate filters fill up with dust or fume, they become harder to breathe through but are more efficient, since air is being filtered through the layer of trapped particles as well as the filter itself.

While particulate filters can provide good protection against particles such as dusts, mists, or fumes, they cannot filter out gases or vapours because of the very small size of gas and vapour molecules.

Particulate filters for non-powered air-purifying respirators are divided into three levels of filter efficiency: 95%, 99%, and 99.97%. These numbers refer to the percentage of particles the filter can remove, based on the particle size most difficult to trap. Filters rated to these efficiencies outperform the dust/mist and dust/fume/mist filters of the past. For workers removing asbestos insulation or lead paint, for instance, the 99.97% efficiency cartridge would be the best choice. This is known as the 100 efficiency class, previously identified as the HEPA filter.

Oil has been found to ruin the filtering ability of some filter material. Oil coats the filter fibres, preventing the electrostatic charge on the fibres from attracting and removing particulates. Therefore, to ensure that a suitable filter is being used, particulate filters have an N, R, or P designation:

N – **N**ot resistant to oil

R – **R**esistant to oil

P – oil-**P**roof.

The N series of filters is suitable for airborne particles such as wood dust, when there are no oil-based particles also in the air. For example, an N series filter would be recommended during the removal of old lead paint. However, when spraying form oil or putting down hot asphalt—operations that involve airborne oil particles—the correct filter would have an R or P designation.

The R series—resistant to oil—should only be used for a single shift when solvent or oil mist is present in the air. This filter resists oil but may lose its filtering ability when in contact with oil over a long time.

When using P series filters, check the manufacturer's instructions to determine how long the filter can be used when airborne oil particles are present. P series filters were originally thought to be oil-proof but tests show there may be some loss of filtering ability with long-term oil exposure.

Warning: N, R, and P series filters by themselves do not provide protection against organic vapours.

Gas/Vapour Cartridge Filter

This type uses substances which absorb or neutralize gases and vapours. Unlike particulate filters, gas/vapour cartridge filters become less efficient the longer they are used. They act like sponges and, when full, allow gas or vapour to pass through without being absorbed. This is called "breakthrough."

Common gas/vapour cartridge filters include the following:

- "Organic Vapour Cartridges" usually contain activated charcoal to remove vapours such as toluene, xylene, and mineral spirits found in paints, adhesives, and cleaners.
- "Acid Gas Cartridges" contain materials which absorb acids and may be used for protection against limited concentrations of hydrogen chloride, sulphur dioxide, and chlorine.
- "Ammonia Cartridges" contain an absorbent designed specifically to remove only ammonia gases.

Note

For respirators equipped with gas or vapour cartridges to be used safely, the contaminant must have good warning properties (odour, taste, or breathing irritation) that let the user know the cartridge is no longer working. When the user senses contaminant starting to penetrate the cartridge, it's time to change the cartridge.

When users depend on odour as a warning, the odour threshold of the contaminant must be below its exposure limit.

Certain cartridges are available with an end-of-service-life indicator. These cartridges have been developed for a few contaminants with poor warning properties such as carbon monoxide. The end-of-service-life indicator changes colour to warn the user to change the cartridge.

Cartridges must not be used for contaminants with poor warning properties unless the respirator manufacturer can offer cartridges with end-of-service-life indicators.

Combination Particulate/Gas/Vapour Cartridge with Filter

This type removes particulate matter, vapours, and gases from the air. It is used where more than one type of hazard is present or may develop.

Supplied-Air Respirators

Supplied-air respirators provide clean breathing air from an uncontaminated source, usually a special compressor located in a clean environment, or from cylinders containing compressed breathing air. The quality of the air supplied should meet the requirements of CSA Standard Z180.1, *Compressed Breathing Air and Systems*.

The moisture content of supplied air should be limited to prevent fogging, corrosion, and freezing of regulators and valves and to prolong the service life of filters used to remove other contaminants.

The "pressure dew point" is important in relation to moisture. The term refers to the temperature at which moisture in compressed air, at a given pressure, will condense out as droplets or "dew." It must be kept at least 5°C below the lowest expected ambient temperature.

For example, if you are working where the temperature is -10°C, the dew point should be at least -15°C. Water vapour can be removed from compressed air with a drying system or water-absorbing materials.

Types of Supplied-Air Respirators

The three basic types of supplied-air respirators are airline unit, ambient air blower, and self-contained breathing apparatus (SCBA).

The **airline unit** depends on a hose connecting the respirator to cylinders of compressed breathing air. An abrasive-blaster's hood is one example (Figure 3, page 55).

The **ambient air blower** draws air through an inlet hose (positioned where the air is clean) and pumps the air under fairly low pressure to the worker's hood, helmet, or facepiece.

The **self-contained breathing apparatus** (SCBA) uses a cylinder of air carried by the wearer (Figure 4). SCBAs are awkward, heavy, and require frequent cylinder changes.

Combination airline/SCBA units are available for work in confined spaces and other high-risk assignments where reserve protection is required (Figure 5).

With these devices or with simple airline units, the wearer's mobility is understandably restricted by the trailing hose and the length of line available. In addition, airlines may get crimped or may snag on equipment.

If an atmosphere is immediately dangerous to life or health, a combination airline/SCBA unit is required.

Both airline and SCBA units are more expensive than air-purifying systems, but they generally provide much greater protection.

Modes of Operation

Respirators can operate in the following modes:

- "negative pressure" or "demand"
- "constant-flow"
- "positive pressure" or "pressure-demand."

Negative Pressure or Demand Mode

Air is delivered only when the wearer inhales. Pressure inside the facepiece is then lower than pressure outside the facepiece. This allows air to pass through the filters in the case of air-purifying respirators, or actuates a valve that allows air into the facepiece in the case of supplied-air respirators. Because contaminated air may leak inward around the facepiece, these devices have limited use in high exposure conditions.

Constant-Flow Mode

As the name implies, these devices deliver a constant flow of air to the wearer. Powered air-purifying respirators (PAPRs) use a battery-powered fan to draw air through the filter and then blow it into the facepiece (Figure 6). Constant-flow supplied-air respirators such as sandblasters' hoods use a simple valve to control the flow of "clean" air from the compressor. Minimum flow rates of 170 litres per minute (6 cubic ft/min) for loose-fitting hoods or helmets and 115 litres per minute (4 cubic ft/min) for tight-fitting facepieces must be maintained to minimize inward leakage of contaminated air and still provide adequate breathing air.

Positive Pressure or Pressure-Demand Mode

Since the previous modes may permit significant inward leakage, a system which maintains a positive pressure inside the facepiece at all times, as well as supplying more air as demanded, was developed.

If leakage occurs, the high pressure inside the facepiece directs the leakage away from the facepiece rather than allowing it in.

This class of device is only available with supplied-air respirators.

Styles of Facepieces

In addition to the type of respirator and mode of operation, the style of facepiece is used to classify respirators. Different styles are available (Figure 7).

Protection Factors

The protection factor (PF) is a measure of the effectiveness of a respirator. PFs are determined by dividing the concentration of a contaminant outside the respirator by the concentration inside the respirator. PFs are used in the selection process to determine the maximum use concentration (MUC) for the respirator. The MUC is determined by multiplying the legislated or recommended exposure limit by the PF.

For example, the exposure limit for chrysotile asbestos in Ontario is 0.1 fibre/cm^3 of air. If we are using a half-mask respirator with N100 filters (PF=10), the MUC is 1 fibre/cm^3. This is obtained by multiplying the PF (10) by the exposure limit (0.1 fibre/cm^3). If the concentration of asbestos becomes greater than 1 fibre/cm^3 during the course of work, a respirator with a greater protection factor must be used.

The Canadian Standards Association (CSA), the US National Institute for Occupational Safety and Health (NIOSH), and the American National Standards Institute (ANSI) have each published slightly different protection factors. In this manual, NIOSH-assigned protection factors are used.

The degree of protection depends on the type of respirator, style of facepiece, and principle of operation.

Generally, supplied-air respirators provide better protection than air-purifying respirators; full-face masks provide better protection than half-face masks; and positive-pressure devices provide more protection than negative-pressure types.

Table 1 on page 57 lists protection factors for the respirators described so far. The information can be used to select the most appropriate device for any given situation.

The protection factors listed in Table 1 were determined by testing a wide variety of devices worn by a large number of people and represent the average degree of protection achieved. Protection factors for individual wearers may differ significantly from the values listed.

Respirator Selection

In order to select the proper respirator for a particular job, it is necessary to know and understand

- the characteristics of the contaminant(s)
- the anticipated exposure conditions
- the performance limitations of the equipment
- any legislation that applies.

It is also important to realize that facial hair and deep facial scars can interfere with the seal between respirator and face. Respirators should only be selected by someone who understands all of these factors.

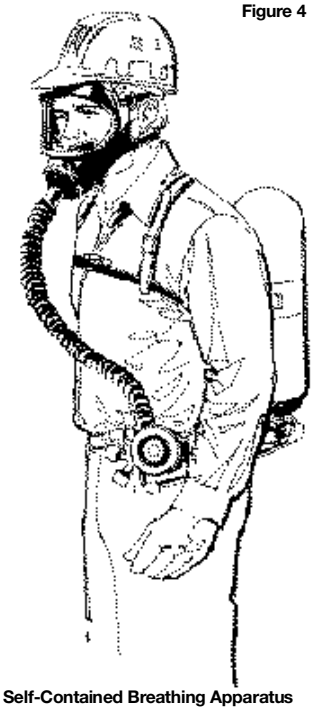
Before using or handling a controlled product, consult the material safety data sheet (MSDS). The MSDS will identify any respiratory protection required. Under the Workplace Hazardous Materials Information System (WHMIS), MSDSs

Figure 3

Type CE abrasive-blast supplied-air respirators are the only respirators suitable for abrasive-blast (sandblasting) operations. As a minimum, NIOSH recommends a type CE, positive pressure, with tight-fitting half-mask facepiece respirator.

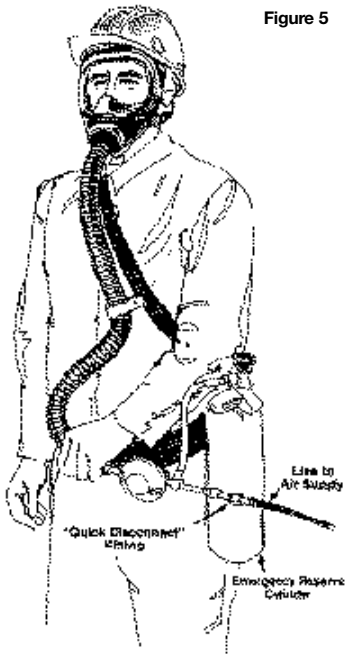
Abrasive–Blaster's Supplied-Air Hood

Figure 4



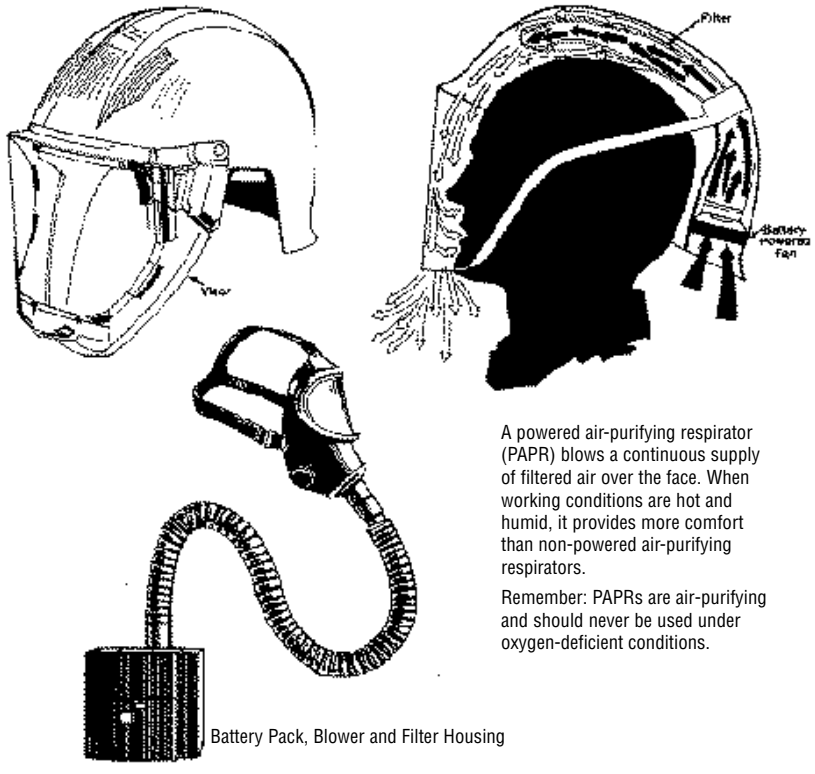
Self-Contained Breathing Apparatus (SCBA)

Figure 5



Combination Airline/SCBA Unit

Figure 6



A powered air-purifying respirator (PAPR) blows a continuous supply of filtered air over the face. When working conditions are hot and humid, it provides more comfort than non-powered air-purifying respirators.

Remember: PAPRs are air-purifying and should never be used under oxygen-deficient conditions.

Battery Pack, Blower and Filter Housing

Powered Air-Purifying Respirators (PAPRs)

must be available to users of controlled products. The MSDS should specify the type of respirator to be worn.

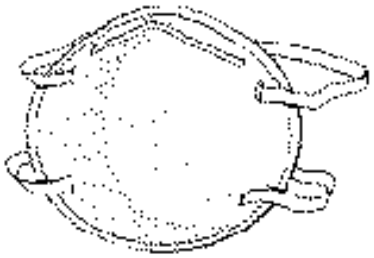
Table 2 on pages 58-59 provides information on respirator selection. The table is intended as a guide only and may not be applicable to every case.

For activities not listed, information regarding type of work, nature of material(s) involved, and working conditions is required and expert advice should be obtained.

If there is any doubt about the correct type of protection for a specific material and operation, consult the manufacturer of the product, a supplier or manufacturer of respirators, or CSAO. When seeking information on the type of respirator for use in specific situations, provide as much of the following information as possible:

a) Name and form of the material (oil or non-oil). If the form is unknown, consider it an oil.
b) Type of work to be done (e.g., painting, welding).
c) Description of worksite conditions (e.g., inside a tank, outdoors).
d) Exposure concentration, if known (e.g., 150 ppm of toluene).
e) Whether the material will be heated, sprayed, etc.

Figure 7



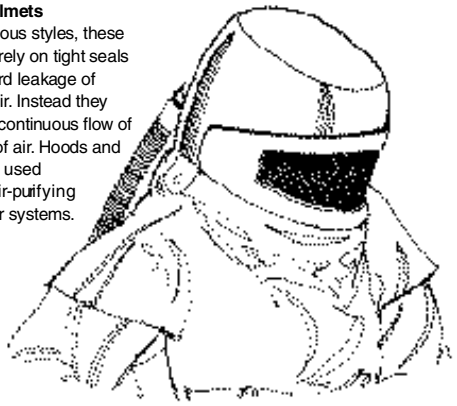
Filtering Facepiece for Particulates

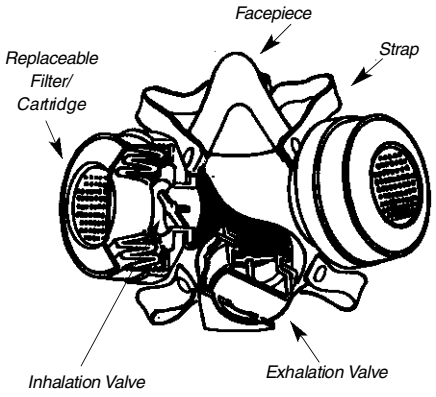
Filtering Half-Facepieces
Most of these devices are designed to be worn only once. They fit over the mouth and nose, rest on the chin, and are held in place by two straps. Some of the more sophisticated versions with adjustable straps and exhalation valves can be worn more than once, provided they are not damaged.

Filtering Facepiece with Exhalation Valves

Full-Face Mask
This style covers the entire face and consists of a moulded rubber or plastic frame and a clear visor. Since it fits against the relatively smooth rim of the face, it provides more protection than other face masks. Full-face masks can be used with air-purifying, powered air-purifying, and supplied-air respirators.

Hoods and Helmets
Unlike the previous styles, these devices do not rely on tight seals to prevent inward leakage of contaminated air. Instead they depend on the continuous flow of large volumes of air. Hoods and helmets can be used with powered air-purifying and supplied-air systems.





Half-Face Mask
This style is widely used as an air-purifying respirator with one or more filters or cartridges attached to the facepiece. The silicone, thermoplastic, or rubber facepiece covers the mouth and nose, cups under the chin, and is usually held in place by two straps. It generally provides better protection than quarter-face masks because the chin cup affords a more secure fit.

f) Other materials being used in the vicinity.

The respiratory protection specialist will evaluate this information and compare it with the following additional data:

g) The permissible exposure limit of the dust, gas, or vapour, often referred to as the TLV® or Threshold Limit Value*. These values are used in conjunction with the protection factors listed in Table 1 to determine the maximum use concentration.

h) The physical properties of the contaminant:
- Vapour Pressure — The maximum amount of vapour which can be generated under given conditions.
- Warning Properties (e.g., irritation, odour, taste) — If the material has poor warning properties (for example, when the lowest concentration that can be detected by odour is greater than the permissible exposure concentration), air-purifying respirators are usually not permitted.
- Types of Effects — With cancer-causing materials a higher degree of protection is usually specified.
- Performance of Filters — With some gases and vapours the filter can become overloaded in just a few minutes. Therefore, knowledge of the filtering material and its performance against specific gases and vapours is necessary.

i) The concentration considered to be Immediately Dangerous to Life or Health (IDLH). IDLH atmospheres pose an immediate threat to life or

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Table 1: Protection Factors (according to NIOSH)

Type of Respirator	Facepiece Style	Facepiece Pressure	Cartridge Type	Hazard Form	Protection Factor
Air-purifying	Filtering Half-Facepiece	N	N/A	Particle	10 ‡
	Half-face mask	N	1	Particle, gas, vapour	10 ‡
	Full-face mask	N	1	Particle	10
	Full-face mask	N	2	Particle	50
	Full-face mask	N	3	Gas, vapour	50 ‡
Powered air-purifying	Loose hood helmet	C	1	Particle, gas, vapour	25 ‡
	Tight-fitting facepiece	C	3	Gas, vapour	50 ‡
	Tight-fitting facepiece	C	2	Particle	50
Airline	Half-face mask	N	N/A	Particle, gas, vapour	10
	Half-face mask	P	N/A	Particle, gas, vapour	1,000
	Full-face mask	N	N/A	Particle, gas, vapour	50
	Full-face mask	P	N/A	Particle, gas, vapour	2,000
	Hood or helmet	C	N/A	Particle, gas, vapour	25
SCBA *	Half-face mask	P	N/A	Particle, gas, vapour	1,000
SCBA *	Full-face mask	N	N/A	Particle, gas, vapour	50
SCBA *	Full-face mask	P	N/A	Particle, gas, vapour	10,000

* SCBA or airline with emergency air bottle adequate for escape from the hazardous environment

‡ Protection factor may be limited by the cartridge. Check with manufacturer.

N Negative
C Constant flow
P Positive
N/A Not applicable

1 Any appropriate NIOSH-approved
2 High efficiency particulate aerosol (HEPA)
3 Appropriate NIOSH-approved gas or vapour

health or the threat of a serious but delayed effect on health (e.g., radioactive dust exposures). One example of an IDLH situation is the repair of a chlorine leak where a worker could be overcome by the gas very quickly. IDLH atmospheres should only be entered by persons wearing SCBA or SCBA/airline respirators as shown in Figures 4 and 5.

j) Possibility of skin absorption. With some chemicals the amount of material which can be absorbed through the skin is of equal or greater concern than the amount of gas or vapour which can be inhaled. For these situations supplied-air protective suits may be necessary.

k) Eye irritation — some contaminants will cause eye irritation, making it difficult to see. For these contaminants, a full-face mask must be worn.

As shown by points a) to k), many factors must be considered to ensure that the proper respirator is selected for a specific situation.

Note

Facial hair and eye protection can adversely affect the respirator seal. Facial hair between the face and a tight-fitting respirator can cause a great deal of leakage and reduce the effectiveness of protection significantly. Respirator wearers should be clean-shaven to achieve the best possible seal. Where eye protection with temple bars or straps passing between face and respirator is necessary, consider wearing a full-face mask.

Fit Testing

Once a respirator has been selected, the next critical step is ensuring that it fits properly. One size does not fit all. With every respirator except hoods or helmets, a tight seal is required between facepiece and face.

With negative-pressure respirators (e.g., non-powered air-purifying respirators and demand supplied-air respirators) gaps in the seal will permit contaminated air to enter the breathing zone.

With positive-pressure respirators (e.g., powered air-purifying respirators and pressure-demand supplied-air respirators) a lot of air will be wasted through outward leakage and the degree of protection provided to the wearer could be reduced. Also, “venturi effects” may allow air to escape in one area and draw contaminated air into the facepiece around the escaping air.

For these and other reasons, the fit of respirators must be carefully tested. Generally there are two types of fit testing – qualitative and quantitative.

Qualitative Fit Tests

1) **Irritant Smoke Test** — The wearer puts on the respirator with “high efficiency or fume filters” in place. A cloud of irritant smoke is created around the wearer. If leakage is detected the respirator should be adjusted.

   Caution: Most of the smoke clouds used in this test are very irritating to the eyes, nose, and throat. Workers are advised to keep their eyes closed during the test and to back out of the smoke as soon as they notice any leakage or irritation.

2) **Iso Amyl Acetate (Banana Oil) Test** — The wearer puts on the respirator with “organic vapour” cartridge filters in place. A cotton swab dipped in iso amyl acetate solution is passed along the outline of the facepiece (iso amyl acetate smells like very ripe

bananas). If the wearer smells the solution, the respirator should be adjusted.

Note: Some people cannot smell iso amyl acetate. Before starting the test, check to ensure that the person can detect the odour. Use two small jars, one containing water, the other containing the test solution. Ask the person whether one smells different and what it smells like.

3) **Saccharin Test** — This test is similar to the iso amyl acetate test except that it uses saccharin as the test material and a dust/mist or high efficiency respirator. If the sweet taste or smell of saccharin is detected, the fit must be adjusted.
4) **Bitrex Solution Aerosol Test** — In this test the wearer puts on the respirator with any particulate filter. A hood or test enclosure is put over the wearer's head and shoulders. Bitrex is then sprayed into the hood or enclosure. Bitrex is a very bitter solution and can easily be detected if it leaks through the face seal. If the wearer cannot taste the Bitrex, then the respirator fits properly.

Quantitative Fit Tests

In these tests the wearer puts on a special respirator which has a probe mounted inside the facepiece. The wearer then goes into a test chamber or booth which contains a known concentration of a specific gas, vapour, or aerosol. The amount of leakage is determined by sampling the air inside the facepiece through the probe. This method is not well suited for use on most construction projects.

User Seal Checks

1) **Negative Pressure Test** — The wearer puts on the respirator and adjusts it so that it feels relatively comfortable. Then the air inlets are blocked off with the hands or a plastic cover, and the wearer inhales gently (Figure 7). If the respirator is properly fitted, it should collapse slightly and not permit any air into the facepiece. If leakage is detected, the mask should be readjusted and the test repeated until the fit is satisfactory
2) **Positive Pressure Test** — The wearer puts on the respirator and adjusts it so that it feels relatively comfortable. Then the exhaust port of the respirator is covered and the wearer tries to exhale gently (Figure 8). The facepiece should puff away from the wearer, but no leakage should occur.

Table 2: Respirator Selection Guide for Common Construction Activities

Note: Suitable respiratory protection is indicated by a ✔ in the appropriate box.

If oil mist is present, use R or P filters.

	Air Purifying												Supplied Air	
	Half-Face Respirators							Full-Face Mask			Powered Air-Purifying Respirator (PAPR)		Hood or Helmet NIOSH type CE Pressure demand	SCBA or SCBA +Airline Full face piece and + pressure
	Filtering Half-Facepiece		Half-Face Mask								Loose fitting	Tight fitting		
Filter Efficiency and Type	**95**	**100**	**95**	**100**	**Organic vapour**	**95 + Organic vapour**	**100 + Organic vapour**	**95**	**100**	**100 + Organic vapour**	**HEPA**	**HEPA**		
Assigned Protection Factor* (NIOSH 1987)	10	10	10	10	10	10	10	50	50	50	25	50	1000	10,000
Dust Exposures														
Asbestos removal using wet methods (chrysotile)				✔ N, R or P					✔ N, R or P		✔	✔		
Asbestos removal: amosite or crocidolite asbestos using wet methods (pipe and boiler insulation)												✔		
Asbestos removal dry (all types)														✔
Asbestos encapsulation							✔ N, R or P			✔ N, R or P		✔ +OV		
Concrete cutting and breaking outside	✔ N, R or P		✔ N, R or P					✔ N, R or P						
Cellulose, fiberglass, mineral wool, calcium silicate installation and removal	✔ N, R or P	✔ N, R or P	✔ N, R or P	✔ N, R or P				✔ N, R or P	✔ N, R or P					
Lead dust from paint removal				✔ N, R or P					✔ N, R or P					
Lead paint abrasive blasting (nozzle operator)													✔	
Lead paint abrasive blasting (workers in area)									✔ N, R or P			✔		
Refractory lining and removal (no asbestos present)			✔ N, R or P	✔ N, R or P				✔ N, R or P	✔ N, R or P			✔		

Table 2: Respirator Selection Guide for Common Construction Activities

Note: Suitable respiratory protection is indicated by a ✔ in the appropriate box.

If oil mist is present, use R or P filters.

	Air Purifying												Supplied Air	
	Half-Face Respirators							Full-Face Mask			Powered Air-Purifying Respirator (PAPR)		Hood or Helmet NIOSH type CE Pressure demand	SCBA or SCBA +Airline Full face piece and + pressure
	Filtering Half-Facepiece		Half-Face Mask								Loose fitting	Tight fitting		
Filtering Efficiency and Type	**95**	**100**	**95**	**100**	**Organic vapour**	**95 + Organic vapour**	**100 + Organic vapour**	**95**	**100**	**100 + Organic vapour**	**HEPA**	**HEPA**		
Assigned Protection Factor* (NIOSH 1987)	10	10	10	10	10	10	10	50	50	50	25	50	1000	10,000
Rock and gravel crushing			✔ N, R or P	✔ N, R or P										
Roofing material removal (built-up roofing, no asbestos)	✔ R or P		✔ R or P					✔ R or P						
Sandblasting (nozzle operator)													✔	
Sandblasting (other workers in enclosed area)									✔ N, R or P			✔		
Rock drilling			✔ N, R or P	✔ N, R or P										
Wood dust, including pressure-treated	✔ N, R or P		✔ N, R or P											
Painting and Using Adhesives														
Latex paint spraying (large scale use)						✔ N, R or P								
Latex paint spraying (small scale use)	✔ N, R or P		✔ N, R or P											
Alkyds and enamels: brush and roller application indoors but well ventilated					✔									
Alkyds and enamels: spray painting in well ventilated area						✔ N, R or P								
Alkyds and enamels: painting in a confined space														✔
Epoxy or polyurethane spray painting														✔
Lead paint spraying										✔ N, R or P		✔ +OV		
Epoxy adhesive (large scale use)														✔
Epoxy adhesive (large scale use)										✔ OV				
Caulking compounds, solvent based, large scale use					✔									
Welding and Flame Cutting														
Any welding in confined spaces when atmosphere not monitored														✔
Aluminum**	✔ N, R, or P		✔ N, R or P											
Galvanized or plated metals	✔ N, R or P		✔ N, R or P											
Lead-painted steel, flame cutting												✔ Good ventilation		✔ Poor ventilation
Stainless steel	✔ N, R, or P		✔ N, R or P											
Miscellaneous														
Roofing membrane heat welding	✔ N, R, or P		✔ N, R or P											
Roofing membrane adhesive welding					✔									
Roofing kettle operators (asphalt)										✔ N, R, or P		✔ +OV		
Form oil spraying					✔ R, or P									

N = not resistant to oil R = oil resistant P = oil proof OV = organic vapour cartridge

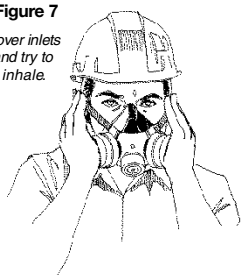
* Assigned Protection factor = The protection factor assigned by NIOSH. A measure of the effectiveness of a type of respirator and suitable filter. Higher numbers mean greater protection.

** Protection from ozone may be required in some circumstances. Contact your respirator manufacturer.

Note: Respirators with a protection factor greater than indicated above may be used. Never use a respirator with a smaller protection factor.

Figure 7

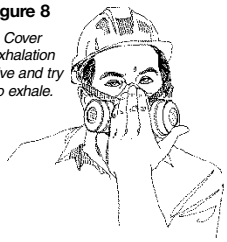
Cover inlets and try to inhale.



Negative Pressure Fit Test

Figure 8

Cover exhalation valve and try to exhale.



Positive Pressure Fit Test

Respirator Maintenance

Like any equipment, respirators require maintenance. The following instructions cover the major points.

1) Filters should be changed as follows:
   - Dust/mist/fume filters should be changed when there is noticeable resistance to normal breathing.
   - Chemical cartridge respirators should be changed when the gas or vapour can be tasted or smelled.
   - Any filter should be changed at the interval specified by the manufacturer or when damaged in any way.
2) Inhalation and exhalation valves should be checked before the respirator is used.
3) Damaged facepiece, straps, filters, valves, or other parts should be replaced with "original equipment" parts.
4) Facepieces should be washed with mild soapy water as often as necessary to keep them clean and wearable.
5) Respirators should be assigned to the exclusive use of individual workers.
6) Where a respirator must be assigned to more than one worker, it should be disinfected after each use (check with the manufacturer regarding acceptable sanitizers/disinfectants).
7) Check all supply hoses, valves, and regulators on supplied-air respirators as specified by the manufacturer.
8) SCBA units and high-pressure cylinders of compressed breathing air should be used and maintained in accordance with current Canadian Standards Association Z180.1 *Compressed Breathing Air and Systems,* and Z94.4 *Selection, Care and Use of Respirators*.
9) Compressors and filtration systems used with supplied-air respirators must be maintained in accordance with the manufacturers' recommendations.
10) Consult manufacturer for information on respirator cartridge change-out.

Approvals and Standards

The most commonly referenced standards for respiratory protection in North America are the test criteria used by the National Institute for Occupational Safety and Health (NIOSH).

NIOSH is a U.S. government agency which tests and approves respiratory protective equipment as one of its major activities and publishes a list of approved devices annually.

The Construction Safety Association of Ontario recommends that only NIOSH-approved equipment be used for protection against respiratory hazards. Unapproved devices should be evaluated carefully by a competent respiratory protection specialist before use.

The Canadian Standards Association has issued two standards pertaining to respiratory protection which should be reviewed by the person responsible for the respirator program:

- Z180.1 *Compressed Breathing Air and Systems* lists the criteria for air purity and delivery systems
- Z94.4 *Selection, Care and Use of Respirators* offers recommendations on these three aspects of the subject.

These standards are copyrighted by CSA. Copies can be purchased from

Canadian Standards Association
178 Rexdale Boulevard
Rexdale, Ontario
M9W 1R3
Tel.: (416) 747-4000 www.csa.ca

Review

The following section lists common claims about respirators and explains why the statements are true or false. The information provides a convenient review of major points in this chapter.

1)	All respirators are the same.	(False)	Most respirators, especially air-purifying types, are limited to certain types of hazards. For instance, dust masks may be suitable for dusts, but do not provide protection against gases and vapours.
2)	One size fits all.	(False)	Most manufacturers offer three sizes of facepieces (small, medium and large) to ensure a proper fit. In some cases, no size from one manufacturer may fit an individual and a different brand may be necessary.
3)	Respirators make breathing more difficult	(True)	With air-purifying respirators the air is being inhaled through a filter so some additional effort is required. With most pressure/demand supplied-air respirators additional effort is required to activate the inhalation and exhalation valves.
4)	Air-purifying respirators supply oxygen.	(False)	These devices simply filter out specific gases, vapours, dust, mists, or fumes, but do not increase the oxygen content of the air.

5) Most respirators require maintenance.	(True)	With the exception of disposable and single-use respirators, some maintenance is required.
6) Any source of compressed air will be adequate for supplied-air respirators.	(False)	Compressed breathing air must be “clean” and free from carbon monoxide, oil mist, and other contaminants.
7) Protection factors are the same for everyone.	(False)	The protection factors listed in Table 1 (page 57) are averages obtained by testing a large number or wearers. Individual protection factors can be considerably different from those listed.
8) Respirators are the best way to control respiratory hazards.	(False)	Good ventilation is the best way of controlling respiratory hazards, though it is not always practical in many construction applications.
9) The moisture content of compressed air is important.	(True)	If the moisture content of the air in a pressurized breathing air system is too high, the regulators can freeze shut and cut off the supply of air. Moisture can also cause deterioration of storage cylinders.
10) Parts can be interchanged from one manufacturer to another.	(False)	Using improperly fitted or matched components voids the NIOSH approval and can cause failure of the respirator posing serious risk to the wearer.
11) Fitting of respirators is not important.	(False)	No matter how effective its protection against specific hazards, the respirator must be properly fitted to prevent inward leakage of contaminated air. The only exceptions are hoods and helmets, and even these depend on fit to a certain degree.
12) Self-Contained Breathing Apparatus (SCBA) and air-line respirators provide the best protection.	(True)	They also have disadvantages which make their use impractical in some situations (see pages 53 and 54).
13) Respirators should be checked each time they are used.	(True)	Damaged straps, missing or ill-fitting valves, and other problems can make the device useless.
14) Only one respiratory hazard is present in a particular job.	(False)	Often there are two or more hazards present. For instance, spray painting produces mists **and** vapours while welding can produce fume **and** gases.
15) Respirators can be fitted with filters suitable for more than one hazard.	(True)	Many manufacturers offer filters which will remove selected dusts, fumes, gases, and vapours all at the same time.
16) Single-use dust masks should not be worn more than once.	(True)	These inexpensive respirators are meant to be put on once only. They may not provide adequate protection once the straps have been stretched.
17) Respirators provide absolute protection.	(False)	Every respirator has limitations which the wearer must understand. Protection is ensured not only by the respirator but also by its proper use.
18) Respirators are simple to select for any job.	(False)	In many cases even the respiratory protection specialists have problems in selecting the right device.
19) Respirators interfere with eye protection.	(True)	Protective goggles and glasses may not fit properly with many respirators. Full-face masks may be necessary.
20) NIOSH approvals are important.	(True)	NIOSH approvals indicate that the device has passed a set of minimum design and performance standards. Unapproved respirators may provide similar protection but this can only be evaluated by expert review of the manufacturer’s claims.
21) Beards and mustaches do not affect respiratory protection.	(False)	With the exception of hoods and some helmets, beards and mustaches cause a great deal of leakage and reduce the effectiveness of respirators significantly. Respirator wearers should be clean shaven to obtain the best possible protection.

Summary

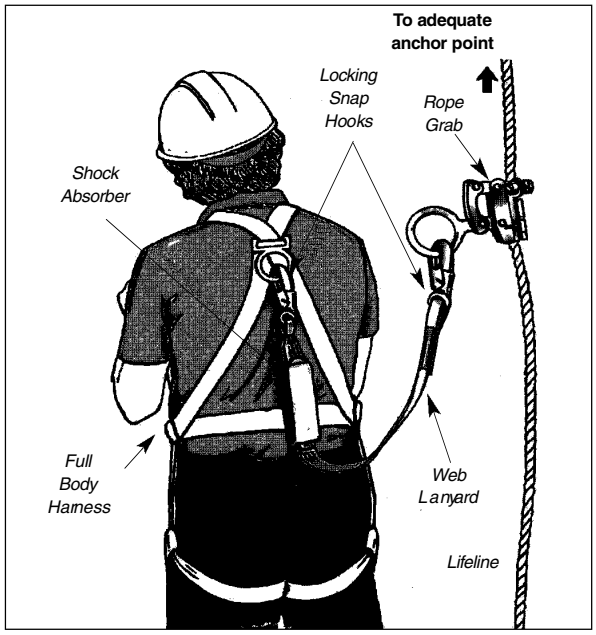
Respiratory protective equipment can prevent illness, disease, and death from breathing hazards. But the equipment must be properly selected, fitted, worn, and maintained to ensure maximum protection.

The Construction Safety Association of Ontario can provide assistance in selecting respiratory protection and training workers in its use, care, and maintenance. For additional information, contact CSAO.

PERSONAL FALL PROTECTION

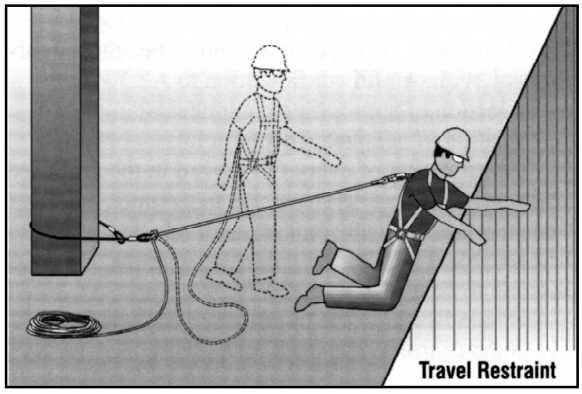
Personal fall protection equipment consists of the components shown in the following illustration.

This equipment can be used for travel restraint or fall arrest.



Travel-Restraint Systems

A travel-restraint system lets a worker travel just far enough to reach the edge but not far enough to fall over.



The basic travel-restraint system consists of

- CSA-approved full body harness
- lanyard
- lifeline
- rope grab to attach harness or lanyard to lifeline
- adequate anchorage (capable of supporting a static load of 2 kilonewtons—450 pounds—with a recommended safety factor of at least 2, that is, 4 kilonewtons or 900 pounds).

Travel-restraint arrangements must be thoroughly planned, with careful consideration given to

- selection of appropriate components
- location of adequate anchor points
- identification of every fall hazard in the proposed work area.

Try to select an anchor point that is as close as possible to being

- perpendicular to the unprotected edge, and
- at the centre of the work area.

All fall hazards in the work area must be identified. Pay special attention to work areas with irregular shaped perimeters, floor openings, or locations near corners.

A fully extended lifeline and/or lanyard that adequately restrains a worker from a fall hazard in one section of the work area may be too long to provide the same protection in another section.

Two methods of travel restraint are commonly used in construction.

1) Connecting an adequately anchored lifeline directly to the D-ring of the worker's full body harness. It's absolutely critical that the length of the lifeline, measured from the anchor point, is short enough to restrain the worker from any fall hazard.
2) Attaching a lanyard from the D-ring of the worker's full body harness to a rope grab on an adequately anchored lifeline. There must be some means—such as a knot in the lifeline—to prevent the rope grab from sliding along the lifeline to a point where the worker is no longer restrained from falling.

Whether method 1 or 2 is used, the system must be adjusted so that the fully extended lifeline and/or lanyard prevents the worker from reaching any point where the worker may fall. The system must also be securely anchored.

Fall-Arrest Systems

Where workers cannot be protected from falls by guardrails or travel restraint, they must be protected by at least one of the following methods:

- fall-restricting system
- safety net
- fall-arrest system.

In the event of a fall, these systems must keep a worker from hitting the ground, the next level below, or any other objects below.

A fall-restricting system is designed to limit a worker's free fall distance to 0.6 metres (2 feet). One type uses a belt grab or belly hook that attaches to a safety rail on a fixed ladder.

A safety net system must be designed by a professional engineer. The system is installed below a work surface where a fall hazard exists.

A fall-arrest system

- must include a CSA-approved full body harness
- must include a lanyard equipped with a shock absorber unless the shock absorber could cause a falling worker to hit the ground or an object or a level below the work
- must include an adequate fixed support; the harness must be connected to it via a lifeline, or via a lanyard and a lifeline

- must prevent a falling worker from hitting the ground or any object or level below the work
- must not subject a falling worker to a peak fall-arrest force greater than 8 kilonewtons.

The construction regulation (O. Reg. 213/91) requires that

- all fall protection equipment must be inspected for damage, wear, and obvious defects by a competent worker before each use
- any worker required to use fall protection must be trained in its safe use and proper maintenance.

Any defective component should be replaced by one that meets or exceeds the manufacturer's minimum performance standards for that particular system.

The regulation also requires that any fall-arrest system involved in a fall be removed from service until the manufacturer certifies all components safe for reuse.

For any worker receiving instruction in fall protection, the manufacturer's instructions for each piece of equipment should be carefully reviewed, with particular attention to warnings and limitations.

Components

The Canadian Standards Association (CSA) provides minimum standards for most components of personal fall protection equipment:

- CAN/CSA-Z259.1-M99 – *Safety Belts and Lanyards*
- CAN/CSA-Z259.2.1-M98 – *Fall Arresters, Vertical Lifelines, and Rails*
- CAN/CSA-Z259.2.2-M98 – *Self-Retracting Devices for Personal Fall-Arrest Systems*
- CAN/CSA-Z259.2.3-M98 – *Descent Control Devices*
- CAN/CSA-Z259.10-M90 – *Full Body Harnesses*
- CAN/CSA-Z259.111-M92 – *Shock Absorbers for Personal Fall-Arrest Systems*.

For any component not covered by these standards, confirm with the manufacturer that the component is suitable for the particular system being considered.

The minimum strength of fall-arrest components depends on whether or not the system uses a shock absorber.

- In systems *without* shock absorbers, all components, including lifeline and lifeline anchorage, must be able to support a static load of at least 8 kilonewtons (1800 pounds) without exceeding the allowable unit stress of the materials used for each component.
- In systems *with* shock absorbers, all components, including lifeline and lifeline anchorage, must be able to support a static load of 6 kilonewtons (1350 pounds) without exceeding the allowable unit stress of the materials used for each component.

In designing both systems, it is recommended that a safety factor of at least two be applied to the stated minimum load capacity. In practical terms, anchorage should be strong enough to support the weight of a small car (about 3600 pounds).

Lifelines

There are three basic types of lifelines:

1) vertical
2) horizontal
3) retractable.

All lifelines must be inspected daily to ensure that they are

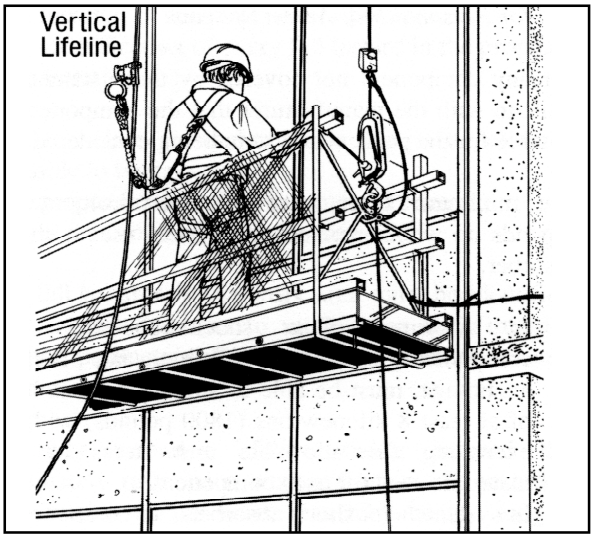
- free of cuts, burns, frayed strands, abrasions, and other defects or signs of damage
- free of discolouration and brittleness indicating heat or chemical exposure.

1) Vertical Lifelines

Vertical lifelines must comply with the current edition of the applicable CSA standard and the following minimum requirements:

- Only one person at a time may use a vertical lifeline.
- A vertical lifeline must reach the ground or a level above ground where the worker can safely exit.
- A vertical lifeline must have a positive stop to prevent the rope grab from running off the end of the lifeline.

Vertical lifelines are typically 16-millimetre (5/8-inch) synthetic rope (polypropylene blends).



2) Horizontal Lifelines

The following requirements apply to any horizontal lifeline system:

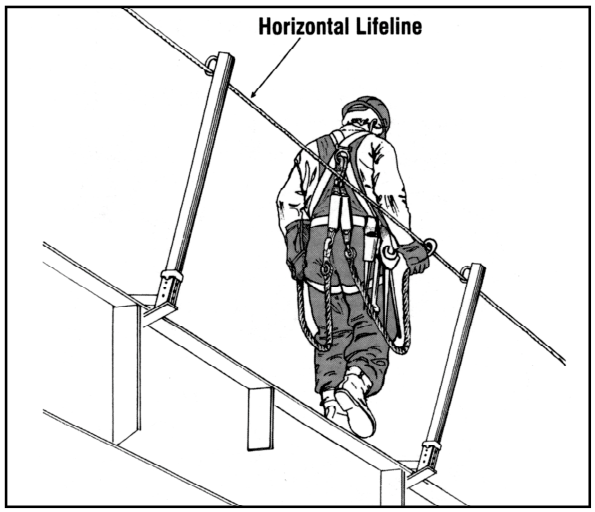
- The system must be designed by a professional engineer according to good engineering practice.
- The design can be a standard design or specifically engineered for the site.

The design for a horizontal lifeline system must

✓ clearly indicate how the system is to be arranged, including how and where it is to be anchored
✓ list and specify all required components
✓ clearly state the number of workers that can safely be attached to the lifeline at one time
✓ spell out instructions for installation, inspection, and maintenance
✓ specify all of the design loads used to design the system.

The system must be installed, inspected, and maintained in accordance with the professional engineer's design.

Before each use, the system must be inspected by a professional engineer or competent worker designated by a supervisor. A complete and current copy of the design must be kept on site as long as the system is in use.



CAUTION: The construction regulation requires that "a horizontal or vertical lifeline shall be kept free from splices or knots, except knots used to connect it to a fixed support." Knots along the length of either a horizontal or vertical lifeline can reduce its strength by as much as 40%.

3) Retractable Lifelines
Retractable lifelines consist of a lifeline spooled on a retracting device attached to adequate anchorage. Retractable lifelines must comply with CAN/CSA-Z259.2.2-M98.

In general, retractable lifelines

- are usually designed to be anchored above the worker
- employ a locking mechanism that lets line unwind off the drum under the slight tension caused by a user's normal movements
- automatically retract when tension is removed, thereby preventing slack in the line
- lock up when a quick movement, such as that caused by a fall, is applied
- are designed to minimize fall distance and the forces exerted on a worker's body by fall arrest.

Always refer to the manufacturer's instructions regarding use, including whether a shock absorber is recommended with the system.

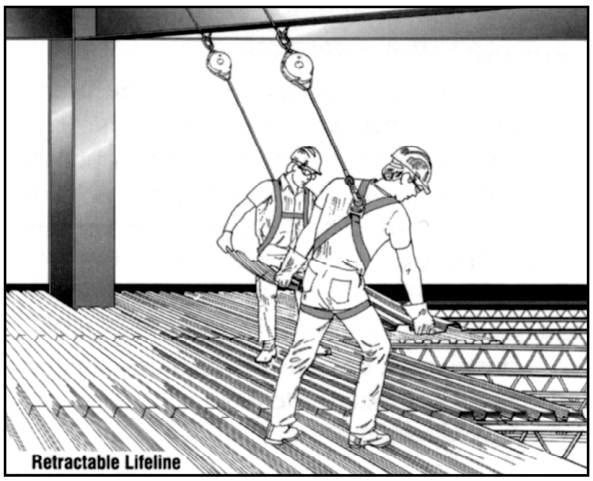
Any retractable lifeline involved in a fall arrest must be removed from service until the manufacturer or a qualified testing company has certified it for reuse.

Lifeline Hazards

Ultraviolet light – Exposure to the sun may damage or weaken synthetic lifelines. Ensure that material being considered for lifelines is UV-resistant.

Temperature – Extreme heat can weaken or damage some lifelines while extreme cold can make others brittle. Ensure that material being considered for lifelines can stand up to the most extreme conditions expected.

Friction and abrasion – Normal movement may wear, abrade, or otherwise damage lifelines in contact with sharp or rough surfaces. Protection such as wood softeners or rubber mats can be used at contact points to prevent wear and tear.



Sparks or flame – Hot work such as welding or flame cutting can burn, melt, cut, or otherwise damage a lifeline. Ensure that material being considered for lifelines is flame-resistant or provide appropriate protection where sparks or flame may be encountered.

Chemicals – Chemical exposure can burn or degrade a lifeline very quickly. Ensure that material being considered for lifelines will resist any chemicals encountered on the job.

Storage – Always store lifelines separately. Never store them where they may contact hazards such as sharp objects, chemicals, or gasoline.

Anchor Systems

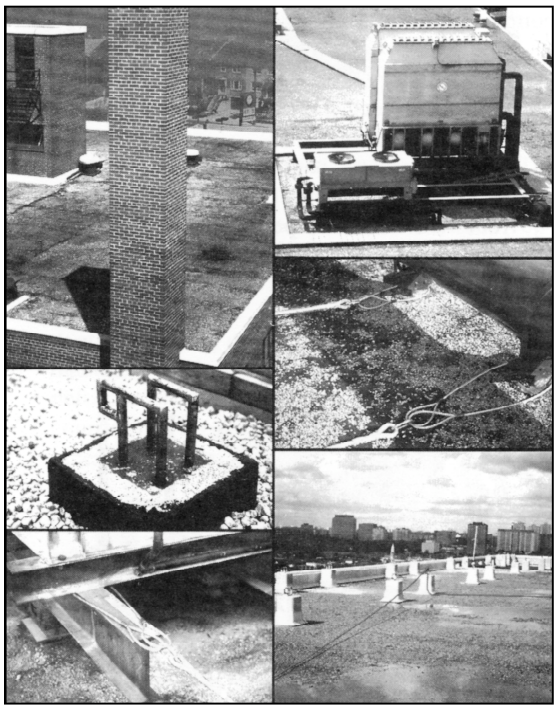
There are three basic types of anchor systems for fall protection:

1) **designed fixed support** – load-rated anchors specifically designed and permanently installed for fall protection purposes as an integral part of the building or structure (for example, roof anchors on high-rise buildings)
2) **temporary fixed support** – anchor systems designed to be connected to the structure using specific installation instructions (for example, nail-on anchors used by shinglers)
3) **existing structural features or equipment** not intended as anchor points but verified by a professional engineer or competent person as having adequate capacity to serve as anchor points (for example, rooftop mechanical rooms, structural steel, or reinforced concrete columns).

Designed fixed support can be used to anchor a fall-arrest system, fall-restricting system, or travel-restraint system if the support has been installed according to the *Building Code* and is safe and practical to use.

Temporary fixed support can be used as anchorage if it meets the following conditions:

✓ it can support at least 8 kilonewtons (1800 pounds) without exceeding the allowable unit stress for each material used;
✓ when used with a fall-arrest system incorporating a shock absorber, it can support at least 6 kilonewtons (1350 pounds) without exceeding the allowable unit stress for each material used; or



Examples of adequate anchorage

✓ when used with a travel-restraint system, it can support at least 2 kilonewtons (450 pounds) without exceeding the allowable unit stress for each material used.

In all cases, a safety factor of at least two should be applied when determining the minimum load that an anchor point must support.

As a general rule with fall-arrest systems, choose an anchor capable of supporting the weight of a small car (about 3600 pounds).

When existing structural features or equipment are used as anchor points, avoid corners or edges that could cut, chafe, or abrade fall protection components.

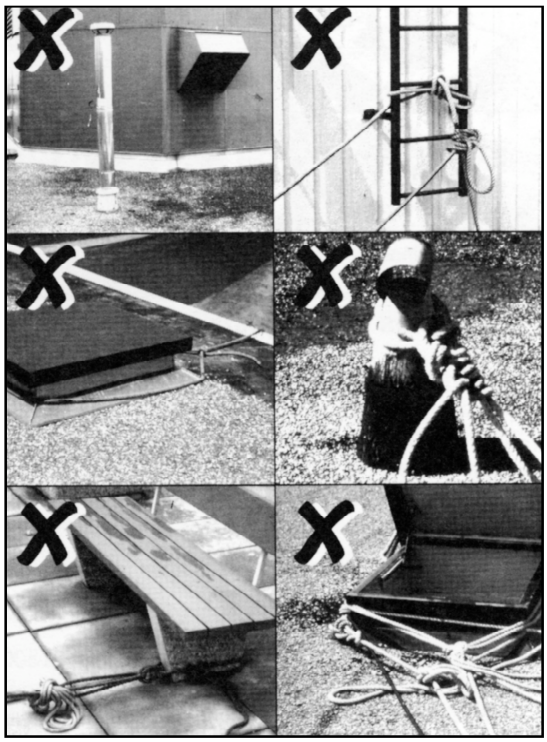
Where necessary, use softeners such as wood blocking to protect connecting devices, lifelines, or lanyards from damage.

Never anchor to

- roof vents or stink pipes
- roof hatches
- small pipes and ducts
- metal chimneys
- TV antennas
- stair or balcony railings.

Full Body Harness

- Chest strap should be adjusted so that it's snug and located near the middle of the chest. In a headfirst fall a properly adjusted chest strap will prevent the worker from coming out of the harness.
- Leg straps should be adjusted so the user's fist can fit snugly between strap and leg.
- Harness straps should be adjusted to put the D-ring between the shoulder blades. A properly positioned D-ring will keep a worker upright after fall arrest.



Examples of inadequate anchorage

Inspect harness for

✓ burns, cuts, or signs of chemical damage
✓ loose or broken stitching
✓ frayed web material
✓ D-ring and keeper pads free from distortion and signs of undue wear or damage
✓ grommets and buckles free of damage, distortion, or sharp edges.

Lanyards

- Use manufactured lanyards only. They can be made of wire rope, synthetic fibre rope, or synthetic webbing.
- Lanyards are manufactured to specific lengths. Never try to shorten a lanyard by tying knots in it. Knots can seriously reduce its rated strength.
- Never store lanyards around chemicals, sharp objects, or in wet places. Never leave them exposed for long periods to direct sunlight.
- Inspect lanyards for
  - ✓ burns, cuts, or signs of chemical damage
  - ✓ loose or broken stitching
  - ✓ frayed web material.

Shock Absorbers

- Shock absorbers absorb some of the force generated by fall arrest. Shock absorbers can be purchased as separate equipment or built into lanyards.
- One end of the shock absorber must be connected to the D-ring on the full body harness.
- In most cases the shock-absorbing component is

enclosed in a snug-fitting jacket to protect it from the user's day-to-day activities. In a fall, the jacket tears open as the shock absorber deploys.
- Check the cover jacket for stress or tearing (many shock absorbers have a tag on the jacket that tears if the unit is exposed to a shock load—make sure this tag is intact).
- Ensure that a shock absorber built into a lanyard has a constant cross-section or diameter.

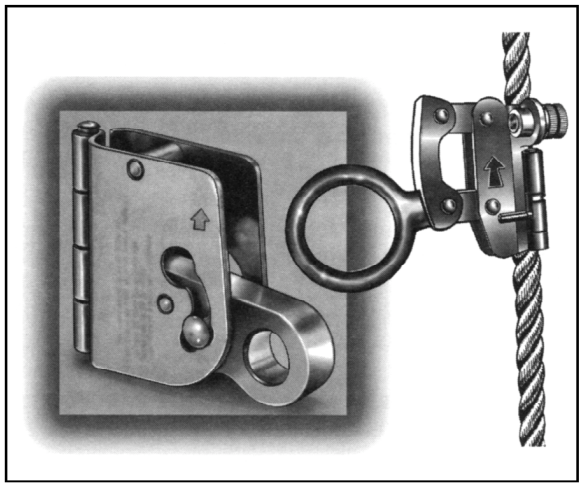
Connecting Devices

Locking Snap Hook – has a spring-loaded keeper across the opening of the hook that cannot be opened unless the locking mechanism is depressed.

Karabiner (D-Clip) – designed not to open under twist loads. To open the gate or keeper requires two separate actions: 1) twisting the locking mechanism and (2) pulling the locking mechanism back. When released, the spring-loaded locking mechanism flicks back into the locked position.

Rope Grab – used to connect lanyard to lifeline. These devices can be moved up and down the lifeline when a steady force is applied but will lock when a sharp tug or pull is applied. They will remain locked on the lifeline until the applied force is released.

Each rope grab is designed and manufactured for use with a specific diameter and type of lifeline. Specifications are usually listed on the housing.



Rope grab and lifeline must be compatible. The rope grab must also be attached to the lifeline in the correct direction—not upside down. On most rope grabs an arrow indicates the direction in which to orient the device.

Check all connecting devices for

- ✓ damage, cracking, dents, bends, or signs of deformation
- ✓ connecting rings centred—not bent to one side or otherwise deformed
- ✓ rust
- ✓ moving parts working smoothly
- ✓ signs of wear or metal fatigue.

Fall-Arrest Planning

Before deciding on a fall-arrest system, assess the hazards a worker may be exposed to in case of a fall.

Before the fall is arrested, will the worker "bottom out," that is, hit ground, material, equipment, or a lower level of the structure? Will the pendulum effect cause the worker to swing from side to side, possibly striking equipment, material, or structure? In the event of fall arrest, how will the suspended worker be rescued? Planning must take into account these and other concerns.

Total Fall Distance is the distance required to fully arrest a fall. It consists of

- Free Fall Distance, which should be kept to 1.5 metres (5 feet) or less, plus
- Fall Stopping Distance, which includes stretch in the lanyard (minimal) and lifeline, slack in the harness (maximum 30 cm or 1 foot due to allowable adjustments for user's comfort), and deployment of the shock absorber (maximum 1.1 metres—or 42 inches).

Free Fall Distance is measured from the D-ring of a worker standing on the work surface down to the point where either the lanyard or the shock absorber begins to arrest the fall. It is strongly recommended that this distance be kept as short as possible.

To minimize free fall, workers should tie off to an anchor overhead and use as short a lanyard as the work will allow.

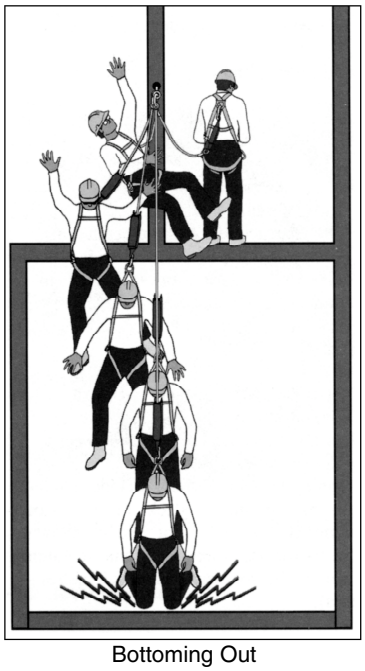
Where a worker is connected to a vertical lifeline by a rope grab, the rope grab should be positioned as high above the D-ring as the work will allow. By doing this, the worker minimizes not only the Free Fall Distance but also the Fall Stopping Distance required to completely arrest a fall.

Bottoming Out

Bottoming out occurs when a falling worker hits a lower level, the ground, or some other hazard before the fall is fully arrested.

This occurs when Total Fall Distance is greater than the distance from the work surface to the next level, the ground, or some other hazard below.

Fall-arrest systems must be planned, designed, and installed to prevent any risk of bottoming out.



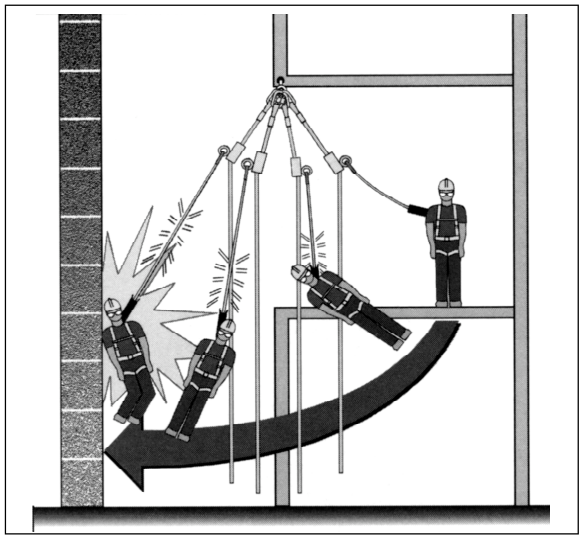
Bottoming Out

Pendulum Effect

The farther you move sideways from your anchor point, the greater the chance of swinging if you fall. This is known as the "pendulum effect." And the more you swing, the greater the force with

which you'll strike columns, walls, frames, or other objects in your path.

Swinging may even cause your taut lanyard or lifeline to break where it runs over rough or sharp edges.



Swing Fall or Pendulum Effect

To minimize pendulum effect, workers should keep lanyard or lifeline perpendicular from edge to anchor. Where work extends along an open edge, anchor points can be changed to keep lanyard or lifeline perpendicular as work progresses.

Another solution is to run a horizontal lifeline parallel to the edge. The worker attaches lanyard to lifeline, moves along the edge, and the lanyard travels at the same pace, remaining close to perpendicular at all times.

Emergency Rescue

The construction regulation (O. Reg. 213/91) requires that before workers use any fall-arrest system or safety net on a project, the employer must develop written rescue procedures. It's important that a worker involved in a fall arrest be brought to a safe area as quickly as possible without causing injury or putting rescuers at risk.

In many cases, the rescue plan can be simple. A ladder or elevating work platform can be used to reach suspended workers and get them down safely. Other workers may be hauled back up to the level from which they fell or pulled in through a nearby window or other opening.

In other cases, procedures may be more complicated. For instance, workers trapped on a failed swingstage, or hanging from it, may need to be rescued by specially trained and equipped personnel from the local fire department. Aerial ladder trucks or other high-reach equipment may be necessary. In extreme cases, the fire department may use rappelling techniques to reach trapped workers and lift or lower them to a safe level.

Plans should cover the on-site equipment, personnel, and procedures for different types of rescue. Any off-site rescue services that might be required should be contacted and arranged in advance to familiarize them with the project. CSAO's Emergency Response poster (P103) can be used to indicate the nearest hospital and the phone numbers of fire, ambulance, and police services.

Site management must ensure that

- everyone on site is aware of the rescue plan
- equipment and other resources are available
- designated personnel are properly trained.

Workers must receive training from their employer regarding the specific fall protection equipment and procedures they will use. Products differ not only between manufacturers but also between product lines in a single company. Training must therefore cover the exact harness, lanyard, shock absorber, rope grab, lifeline, and anchorage each worker will rely on, as well as the applications to be encountered.

Conclusion

Employers, supervisors, and workers all have responsibilities in reducing or eliminating falls in construction.

This section has provided guidelines for fall protection, including both fall prevention and fall arrest. But the information means nothing unless employers, supervisors, and workers apply it on the job.

Workers who have any questions about fall hazards or fall protection should ask their supervisor. When it comes to fall protection, make sure you know how the equipment works and how to use it. Your life depends on it.

HAND/SKIN PROTECTION

In construction, exposed hands and skin are susceptible to physical, chemical, and radiation hazards. Personal hand/skin protection is often the only practical means of preventing injury from

- physical hazards—sharp or jagged edges on materials and tools; heat; vibration
- corrosive or toxic chemicals
- ultraviolet radiation.

Physical Hazards

For physical hazards such as sharp edges, splinters, and heat, leather gloves are the preferred protection. Cotton or other materials do not stand up well and are recommended only for light-duty jobs.

Vibration transferred from tools and equipment can affect hands and arms. One result may be hand/arm vibration syndrome (HAVS). This disease causes the following changes in fingers and hands:

- circulation problems such as whitening or bluish discoloration, especially after exposure to cold
- sensory problems such as numbness and tingling
- musculoskeletal problems such as difficulty with fine motor movements—for instance, picking up small objects.

Workers who use vibrating tools such as jackhammers, grinders, riveters, and compactors on a daily basis may develop HAVS. Preventing this disease requires cooperation between employers and workers.

Employers

- Provide power tools with built-in vibration-reducing components.
- Review exposure times and allow rest breaks away from vibrating tools.
- Ensure proper tool maintenance (worn grinding wheels or tool bearings can lead to higher vibration levels).
- Train exposed workers in prevention techniques.
- Provide anti-vibration gloves.

Workers

- Wear appropriate clothing in cooler weather to maintain core body temperature.
- Wear gloves whenever possible.
- Wear anti-vibration gloves when using power tools and equipment.
- Avoid smoking (smoking contributes to circulatory problems).
- Report any poorly functioning tools immediately.

Chemical Hazards

For protection against chemical hazards, the material safety data sheet (MSDS) for the product being used should identify whether gloves are needed and what they should be made of. MSDSs must be available on site for all controlled products being used.

Table 1: Glove Selection Chart

Chemical Name	Glove Selection
Acetone	Butyl Rubber
Cellosolve	PVA, PVC, Neoprene
Cellosolve Acetate	PVA, PVC
Cyclohexane	NBR, Viton®
Hexane	Neoprene, NBR, PVA
Methyl Alcohol	Neoprene, Rubber, NBR
Methyl Chloroform	PVA, Viton
Methylene Chloride	PVA, Viton
Methyl Ethyl Ketone	Butyl Rubber
Methyl Isobutyl Ketone	Butyl Rubber, PVA
Mineral Spirits	Neoprene
Naphtha	NBR, PVA
Perchloroethylene	NBR, PVA, Viton
Stoddard Solvent	PVA, NBR, Rubber
Toluene	PVA, Viton
Turpentine	PVA, NBR
Trichloroethylene	PVA, Viton
1, 1, 1 Trichloroethane	PVA, Viton
1, 1, 2 Trichloroethane	PVA, Viton
Xylene	PVA, Viton

PVA – Polyvinyl Alcohol
PVC – Polyvinyl Chloride
NBR – Nitrite Butyl Rubber
Viton® – Dupont tradename product

Table 1 identifies glove materials to be worn for protection against chemicals that may injure the skin. This information can be used when the MSDS does not specify the type of glove to be worn.

CAUTION: Common glove materials have limited protective properties and do not protect against all hazards. Some solvents, degreasers, and other liquids can penetrate and/or dissolve rubber, neoprene, or PVC.

Ultraviolet Radiation

In recent years there has been growing concern over the health risks of exposure to the sun's ultraviolet (UV) radiation. Construction workers are particularly at risk because they often work outdoors.

Long-term health risks of UV exposure include skin cancer. Every year there has been an alarming increase in the incidence of skin cancer. Sunlight is the main source of UV radiation known to damage the skin and cause skin cancer. Exposure to the sun's UV radiation is widely recognized as a *highly preventable* cause of skin cancer.

Melanoma is the least common but most dangerous type of skin cancer. The incidence of melanoma in men is rising faster than all other cancers. According to the Canadian Dermatology Association (CDA), the mortality rate from malignant melanoma is increasing, particularly in middle-aged males.

Melanomas most often appear on the upper back, head, and neck. The CDA also notes that there is generally a lag time of 10 to 30 years for the clinical appearance of skin cancer to occur. Consequently, it is critical for young workers to beware of the cumulative effect of unprotected sun exposure. The more time they spend unprotected in the sun, the higher the risk of developing skin cancer.

Although most construction workers generally cover up their arms, legs, and torso on site, their faces and necks are still exposed to the sun's harmful rays. In addition, areas like the tips of the ears and the lips are often overlooked when it comes to sun protection.

The type of skin cancer that develops on the ear or the lip has a high chance of spreading to other parts of the body and causing death. Melanoma may also occur on the sun-exposed parts of the head and neck.

In fact the majority of skin cancers (2 out of 3) occur on the head and neck, followed by the forearm and back of the hand. Workers too often leave these critical areas exposed to the harmful effects of UV radiation.

Individual risk factors for developing skin cancer include

- fair skin that burns easily
- blistering sunburns in childhood and adolescence
- family history of melanoma
- many freckles and moles.

In addition to the harmful effects of the sun's direct rays, some workers may be exposed to indirect UV radiation. Workers can receive additional radiation if they are on or near a surface that reflects sunlight. Reflective surfaces such as concrete, water, unpainted corrugated steel, building glass, and aluminum can increase the amount of ultraviolet radiation to which a worker is exposed.

Another source of indirect UV radiation is from the hard hat itself. UV rays can reflect off the hard hat onto a worker's face, magnifying the amount of UV exposure.

Although all construction workers are at risk, those who don't have ready access to shade and/or work at heights are at a higher risk for UV overexposure. These trades include

- concrete finishing workers
- roofers
- rodworkers
- formworkers on high-rise and residential sites
- roadworkers
- traffic signallers
- ironworkers.

In addition, working at sites with southern exposure decreases the daytime shade available and increases UV exposure.

Remember—even on cloudy or hazy days, UV radiation can penetrate the atmosphere and burn your skin.

What Workers Can Do

✓ Apply a broad-spectrum sunscreen with a sun protection factor (SPF) of 15 or greater to all exposed skin areas. Be sure to cover your ears and the back of your neck. Apply sunscreen 20 to 30 minutes before you go out in the sun. Reapply sunscreen every 2 hours.

✓ Use an SPF 15 or higher sunscreen lip balm and reapply every two hours. Skin cancers can develop on lips.

✓ You may add UV protection to the back of your neck by using fabric to block the sun's rays. Neck protectors that clip onto your hardhat are available.

✓ Wear UV-absorbent safety glasses (CSA-approved polycarbonate glasses incorporate this feature).

✓ Wear clothing that covers as much of the skin as possible. Tightly woven material will offer greater protection as a physical block to UV rays.

✓ If you sweat heavily, you may need to reapply sunscreen more often. Additionally, when clothing is wet, it loses some of its ability to block out the sun's rays. Ensure you have additional dry clothing if necessary.

✓ Try to find a shaded area for your breaks and lunch.

✓ Wear a wide-brim hard hat designed to protect your face and neck from the sun. Adding a glare guard under the peak of your hard hat will help reduce reflective UV rays.

✓ Examine your skin regularly for any unusual changes. The most important warning sign for skin cancer is a spot on the skin that is changing in size, shape, or colour. The danger signs include any wound or skin patch that doesn't heal properly or scales. Be particularly attentive to any mole that grows or becomes irregular in shape, especially if it is multi-coloured. If anything looks unusual, see your doctor as soon as possible. **Skin cancers detected early can almost always be cured.**

What Employers Can Do

✓ Supply workers with a broad-spectrum sunscreen with an SPF of 15 or higher.

✓ Ensure adequate shaded areas for workers on breaks and lunch.

✓ If possible, rotate workers to shaded areas of the jobsite.

✓ Educate workers on the hazards of UV radiation.

✓ Ensure that workers use UV-absorbent safety glasses.

The majority of skin cancers are preventable. Taking basic precautions can significantly reduce the health effects of chronic sun exposure.

HIGH-VISIBILITY CLOTHING

The construction regulation (O. Reg. 213/91) requires that any worker who may be endangered by vehicular traffic on a project must wear a garment that provides a high level of visibility.

There are two distinct features to high-visibility clothing.

Background Material

This is the fabric from which the garment is made. It must be fluorescent orange or bright orange in colour and afford increased daytime visibility to the wearer. Fluorescent orange provides a higher level of daytime visibility and is recommended.

Retroreflective Stripes or Bands

The stripes or bands must be fluorescent and retroreflective and be arranged on the garment with two vertical stripes down the front and forming an X on the back. The stripes must be yellow and 50 mm wide. Retroreflective stripes are to afford the worker both low-light and night-time visibility.

For night-time work, additional stripes or bands are required on the arms and legs. One way to meet this requirement is to dress workers in fluorescent orange coveralls with retroreflective bands or stripes attached.

Risk Assessment

Before selecting high-visibility garments, assess the risks to be controlled. Workers who require greater visibility, such as roadway construction workers, should wear clothing that is highly conspicuous under the conditions expected.

For further recommendations on high-visibility clothing, consult CSA's standard Z96-02.

2 GUARDRAILS

A worker at risk of falling more than 3 metres (10 feet) must be protected by a guardrail system. If such a system is not practical, then a travel-restraint system, fall-arrest system, or safety net must be used. In many cases, guardrails are the most reliable and convenient means of fall protection.

A guardrail system meeting regulated requirements must be used if a worker has access to the unprotected edge of any of the following work surfaces and is exposed to a fall of 2.4 metres (8 feet) or more:

- a floor, including the floor of a mezzanine or balcony
- the surface of a bridge
- a roof while formwork is in place
- a scaffold platform or other work platform, runway, or ramp.

Other areas to be protected by guardrails include

- openings in floors, roofs, and other working surfaces not otherwise covered or protected
- edges of slab formwork for floors and roofs
- locations where a worker may fall into water, operating machinery, or hazardous substances.

Basic requirements for wood guardrails (Figure 33) include

- top rail, mid rail, and toeboard secured to vertical supports
- top rail between 91 cm (3 feet) and 1.07 metres (3 feet 6 inches) high
- toeboard at least 10.2 cm (4 inches) high – 89 mm (3 1/2 inches) high if made of wood – and installed flush with the surface
- posts no more than 2.4 metres (8 feet) apart.

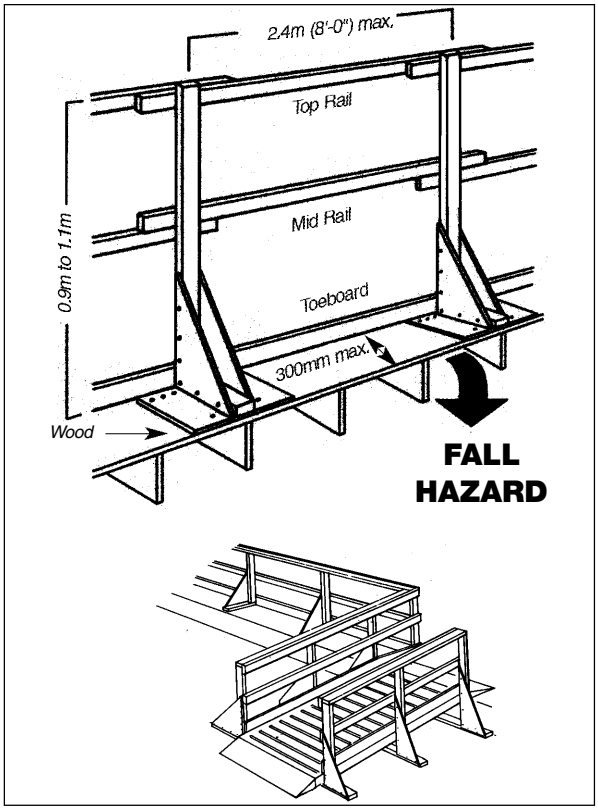
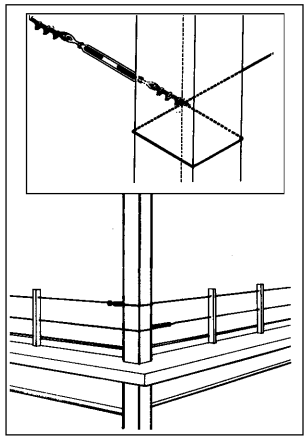
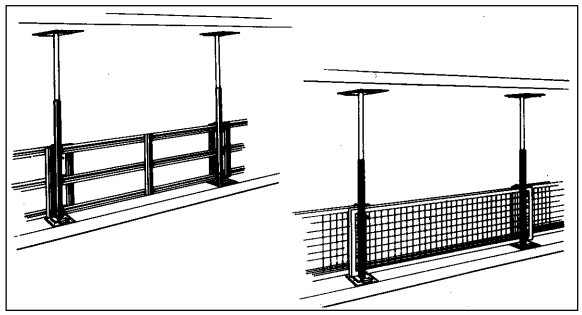


Figure 33

Other systems are acceptable (Figure 34) if they are as strong and durable as wood guardrails with the same minimum dimensions.



Wire Rope Guardrail System



Manufactured Safety Fences

Figure 34

Guardrails must be installed no farther than 300 mm from an edge.

A guardrail must be capable of resisting – anywhere along its length and without exceeding the allowable unit stress for each material used – the following loads when applied separately:

- a point load of 675 newtons (150 lb) applied laterally to the top rail
- a point load of 450 newtons (100 lb) applied in a vertical downward direction to the top rail
- a point load of 450 newtons (100 lb) applied in a lateral or vertical downward direction to the mid-rail
- a point load of 225 newtons (50 lb) applied laterally to the toeboard.

Support

Typical methods of supporting wood guardrails are shown in Figure 33. Posts extending to top rail height must be braced and solidly fastened to the floor or slab.

Shoring jacks used as posts should be fitted with plywood softener plates top and bottom. Snug up and check the posts regularly for tightness.

For slabs and the end of flying slab forms, manufactured posts can be attached to the concrete with either clamps or inset anchors (Figure 35).

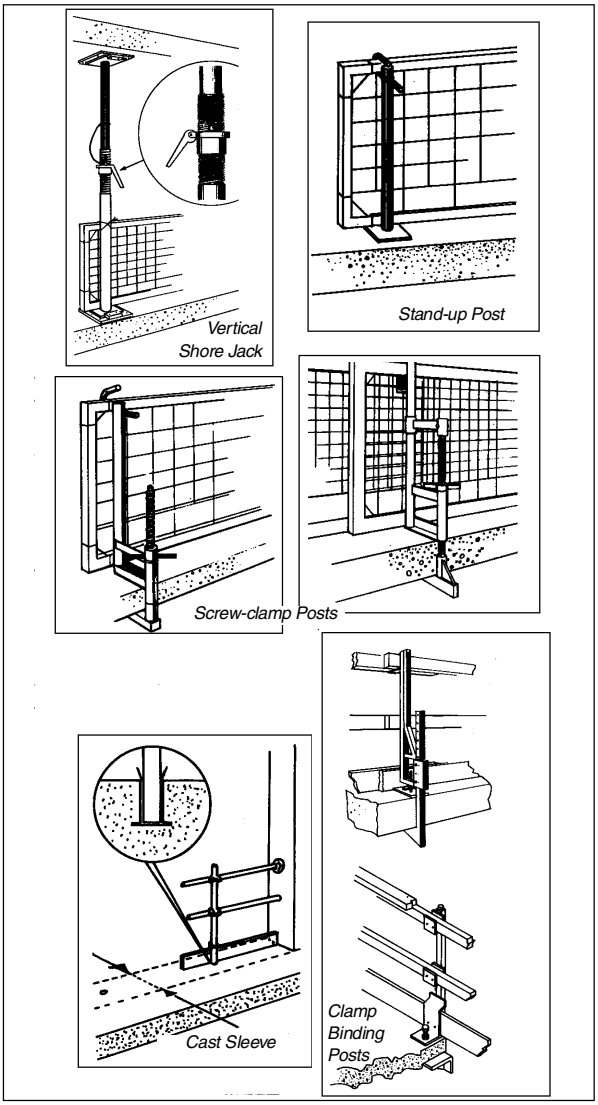


Figure 35

Maximum Strength

For maximum resistance to sideways force, the top rail of wooden guardrails should be laid flat, with the larger dimension horizontal.

To strengthen guardrails, reduce the spacing of posts to between 1 and 2 metres (3 feet and 4 inches and 6 feet and 8 inches) and double the 2 x 4 top tail. Posts on wooden guardrails must not be further apart than 2.4 metres (8 feet).

Where guardrails must be removed, open edges should be roped off and marked with warning signs. Workers in the area must use a fall-arrest or travel-restraint system (Figure 36).

Floor Openings

Guardrails are the preferred method for protecting wo rkers near floor openings but may not always be practical. Narrow access routes, for example, may rule them out. In such cases, securely fastened covers – planks, plywood, or steel plates – may be the best alternative.

Use 48 mm x 248 mm (1 7/8" x 9 3/4") full-sized No. 1 spruce planks.

Make opening covers stand out with bright paint. Include a wa rning sign – DANGER! OPENING – DO NOT REMOVE! DO NOT LOAD!

Fasten the cover securely to the floor to prevent wo rkers from removing it and falling through the opening.

Stairs

The open edges of stairs require guardrail protection. specifications for a wooden arrangement are shown in Figure 37.

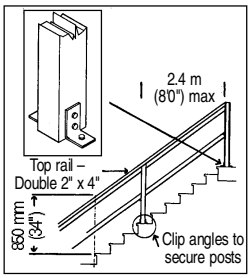


Figure 37
Guardrails on Stairs

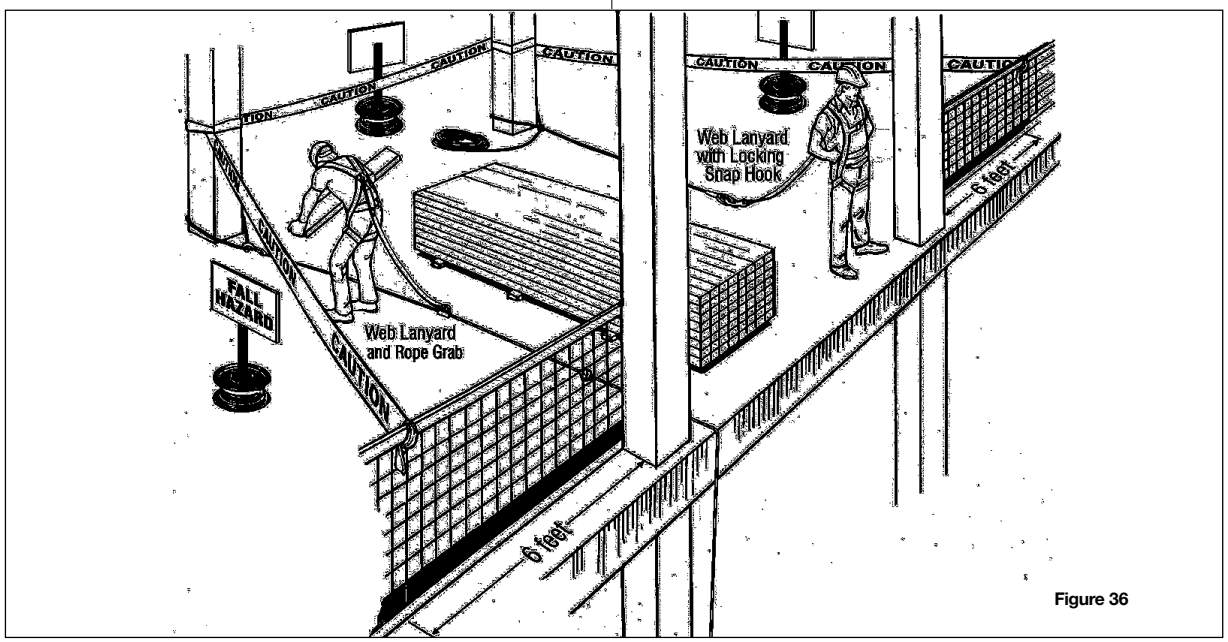


Figure 36

3 LADDERS

INTRODUCTION

Every year in the Ontario construction industry more than 800 lost-time injuries are caused by ladder accidents. Many of these accidents involve falls resulting in serious injuries and fatalities. Falls from ladders are common to all trades and pose one of the most serious safety problems in construction. The following are major causes of accidents.

- Ladders are not held, tied off, or otherwise secured.
- Slippery surfaces and unfavourable weather conditions cause workers to lose footing on rungs or steps.
- Workers fail to grip ladders adequately when climbing up or down.
- Workers take unsafe positions on ladders (such as leaning out too far).
- Placement on poor footing or at improper angles causes ladders to slide.
- Ladders are defective.
- High winds cause ladders to topple.
- Near electrical lines, ladders are carelessly handled or improperly positioned.
- Ladder stabilizers are not used where appropriate.

To assist supervisors and foremen in preventing such accidents, this chapter provides guidelines for selecting, setting up, maintaining, and using ladders. Because ladders are the most common type of access equipment in the construction industry, thousands are used every working day. As a result, there are many thousands of hours of exposure to ladder hazards every week.

The extensive exposure, the high fatality rate, and the large number of lost-time injuries as well as the associated costs and suffering from ladder accidents justify increased training of the workforce and better supervision of ladder use. Worker training alone will not yield sufficient improvement. Any significant reduction in ladder accidents will require regular supervisory reinforcement of training as well as improved site control of operations involving ladders.

STANDARDS AND MATERIALS

Standard manufacturing specifications exist for most types of ladders. CSA Standard Z11 sets out standard requirements for manufacturing portable ladders. The Ontario Ministry of Labour has established standards for job-built wooden ladders, while the International Standards Organization has issued Standard ISO-2860 relating to “Access Ladders on Earth Moving Machinery”.

The most common materials for ladders are aluminum, wood, steel, and fiberglass-reinforced plastic.

Wooden ladders deteriorate more rapidly than those made of more durable materials. They must never be painted because paint hides signs of deterioration and may accelerate rotting by trapping moisture in the wood. However, they may be treated with a clear non-toxic wood preservative or coated with a clear varnish. Inspect wooden ladders frequently for splits, shakes, or cracks in side rails and rungs; warping or loosening of rungs; loosening of attached metal hardware; and deformation of metal parts.

Although aluminum ladders are popular and more widely used than wooden ladders in construction, they are also more susceptible to damage by rough usage. Because they conduct electricity well, aluminum ladders must not be used where electrical contact is possible. Check side rails and rungs regularly for dents, bends, and loose rungs. If dented, the ladder should be taken out of service until repaired by a competent person. If repair is not possible, the ladder should be destroyed.

Fiberglass-reinforced plastic side rails are becoming more common and are generally used with aluminum rungs. They do not conduct electricity well and are resistant to corrosion. They are lightweight and available in various colours. They are, however, costly and heat-sensitive. They must not be exposed to temperatures above 93.3°C (200°F).

Fiberglass ladders should be inspected regularly for cracks and “blooming.” This condition is evidenced by tufts of exposed glass fiber where the mat has worn off. The worn area should be coated with an epoxy material compatible with the fiberglass.

Because of their weight, steel ladders are generally not used as portable ladders in the construction industry. They are, however, often fixed to permanent structures or mobile machinery.

TYPES

The many types of ladders used on construction sites range from metal ladders permanently mounted on equipment to job-built wooden ladders.

Portable Ladders (Figure 1)

All portable ladders must have non-slip feet or be set up so that the feet will not slip.

Portable ladders are available in various grades: light duty or grade 3; medium duty or grade 2; heavy duty or grade 1. The ladders may or may not be certified to CSA Standard Z11. For construction purposes, it is strongly recommended that only ladders bearing the CSA certification label be purchased and used. They may be slightly more expensive but CSA certification assures that the ladder has been manufactured to a high standard set by experts in ladder construction and use.

The type purchased should be compatible with the degree of rough usage expected. For general construction applications, heavy duty portable ladders are recommended. For certain types of finishing work, however, this degree of ruggedness may not be necessary and medium duty ladders will provide acceptable service. Where medium duty ladders are used, they should be restricted to the application for which they were manufactured and not “borrowed” for rougher service.

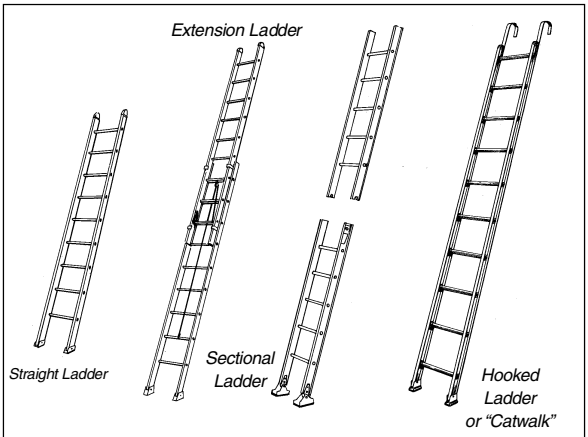
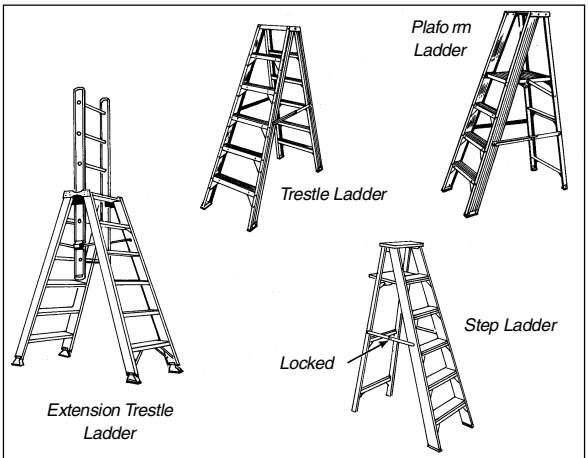


Figure 1



SPREADER ARMS SHOULD LOCK IN THE OPEN POSITION

Figure 2

Step, Trestle and Platform Ladders (Figure 2)

Apart from the standards of sound construction and reliable service that should apply to all ladders used on site, the primary consideration with these ladders is that they have strong spreader arms which lock securely in the open position.

Fixed Ladders (Figure 3)

Steel ladders permanently fixed to structures such as stacks and silos are designed for service after construction is complete but are often used by workers during construction. If the ladders are vertical and there is a risk of falling more than 3 metres (10 feet), a body harness and lifeline, or body harness and channel lock device, should be used by workers climbing up and down or working from the ladders. These ladders must have safety cages starting no more than 2.2 metres (7 feet) from the bottom of the ladder and extending at least 0.9 metres (3 feet) above the top landing. Rest platforms with ladder offsets are required at intervals no more than 9 metres (30 feet) apart where a fall-arrest system is not used. Vertical ladders permanently fixed to structures should comply with Ontario Ministry of Labour data sheet 2-04.

Special Purpose Ladders (Figure 4)

These ladders should be used in accordance with manufacturers' directions and only for the special applications intended.

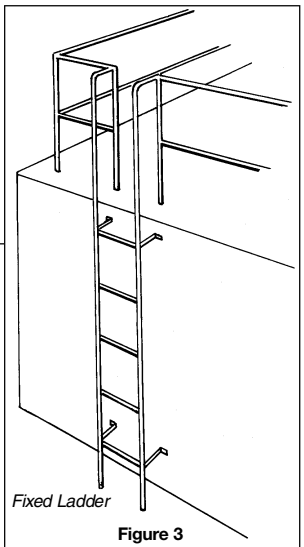


Figure 3

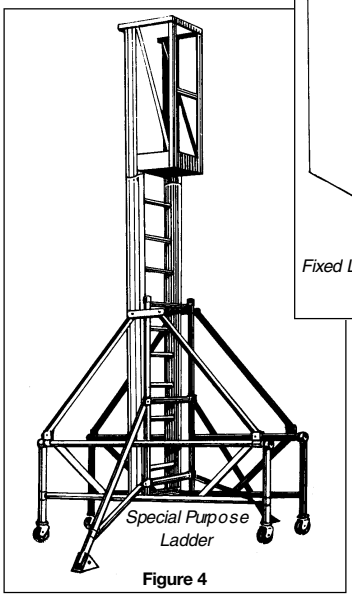


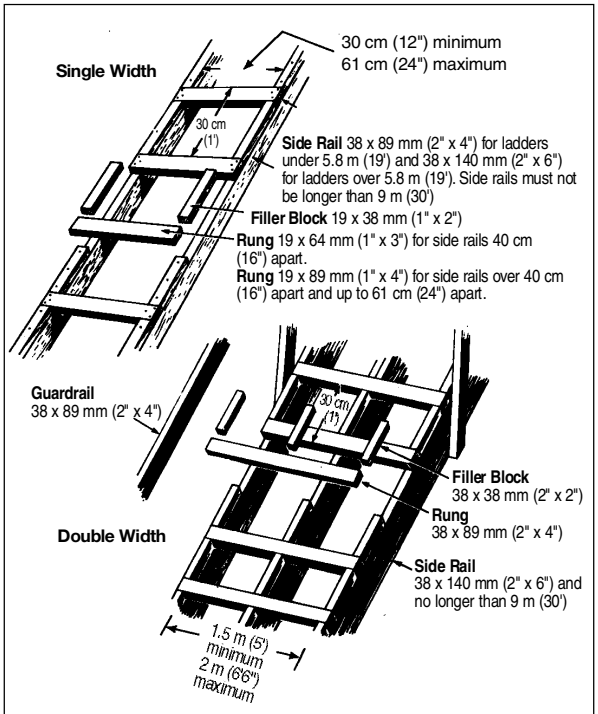
Figure 4

Job-Built Wooden Ladders (Figure 5)

Job-built ladders should be constructed according to good structural carpentry practice.

The wood should be straight-grained and free of loose knots, sharp edges, splinters, and shakes. Rungs should be clear, straight-grained, and free of knots.

Job-built ladders must be placed on a firm footing and be securely fastened in position.



Job-Built Ladders

Figure 5

Remember — a wooden ladder should not be painted or coated with an opaque material.

A straight wooden ladder should not be longer than 9 metres (30 feet).

Job-built ladders are heavy and not recommended where portability is important. Because they are made of wood and often used by a whole crew of workers, job-built ladders deteriorate rapidly. They should be inspected every day or so. If defective, they must be repaired immediately or taken out of service and **destroyed**.

SUPERVISION AND USE

The Supervisor's Task

Ladder injuries can be significantly reduced by control of usage and improved site management. This requires that supervisory personnel

— train workers to maintain and use ladders properly
— evaluate the access requirements of a specific work assignment
— choose the best means of access for the job.

Because portable ladders are inherently hazardous, they should only be used where safer means of access such as stairs, scaffolds, manlifts, or ramps are not suitable or practical. Supervisors must consider the number of workers requiring access to elevated work locations as well as the extent and duration of the work before deciding on the safest and most economical means of access.

Ladders should not be used by large crews of workers. Basic considerations of efficiency usually indicate that other types of access such as stairs or even personnel hoists are much more suitable where significant numbers of workers are making repeated use of the access.

Where a significant amount of elevated work is to be performed by even one tradesman in an area, ladders are not recommended. Other types of access such as stationary or rolling scaffolds or powered elevating platforms will usually be more efficient and significantly reduce the potential for accidents.

In deciding on the best type of access for various tasks and work locations, management should also consider the amount of material involved; the time workers spend on the access equipment; weather conditions; equipment available on site; condition of surface from which access must be made; room available; potential for shared use with other trades, and so on. It is critical that consideration be given to worker access for specific tasks and for entire work areas. Ladders must not be used where other means of access are practical and safer.

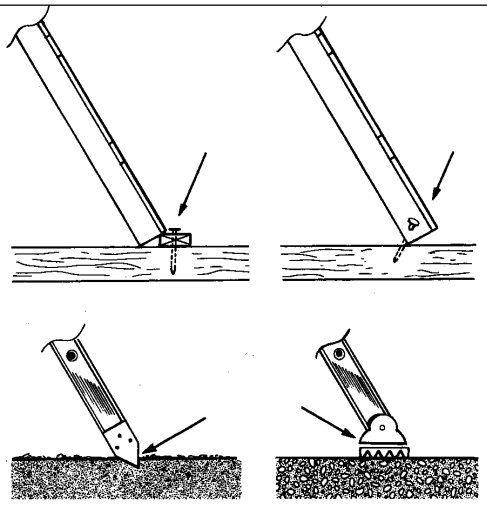
If there is no practical alternative to ladders, supervisors should ensure that ladders are suitable and in good condition and personnel are trained to use them properly. Ladder stabilizers on straight and extension ladders are strongly recommended where ladders are the only means of access.

In addition to proper training, planning, and organizing for worker access, supervisory personnel must exercise control of all access situations. The supervisor must check that planning and directions are being carried out by workers. Although very important, the control function is often given insufficient attention by the busy supervisor. With ladders, as with other supervisory responsibilities, details overlooked today can become problems tomorrow.

Proper Use of Ladders

More than 80 percent of ladder accidents are related to improper use or application of the equipment. Supervisors must control the application of equipment to particular situations. But personnel using the equipment must also be trained to use it. Training should include the following precautions.

— Check the ladder for defects at the start of a shift, after it has been used in another location by other workers, or after it has been left in one location for a lengthy period of time. (See page 76 for inspection procedures.)
— Areas surrounding the base and top of the ladder should be clear of trash, materials and other obstructions since getting on and off the ladder is relatively more hazardous than other aspects of use.
— The base of the ladder should be secured against accidental movement. Use a ladder equipped with non-slip feet appropriate for the situation, nail a cleat to the floor, or otherwise anchor the feet or bottom of the side rails (Figure 6).



Methods of securing ladder base against displacement

Figure 6

— The ladder must be set up on a firm level surface. If its base is to rest on soft, uncompacted or rough soil, a mud sill should be used (Figure 7).
— The top of the ladder should be tied off or otherwise secured to prevent any movement (Figure 8). If this is not possible, given the type of ladder or circumstances of its use, one worker should hold the base of the ladder while it is being used.
— If a ladder is used for access from one work level to another, the side rails should extend a minimum of 900 millimetres (3 feet) above the landing. Grab rails should be installed at the upper landing so that a worker getting on and off the ladder has secure handholds.
— All straight or extension ladders should be erected at an angle such that the horizontal distance between the top support and the base is not less than one-quarter or greater than one-third the vertical distance between these points (Figure 9).

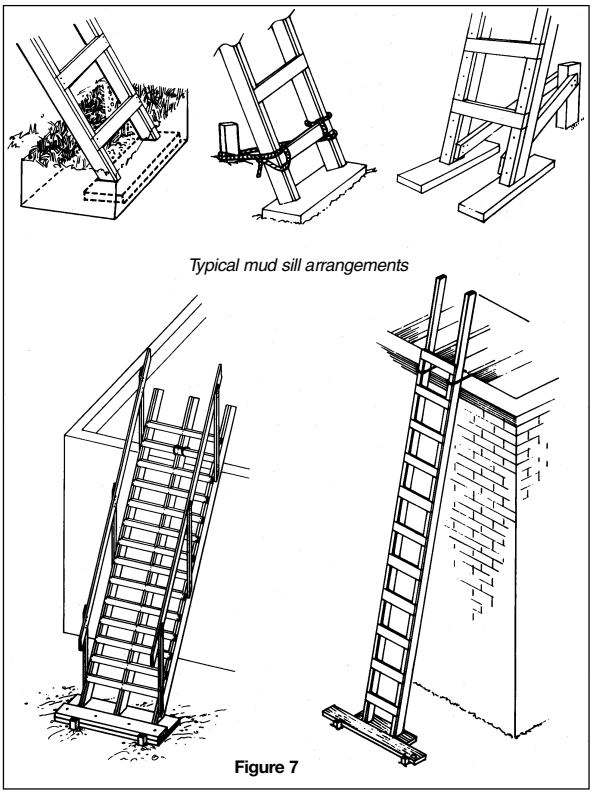


Figure 7

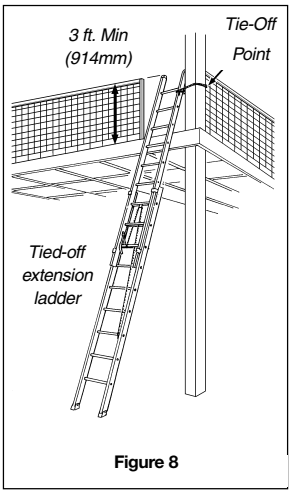


Figure 8

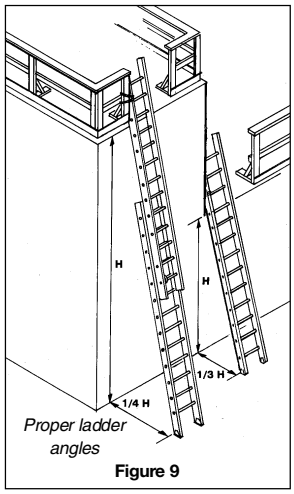


Figure 9

— Before setting up straight or extension ladders, check the area for overhead power lines. Ladders made of aluminum or other conductive material should never be used near power lines. Only competent electricians and linemen using ladders made of non-conductive material are allowed to work in close proximity to energized electrical lines.
— Portable ladders should never be used horizontally as substitutes for scaffold planks, runways, or any other service for which they have not been designed.
— When a task can only be done while standing on a portable ladder, the length of the ladder must be such that the worker stands on a rung no higher than the fourth from the top. The ladder should also be tied off or equipped with a suitable stabilizer.
— Short ladders must never be spliced together to make a longer ladder. Side rails will not be strong enough to support the extra loads.
— Straight ladders should not be used as bracing, skids, storage racks, or guys. They were not designed for these purposes and the damage caused by such abuse can later result in an accident during normal use.
— Unless suitable barricades have been erected, ladders should not be set up in passageways, doorways, driveways, or other locations where they can be struck or displaced by persons or vehicles using the access route.
— Only one person at a time should be allowed on a single-width ladder. In the case of a double-width ladder, no more than two people should be allowed on it at one time and each should be on a separate side.
— Ladders should not be placed against flexible or movable surfaces.
— Always face the ladder when climbing up or down and when working from it.
— Maintain 3-point contact when climbing up or down a ladder. That means two hands and one foot or two feet and one hand on the ladder at all times. This is especially important when you get on or off a ladder at heights (Figure 10).

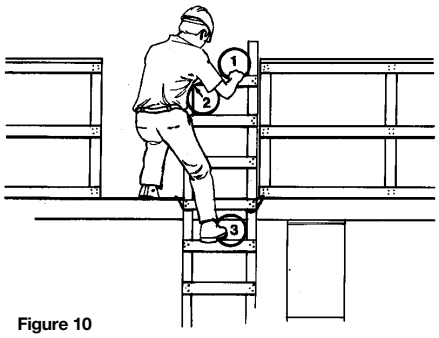
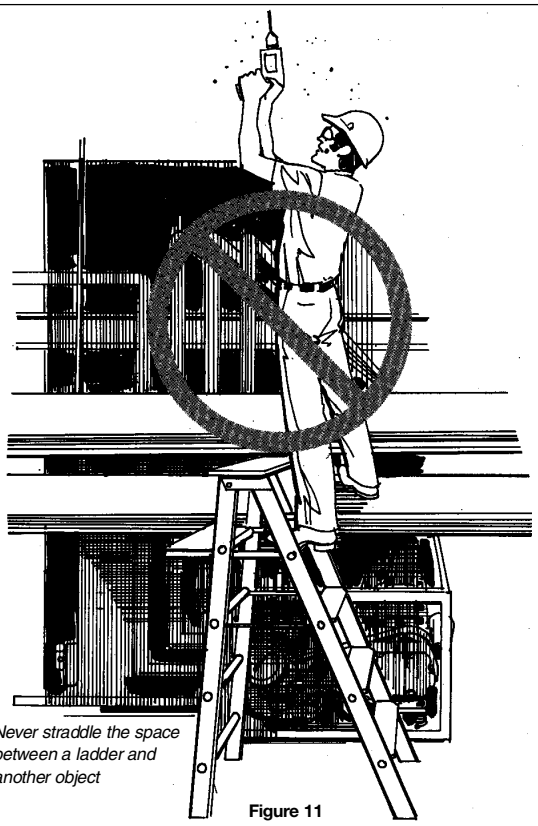


Figure 10

— When working from a ladder, keep your centre of gravity between the side rails. A person's centre of gravity is approximately in the centre of the body at belt height. The location of your centre of gravity can shift when you reach out to either side of a ladder, especially with materials, tools, or equipment in your hands. As the centre of gravity of your body and hand-held objects moves beyond the side rails, the ladder is tending toward instability.
— Whenever possible, avoid climbing up or down a ladder while carrying anything in your hands. Tools, equipment and materials should be placed in a container and raised or lowered by rope, if necessary.
— Workers should be instructed and frequently reminded to keep their boots free of mud, snow, grease, or other slippery materials if they are using ladders.
— Always hold onto the ladder with at least one hand. If this is not possible because of the task to be done and in particular if the work is 3 metres (10 feet) or more above the floor, the worker must wear a safety harness and tie the lanyard off to the structure or to a lifeline before beginning work.
— Never straddle the space between a ladder and another object (Figure 11).



Never straddle the space between a ladder and another object

Figure 11

— Persons frequently required to use or work from ladders should wear protective footwear with soles and heels made of slip-resistant materials such as soft urethane.
— Never erect ladders on boxes, carts, tables, or other unstable surfaces.
— Fall-arresting equipment such as ladder climbing devices or lifelines should be used when working from long fixed ladders or when climbing vertical fixed ladders.
— Never rest a ladder on any of its rungs. Ladders must rest on their side rails.
— When erecting long, awkward, or heavy ladders, two or more persons should share the task to avoid injury from over-exertion.
— Instruct all personnel to watch for overhead power lines before attempting to erect any ladder. When overhead power lines are in proximity of the work, aluminum ladders must not be used.

INSPECTION AND MAINTENANCE

Regular inspection and maintenance will increase the useful life of ladders and reduce the number of accidents. A suggested checklist for inspection has been provided on page 77. Repairs should only be carried out by someone competent and familiar with this kind of work.

Ladders found to be defective should be taken out of service and either tagged for repair or scrapped. Once tagged, the ladder must not be used until repaired. Ideally, the tag should only be removed by the person who took the ladder out of service initially. The tag should be printed in big bold letters with the words “DANGER – DO NOT USE”.

General Procedures

Ladders should be inspected for structural rigidity. All joints between fixed parts should be tight and secure. Hardware and fittings should be securely attached and free of damage, excessive wear, and corrosion. Movable parts should operate freely without binding or excessive play. This is especially important for gravity-action ladder locks on extension ladders.

Non-skid feet should be checked for wear, imbedded material, and proper pivot action on swivel feet.

Deteriorated, frayed or worn ropes on extension ladders should be replaced with a size and type equal to the manufacturer's original rope.

Aluminum ladders should be checked for dents and bends in side rails, steps, and rungs. Repairs should be made only by the manufacturer or someone skilled in good aluminum or metal work practices. Replacing a rung with a piece of conduit or pipe is not good practice and should not be permitted.

Wooden ladders are susceptible to cracking, splitting, and rot and should be either unpainted or covered with a transparent finish in order that checks, cracks, splits, rot, or compression failures can be readily detected. Repairs should be consistent with good woodworking practice. Only wood equal to or better than the wood used by the manufacturer should be used in the repair.

The bases, rungs, and steps of all ladders should be examined for grease, oil, caulking, imbedded stone and metal, or other materials that could make them slippery or otherwise unsafe.

Methods of storage and transportation are important. Storage areas should permit easy access and be cool and dry, particularly if wooden ladders are kept there. Areas where the moving of other materials can damage ladders should be avoided. Ladders should be supported during storage and transportation to prevent sagging or chafing. When being transported, ladders should be “top freight” — nothing should be piled on them. If damage does occur, the condition causing the damage should be corrected as well as having the ladder repaired.

Special Considerations

All trades have frequent ladder accidents. To improve accident prevention, supervisors should devote more time to training and reinforcement of training on the job.

Approximately 50 percent of all ladder accidents occur while tasks are being performed from the ladder. Many of these accidents could be prevented by using other types of access equipment such as scaffolds or powered elevating platforms.

Between 30 and 40 percent of all ladder accidents involve unexplained loss of footing. Because inattention may be a cause, training should be strengthened to maintain awareness of the hazards involved in working from ladders.

Many ladder accidents are related to unfavourable weather conditions such as wind, mud, ice, snow, and rain which create slippery and unstable situations. This is an especially important consideration for the outside trades

such as labourers, bricklayers, sheet metal applicators, roofers, and carpenters.

A surprising number of accidents occur when workers take the first step onto the bottom rung of a ladder. While falls from this distance are usually not as serious as those from greater heights, they nevertheless create injuries such as sprains, strains, fractures, and contusions that often result in lost-time claims. Workers should be advised to be careful when stepping onto any ladder. It is often at this point that the unstable, insecure ladder will slide or tip and that muddy or snow-covered boots will slip on the first or second rung. Make sure that boots are clean, that ladders are secure and stable, and that workers are aware of the hazards. Again, this involves supervisor training and continuous reinforcement.

Finally, a large number of accidents occur because workers use straight ladders that are not secured. Site supervisors must rigidly ensure that ladders are either firmly secured (Figures 6-8) or held in place by a second worker.

LADDER USE CHECKLIST

DO

☐ Familiarize personnel with your ladder safety policy.

☐ Use a ladder properly suited to the task.

☐ Construct job-built ladders properly.

☐ Inspect ladders before use.

☐ Erect ladders with the proper slope (between 4:1 and 3:1).

☐ Avoid placing ladders in areas with high traffic or activity such as walkways, entrances, and exits.

☐ Tie ladders off at the top.

☐ Block or otherwise secure the ladder base or have the ladder held by a second worker when in use.

☐ When outdoors, place the ladder base on firm footings such as compacted soil or mudsills.

☐ Extend the ladder 900 mm (3 feet) above the top landing.

☐ Clear material, debris, and other obstructions from the top and bottom of ladders.

WHEN CLIMBING

☐ Use a single-width ladder one person at a time only.

☐ Maintain three-point contact.

☐ Do not carry anything in your hands.

☐ Face the ladder.

☐ Use a fall-arrest system on long ladders.

DO NOT

☐ use ladders when a safer means of access is available and practical.

☐ use metal ladders near live electrical equipment or conductors.

☐ use ladders horizontally or for some other purpose for which they haven't been designed.

☐ damage ladders during transport and storage.

☐ support ladders on their rungs.

☐ erect long or heavy ladders by yourself.

LADDER INSPECTION CHECKLIST

		YES	NO
1.	Are any wooden parts splintered?	☐	☐
2.	Are there any defects in side rails, rungs, or other similar parts?	☐	☐
3.	Are there any missing or broken rungs?	☐	☐
4.	Are there any broken, split, or cracked rails repaired with wire, sheet metal, or other makeshift materials?	☐	☐
5.	Are there any worn, damaged, or missing feet?	☐	☐
6.	Are there any worn, damaged, or unworkable extension ladder locks, pulleys, or other similar fittings?	☐	☐
7.	Is the rope on extension ladders worn, broken, or frayed?	☐	☐
8.	Has the rope on extension ladders been replaced by material inferior to the ladder manufacturer's original rope?	☐	☐
9.	Are the spreader arms on step ladders bent, worn, broken, or otherwise rendered partly or totally ineffective?	☐	☐

If the answer is “YES” to any of the questions on the Inspection Checklist, the ladder should be tagged so that workers will know it is defective and should not be used. It should be taken out of service immediately and placed in a location where it will not be used until repairs are completed. If the ladder is not to be repaired it should be destroyed.

4 SCAFFOLDS

Contents

1. Introduction
2. Problem areas
3. Selection
4. Basic types of scaffolds
5. Scaffold components
6. Erecting and dismantling scaffolds
7. Scaffold stability
8. Platforms
9. Proper use of scaffolds

1 INTRODUCTION

Over 600 scaffold accidents occur annually in the Ontario construction industry. More than half of these are falls. Several fatalities are also related to scaffolds each year. The number and severity of injuries involved make scaffold accidents one of the more serious safety problems in construction.

2 PROBLEM AREAS

The main problem areas are

- erecting and dismantling scaffolds
- climbing up and down scaffolds
- planks sliding off or breaking
- improper loading or overloading
- platforms not fully planked or “decked”
- platforms without guardrails
- failure to install all required components such as base plates, connections, and braces
- moving rolling scaffolds in the vicinity of overhead electrical wires
- moving rolling scaffolds with workers on the platform.

2.1 Erecting and Dismantling

From 15 to 20% of scaffold-related injuries involve erecting and dismantling. The most common problem is the failure to provide an adequate working platform for a worker to use when installing the next lift of scaffold. Working from one or two planks is not recommended.

The next important consideration involves components, such as tie-ins, which you should install as the assembly progresses. Failure to do so makes the scaffold less stable and, while it may not topple, it may sway or move enough to knock someone off the platform. This happens more often when platforms are only one or two planks wide and guardrails are missing, as is frequently the case during erection and dismantling.

2.2 Climbing Up and Down

Approximately 15% of scaffold-related injuries occur when workers are climbing up and down. Climbing up and down frames is a common but unacceptable practice that has resulted in numerous injuries and fatalities. Climbing up and down braces is also a frequent cause of accidents. You must provide adequate ladders to overcome this problem. In addition, workers must use proper climbing techniques (three-point contact).

2.3 Planks Sliding Off or Breaking

Many scaffold injuries involve problems with planks. If scaffold planks are uncleated or otherwise unsecured they easily slide off – this causes a surprising number of injuries. Scaffold planks can also break if they are in poor condition or overloaded. It is therefore important to use proper grades of lumber and to inspect planks before erection to ensure that there are no weak areas, deterioration, or cracks. Another common problem is insufficient or excessive overhang of planks at their support. Excessive overhang can cause a plank to tip up when a worker stands on the overhanging portion. Insufficient overhang is a leading cause of planks slipping off.

2.4 Improper Loading or Overloading

Overloading causes excessive deflection in planks and can lead to deterioration and breaking. Overloading occurs most often in the masonry trade where skids of material can exceed 1500 kg (3000 lb.). If material is left overhanging the scaffold platform it can cause an imbalance leading to the scaffold overturning.

2.5 Platforms Not Fully Decked

This situation is related to injuries not only during erection and dismantling but in general scaffold use. The Construction Regulation (Ontario Regulation 213/91) requires that all scaffold platforms must be at least 450 mm (18 inches) wide. All platforms above 2.4 metres (8 feet) must be fully decked.

2.6 Platforms without Guardrails

Platforms without guardrails are a serious safety problem in construction. Guardrails are an important fall prevention measure not only for high platforms but also for low ones. Over one-third of the falls from scaffolds are from platforms less than 3 metres (10 feet) in height. Therefore, guardrails are recommended during normal use for all scaffold platforms over 1.5 metres (5 feet) high. Guardrails for all working platforms should consist of a top rail, a mid-rail, and a toeboard.

2.7 Failure to Install All Required Components

Failure to use all of the proper scaffold components is a serious safety problem. Workers are more likely to cut corners when scaffolds are only a few frames in height. All too frequently they fail to install base plates, braces, proper securing devices such as “banana” clips or “pig tails” at the pins of frame scaffolds, and adequate tie-ins. Those erecting the scaffold must have all the necessary components, and must use them to ensure that the scaffold is safe. Furthermore, workers should install these parts as the scaffold erection progresses.

2.8 Electrical Contact with Overhead Wires

Scaffolds seldom make contact with overhead electrical lines, but when it does happen it almost always results in a fatality. Failure to maintain safe distances from overhead powerlines while moving scaffolds is a major problem. Before attempting to move rolling scaffolds in outdoor open areas, check the route carefully to ensure that no overhead wires are in the immediate vicinity. Partial dismantling may be necessary in some situations to ensure that the scaffold will make the required safe

clearances from overhead powerlines. The required minimum safe distances are listed in Table 1. Hoisting scaffold material by forklift or other mechanical means requires careful planning and should be avoided in the vicinity of powerlines. Transporting already-erected scaffolds by forklift, particularly in residential construction, has been the cause of many electrical contacts – this is a dangerous practice. Workers handling materials or equipment while working on the platform must also take care to avoid electrical contact.

Table 1: Minimum distance from powerlines

Voltage Rating of Power Line	Minimum Distance
750 to 150,000 volts	3 metres (10 feet)
150,001 to 250,000 volts	4.5 metres (15 feet)
over 250,000 volts	6 metres (20 feet)

2.9 Moving Rolling Scaffolds with Workers on the Platform

Moving rolling scaffolds with workers on the platform can be dangerous. Where it is impractical for workers to climb down, and the scaffold is over 3 metres (10 feet) in height, each worker must be tied off with a full body harness and lanyard. Lifelines must be attached to a suitable anchor point other than the scaffold. Holes, depressions, curbs, etc. have all been responsible for scaffolds overturning while being moved. In some jurisdictions moving a scaffold with workers on the platform is prohibited if the platform exceeds a certain height.

3 SELECTION

The safe and efficient use of scaffolding depends first on choosing the right system for the job. If the scaffold's basic characteristics are unsuited to the task, or if all the necessary components are not available, personnel are forced to make do and improvise. These conditions lead to accidents.

Proper selection of scaffolding and related components requires basic knowledge about site conditions and the work to be done. Considerations include

- weight of workers, tools, materials, and equipment to be carried by the scaffold
- site conditions (e.g., interior, exterior, backfill, concrete floors, type and condition of walls, access for the equipment, variations in elevation, anchorage points)
- height or heights to which the scaffold may be erected
- type of work that will be done from the scaffold (e.g., masonry work, sandblasting, painting, metal siding, mechanical installation, suspended ceiling installation)
- duration of work
- experience of the supervisor and crew with the types of scaffolds available
- requirements for pedestrian traffic through and under the scaffold
- anticipated weather conditions
- ladders or other access to the platform
- obstructions
- configuration of the building or structure being worked on
- special erection or dismantling problems including providing practical fall protection for the erector
- the use of mechanical equipment to aid in erecting the scaffold.

4 BASIC TYPES OF SCAFFOLDS

4.1 Standard Tubular Frame Scaffolds

This is the most frequently used scaffold in construction. Historically it has been made of steel tubing, but aluminum is gaining popularity. The scaffold is manufactured in various configurations and spans. On some systems, ladder rungs are built into the end frames (Figure 4.1). These ladders are not suitable for tall scaffold towers unless rest platforms are installed at regular intervals and trapdoors are provided in the platforms. Other models are equipped with ladders that attach to the end frames (Figure 4.3). The ladder shown in Figure 4.3 is continuous and workers gain access via gates at the platform level. Again this ladder is not suitable for high scaffolds. Scaffolds in excess of 9 metres (30 feet) should have built-in stairs with rest platforms. Vertical ladders can reach up to 9 metres, but above 2.2 metres (7 feet) they require a safety cage.

The advantages of the frame scaffold are that it is simple to assemble, many construction trades are familiar with its use, and the components can be lifted manually by workers. However, as with other systems, all parts must be used. Failure to install any of the components, such as bracing and base plates, may lead to accidents.

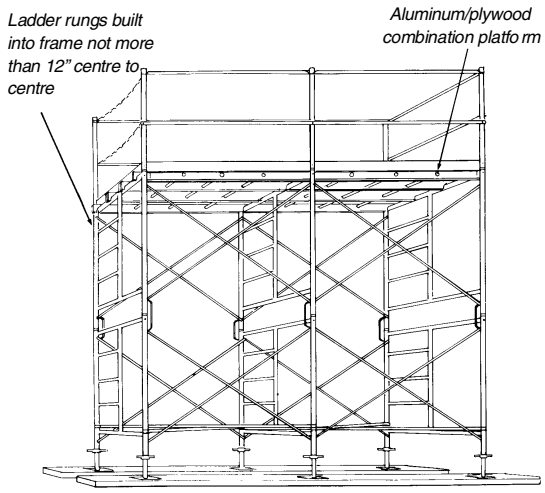


Figure 4.1
STANDARD FRAME SCAFFOLD

4.2 Standard Walk-through Frame Scaffolds

This is a variation of the standard tubular frame scaffold. An example is shown in Figure 4.2. Although primarily designed to accommodate pedestrian traffic at the ground or street level, the walk-through scaffold is frequently used by the masonry trade to provide greater height per tier and easier distribution of materials on platforms at intermediate levels.

4.2.1 Spans of Tower Base

Span lengths are varied using different lengths of vertical bracing. Most manufacturers have braces providing spans between 5 and 10 feet in length, with 7-foot spans being the most common. The use of 7-foot spans is ideal when using 16-foot planks as this allows a 1-foot overhang at each end. When using spans in excess of 7 feet, the load-bearing capacity of the platforms is reduced and must be accounted for in the design.

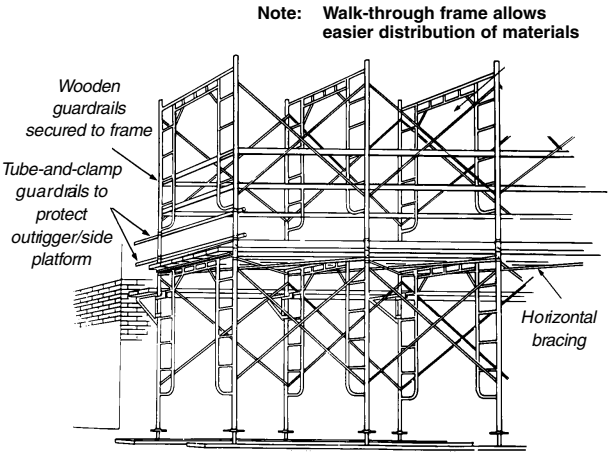


Figure 4.2
WALK-THROUGH SCAFFOLD

4.3 Rolling Scaffolds

Rolling scaffolds are best suited where short-duration work must be carried out at multiple locations. They are used mainly by mechanical and electrical trades. There are two main types of rolling scaffold.

- **Castor Type.** This type of scaffold is best suited for work on smooth floors and is typically used inside buildings. All castors should be equipped with braking devices (Figure 4.3). This kind of scaffold should be erected so that its height-to-width ratio is no greater than 3 to 1. This limits the height of platforms with standard outrigger stabilizers and single span towers to approximately 9 metres (30 feet).
- **Farm Wagon Type**. Scaffolds erected on farm wagons or other devices with pneumatic tires are frequently used for installing sheet metal siding and similar materials on industrial buildings. For safe, effective use, the area around the building should be well compacted, relatively smooth and level. This type of scaffold must also have outrigger beams with levelling devices (Figure 4.4). It is subject to the 3-to-1 height-to-width ratio and is impractical for heights greater than 7.5 metres (25 feet). The scaffold should always be resting on the outriggers while workers are aboard. It should never be used as a work platform while it is "on rubber."

Rolling scaffolds other than those that are lifted off the ground on outriggers should have brakes on all wheels. All brakes should be applied when the scaffold reaches the desired location.

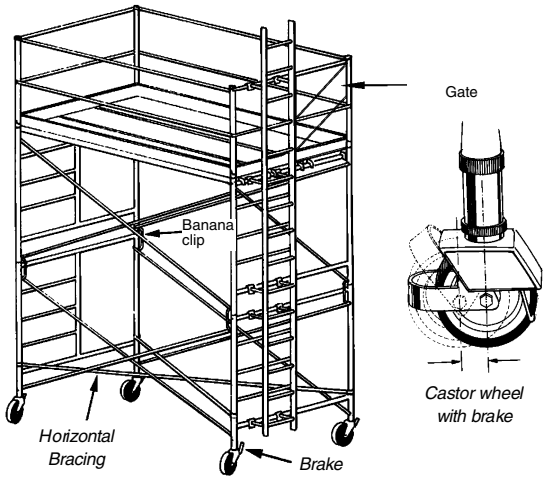


Figure 4.3
ROLLING SCAFFOLD

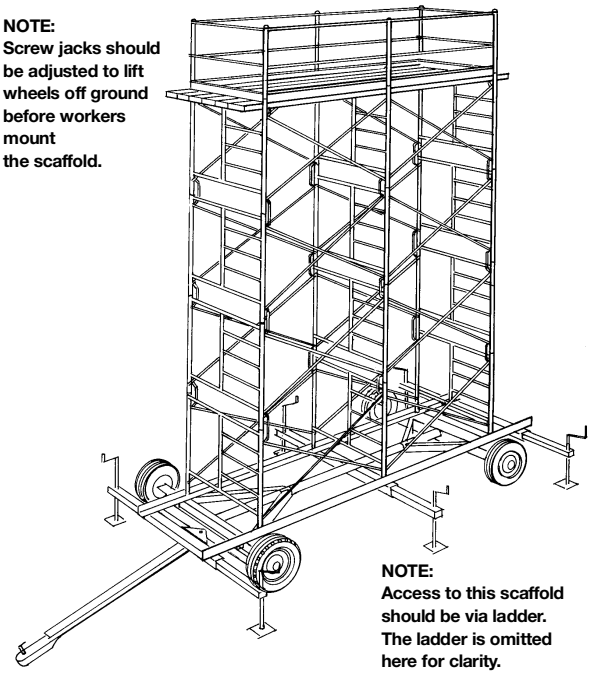


Figure 4.4
FARM WAGON ROLLING SCAFFOLD

It is best not to move rolling scaffolds over one frame in height while a person is on the platform. If people must remain on the platform when the scaffold is being moved they should be tied off to an independent structure using a fall-arrest system. In some jurisdictions moving a scaffold with workers on the platform is prohibited if the scaffold exceeds a certain height. The area through which the scaffold is to be moved should be free of bumps or depressions and cleared of all debris. Overhead hazards, especially powerlines, should be identified.

Rolling scaffolds should always have guardrails. They should also be securely pinned together and be fitted with horizontal bracing as recommended by the manufacturer.

Scaffolds that are not securely pinned together can separate if they drop into a hole or depression, or run into an obstacle at ground level. Horizontal bracing is necessary on a standard frame scaffold to keep it from folding up because the connections between frames and braces are essentially pinned joints.

Castors should be secured to the frame. A castor dropping off in a hole or depression in floors has been the cause of serious accidents and injuries. Each castor should have a brake which is in good working order and can be applied easily. The castors or wheels should be suitable for the surface on which the scaffold is being used. Small wheels are suitable for pavement or concrete floors. You need larger pneumatic wheels when soils are the working surface. Before using rolling scaffolds, the surface must be smooth, free of depressions and reasonably level.

4.3.1 Electrical Contact

One of the biggest concerns with rolling scaffolds is the possibility of contact with overhead electrical wires. Scaffolds making accidental contact with powerlines have caused many deaths. Before moving a rolling scaffold, check the intended path of travel and maintain the required minimum clearances as set out in Table 1.

4.4 Fold-up Scaffold Frames

Fold-up scaffold frames (Figure 4.5) are frequently used by trades such as electricians, painters, and suspended ceiling erectors. Widths range from dimensions that will pass through a 750-mm (30-inch) opening to the standard width of about 1.5 metres (5 feet). Frequently made of aluminum, this type of scaffold is easily and quickly transported, erected, and moved about construction sites and from job to job. It should be used only on a smooth, hard surface.

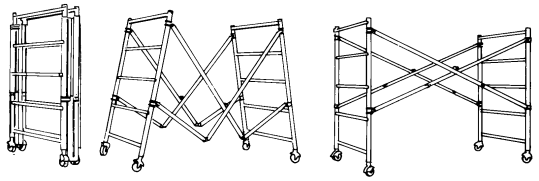


Figure 4.5
FOLD-UP SCAFFOLD

4.5 Adjustable Scaffolds

Figure 4.6 illustrates another type of scaffold with uses similar to the fold-up model. Although it is not so easily erected, the system is light and very easily adjusted for height. It breaks down into a minimum of components readily transported from job to job. These devices should also be used only on smooth, hard surfaces. They are not intended to carry heavy loads.

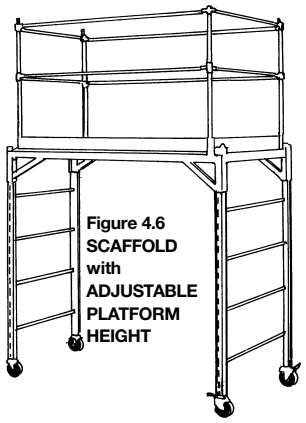


Figure 4.6
SCAFFOLD with ADJUSTABLE PLATFORM HEIGHT

4.6 Tube-and-Clamp Scaffolds

Tube-and-clamp scaffolds (Figure 4.7) are frequently used where obstructions or non-rectangular structures are encountered. The scaffolds are infinitely adjustable in height and width. They can also be used for irregular and circular vertical configurations.

Personnel erecting tube-and-clamp scaffolds must be experienced. It is strongly recommended that, for each application, a sketch or drawing be prepared by someone who understands general structural design and the need for diagonal and cross bracing. In general, this type of scaffold takes longer to erect than the standard tubular frame type. Tube-and-clamp scaffolds above 10 metres (33 feet) must be designed by a professional engineer.

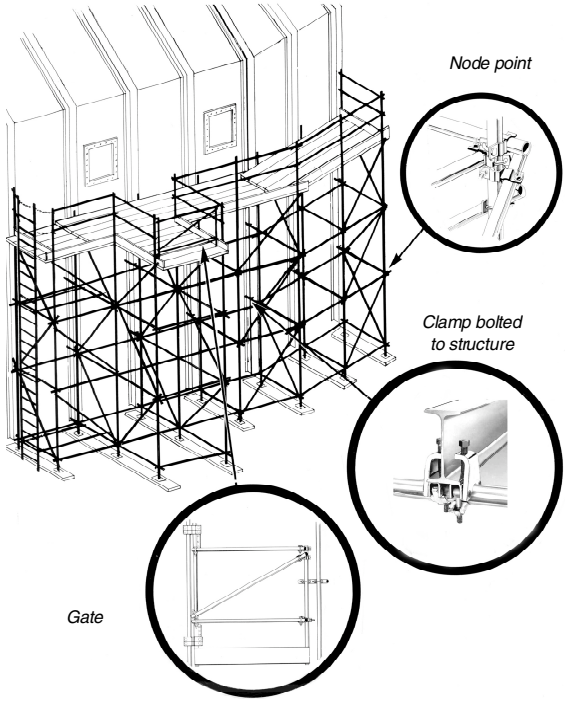
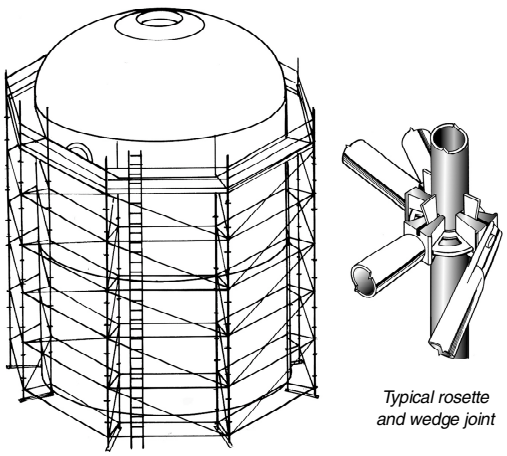


Figure 4.7
TUBE-AND-CLAMP SCAFFOLD

4.7 Systems Scaffolds

European scaffold systems have become very popular in applications that were traditionally suited to tube-and-clamp. Although they are not as adjustable as tube-and-clamp scaffolds, they can be applied to a wide variety of non-rectangular, circular, or dome-shaped structures. A typical example is shown in Figure 4.8. As with tube-and-clamp scaffolds, personnel carrying out the erection should be experienced with that type of system and a sketch or drawing of the scaffold to be erected is recommended for each application. Systems scaffolds above 10 metres (33 feet) in height must be designed by a professional engineer.

There are a great many systems available, ranging from light-duty aluminum to heavy-duty steel support structures. They all employ different patented locking devices (wedges, locking pins, etc.) which are not intended to be interchanged with other systems.



Typical rosette and wedge joint

Figure 4.8
SYSTEMS SCAFFOLD

4.8 Mast-Climbing Work Platforms

The use of mast-climbing work platforms (Figure 4.9) is becoming increasingly common, particularly in the masonry industry. They are best suited for medium to high-rise projects, and are used also by siding installers, window installers, drywallers, and other trades. For low to medium-height projects they can be freestanding, depending on ground conditions and manufacturers' instructions. For high-rise applications they can be tied to the structure at regular intervals as set out by the manufacturer.

Mast-climbing work platforms can be used as a single tower or as multiple towers braced together. The platform climbs the mast, normally powered by an electric or gas engine. The climbing mechanism will have a failsafe system to prevent accidental lowering or failing of the platform.

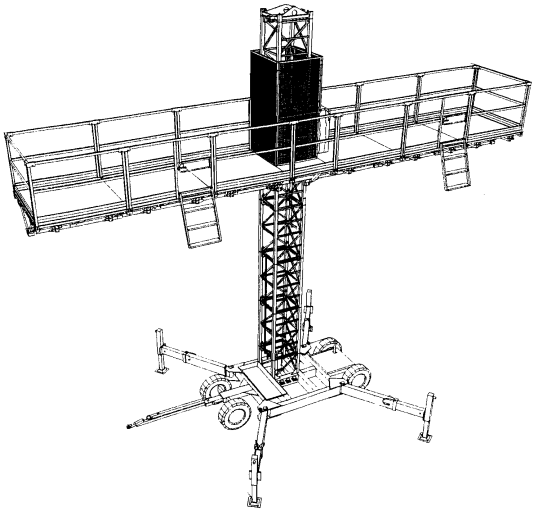


Figure 4.9
MAST-CLIMBING WORK PLATFORM

Although not shown here, the working platform can be a set distance below the material platform. This allows material to be stacked at a convenient height for the worker. The entire platform can be raised to whatever height is required. As such it has significant ergonomic advantages.

Engineered drawings should accompany this work platform outlining such components as load capacity, tie-in requirements, and bracing.

The potential for fall-related accidents is reduced when using mast-climbing work platforms since workers stay on a wide, secured platform even during erection and dismantling.

Manufacturers' instructions must be followed at all times. A competent worker should supervise the erection.

4.9 Crank-up or Tower Scaffolds

Although crank-up scaffolds (Figure 4.10) are more popular in the United States, some Canadian masonry contractors use them. They consist of towers, bases, and platforms that can be lifted by winches.

The working platform is located 600 to 900 mm (2 to 3 feet) below the material platform, which is in an ergonomically good position for the worker.

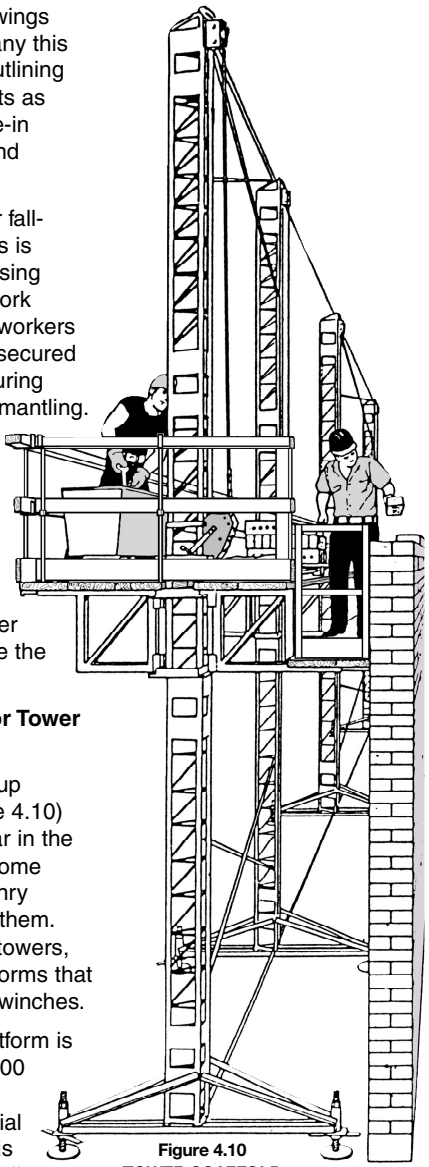


Figure 4.10
TOWER SCAFFOLD

The entire scaffold can be raised easily, allowing the worker a comfortable working height. Crews must be trained to erect, use, dismantle, and maintain tower scaffolding safely and efficiently. **Manufacturers' instructions must be followed at all times.** Tower scaffolds must be tied to the structure according to manufacturer's instructions.

5 SCAFFOLD COMPONENTS

Tubular Frame Scaffolds: There are many tubular frame scaffold components available (Figures 5.1, 5.2). Some components are necessary in almost all situations; others are optional depending on use and manufacturers' instructions. In addition to scaffold end frames, the minimum components required are

- base plates or castors
- mudsills
- adjustable screw jacks
- vertical braces on both sides of frames unless

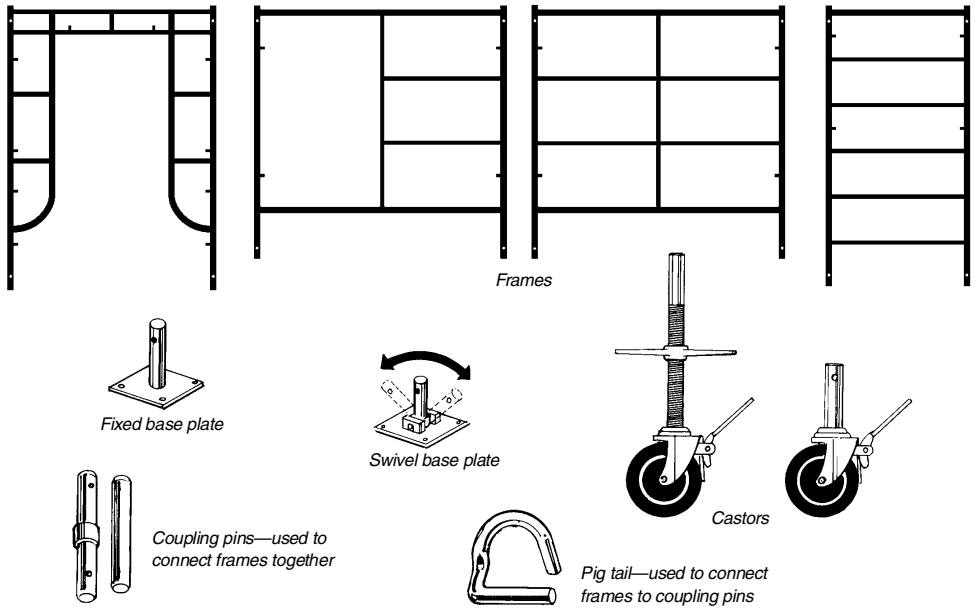


Figure 5.1
FRAME SCAFFOLD COMPONENTS

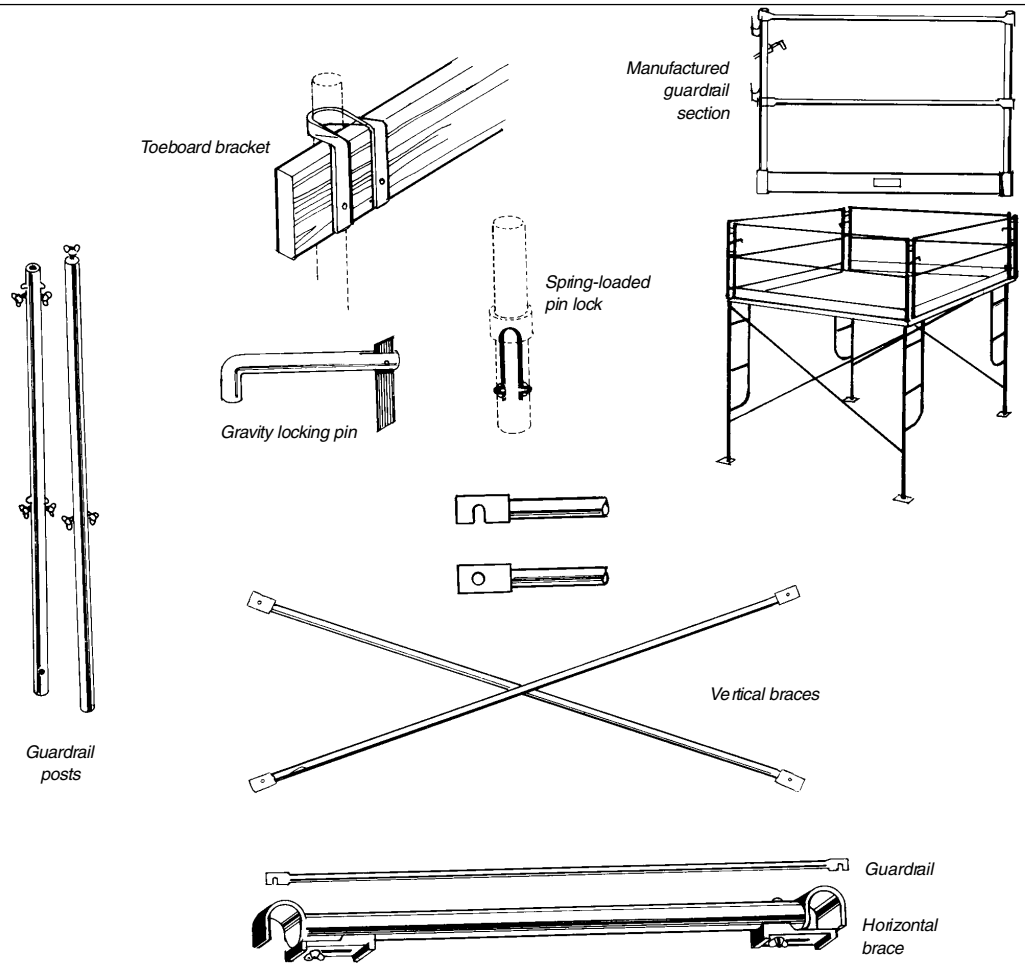


Figure 5.2
FRAME SCAFFOLD COMPONENTS

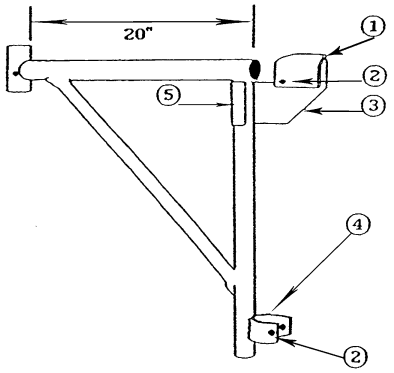


Figure 5.3
OUTRIGGER/SIDE BRACKET

When purchasing outrigger/side brackets, look for the following features, numbered to correspond with Figure 5.3.

1. Hook tops out at a V-point to sit securely on varying diameters of horizontal frame members
2. Hook and bottom shoe are prepared to receive pin
3. Hook is heavy-gauge, fabricated from one piece of steel
4. Ensure that the lower shoe won't interfere with braces, locks, or other features of different manufacturer's frames
5. Hook plate is wrapped around vertical member and welded on three sides only

• frames are designed with "non-pinned" joints
• additional bracing is provided by a designed system using tube-and-clamp accessories

– horizontal braces on every third tier of frames
– platform materials to fully deck in the intended working level
– guardrails complete with toeboards
– guardrail posts where working platforms will be at the top level
– ladders or stairs for access
– intermediate platfo rms where required—not more than 9metres (30 feet) apart and adjacent to vertical ladders.

Tube-and-Clamp Scaffolds and Systems Scaffolds have individual components unique to each type. These components are identified and discussed in detail in Section 6.

5.1 Platforms

Platforms for frame scaffolds are normally either aluminum/plywood platforms or wood planks. Planks normally come in 8-foot or 16-foot lengths to cover one or two 7-foot bays with adequate overhang. Platforms are dealt with in depth in Section 8.

5.2 Outrigger/Side Brackets

The use of outrigger brackets–also known as side brackets (Figure 5.3)–is very popular in the masonry industry. They are attached to the inside of the frame and accommodate a platform approximately 20" (two planks) wide. They provide a work platform for the mason at an ergonomically convenient location, lower than the material platform. Intended as a work platform only, they are not to be used for material storage.

Instances have been reported of brackets installed on the "wrong" side of the scaffold–facing the forklift, for example, to provide a landing area for skids of material. This is not acceptable because outrigger brackets are not designed for supporting material. Furthermore, the practice may lead to unbalanced loading of the scaffold, causing tip-over.

Figure 5.4 illustrates typical outrigger/side brackets attached to the scaffold for masonry use. For efficient, comfortable work, the brackets should be adjustable in lifts of no more than 600 mm (24 inches). A space no greater than 150 mm (6 inches) should be maintained between the bracket platform and the wall. Although the outrigger brackets illustrated are side brackets, end brackets are also available from most manufacturers.

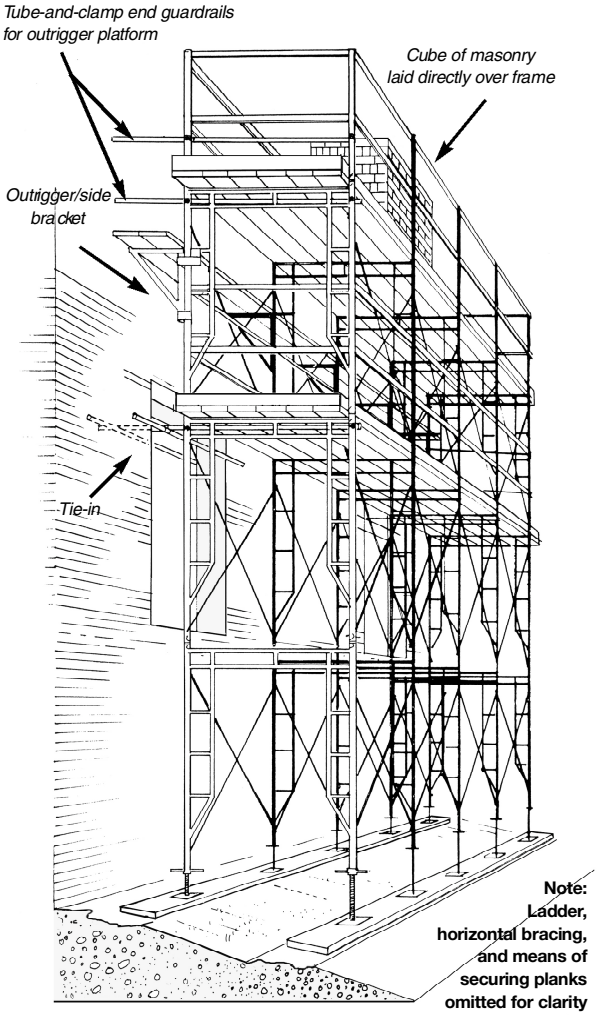


Figure 5.4
MASONRY SCAFFOLD WITH OUTRIGGER/SIDE BRACKETS

Use the following good work practices:

- Do not drop or roughly handle outrigger/side brackets during erection or dismantling. This can bend or damage hooks.
- Use planks that are double-cleated at one end to ensure that the cleats are engaged over a bracket to prevent the bracket from pivoting.
- Inspect brackets as they are being installed on the scaffold to ensure that only sound brackets with no defects are used.

- Tag for repair any brackets that have deformed or cracked hooks, cracked welds, or other defects.
- Make sure that brackets are mounted securely on the frame all the way down.
- Never stock material on the bracket working platform. The working platform is for the worker only.
- Make sure that planks laid on the brackets extend at least 150 mm (6 inches) beyond the frames at either end.
- Place brackets so the level where the worker stands is no more than 1 metre (40 inches) below the level where the material is stored.

Beware of common hazards with outrigger/side brackets:

- hooks bent or deformed to the extent that they will roll off the frame under load
- hooks bent back into place, thereby causing cracks in the metal or welds which then break under load
- homemade brackets that are poorly designed and fabricated, too flimsy to bear the load, or not sized properly to hold two planks
- failure to inspect brackets during erection to ensure that they are not damaged
- failure to use planks that have double cleats on one end.

Other features to look for are

- manufacturer's plate showing name and model number
- brackets that are hot-dipped galvanized
- manufacturer's literature stating that the bracket has been designed and fabricated to meet loading requirements specified in the Ontario regulations and applicable CSA standards.

5.3 Ladders

Whether built into frames, attached as a separate component, or portable, ladders are an important means of access to scaffold platforms. We would substantially reduce the number of falls connected with climbing up and down scaffolds if workers always used adequate and properly erected ladders. Unfortunately, suitable ladders are not often provided or used.

A major problem with ladders built into the frame is that planks sometimes stick out so far that it's difficult to get from the ladder to the platform. This situation results in many injuries but can be overcome in one of three ways:

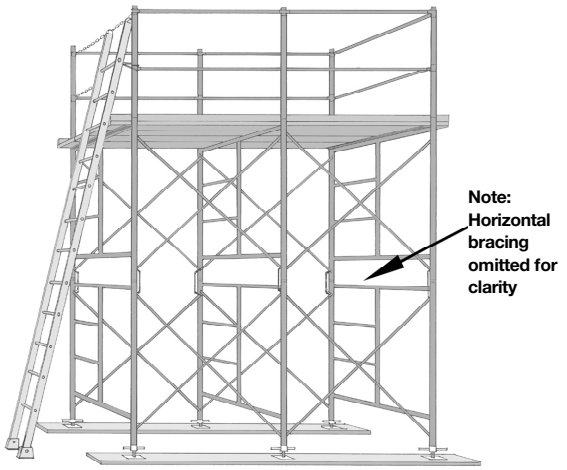
- use manufactured platform components which do not project beyond the support
- use a portable ladder where platform elevations are less than 9 metres (30 feet) in height (Figure 5.5)
- use a stand-off vertical ladder with a cage if the scaffold is above 3 metres (10 feet).

Ladder rails should extend at least 900 mm (3 feet) above the platform level to facilitate getting on and off. Injuries are often connected with stepping on and stepping off the ladder at the platform level.

Rest stations should be decked in on scaffold towers at intervals no greater than every 9 metres (30 feet). Climbing is strenuous work and accidents happen more frequently when climbers suffer from overexertion.

5.4 Guardrails

Failing to use guardrails is one of the main reasons for falls from scaffold platforms. Manufacturers of frame



NOTE:
Ladder rails should extend at least 1 m (3 ft) above platform

Figure 5.5

scaffolds have guardrail components which can be attached to the scaffold frames. These have posts that sit directly onto the connector pins and to which the rails are attached using wing nuts.

Where manufactured guardrails are not available, guardrails can be constructed from lumber (Figure 5.6) or tube-and-clamp components.

Tube-and-clamp guardrails may be constructed from standard aluminum scaffold tubing using parallel clamps to attach the vertical posts to each frame leg (Figure 5.6). Top rails and mid-rails should be attached to the vertical posts using right-angle clamps. Connections in these rails should be made with end-to-end clamps.

Most manufacturers have toeboard clips to fasten toeboards quickly and easily to standard tubular posts on either frames or guardrail posts.

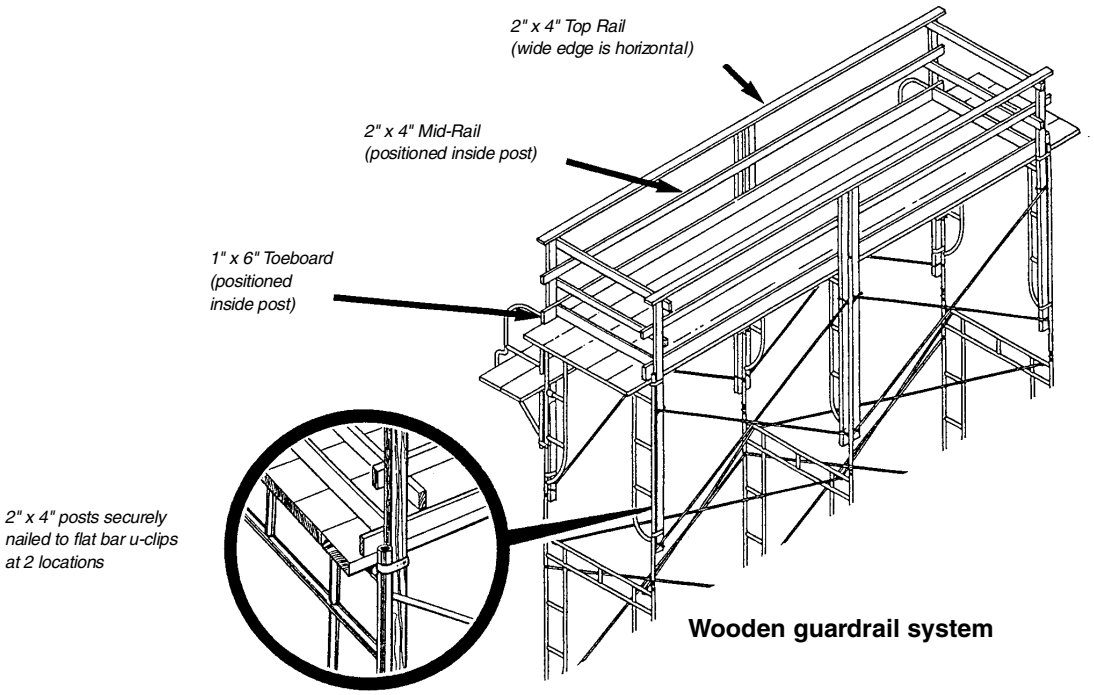
A guardrail should consist of:

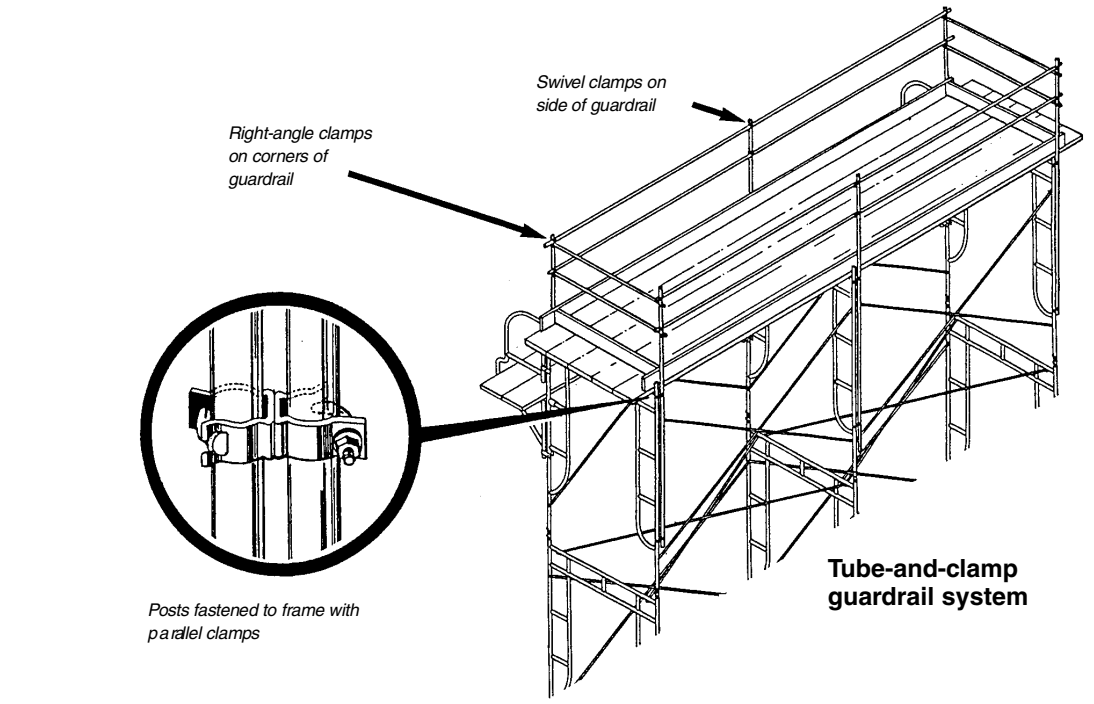
- a top rail about 1 metre (40 inches) above the platform
- a mid-rail about halfway between the platform and the top rail
- a toeboard at least 89 mm (3½") high at the platform level if made from wood, and
- posts no more than 2.4 metres (8 feet) apart if made from wood. Guardrail posts can be farther apart if the materials used are adequate to support the loads specified.

Guardrails should be designed to resist the forces specified in the Construction Regulation.

Frequently, guardrails must be removed to allow material to be placed on the scaffold platform. Workers must protect themselves from falling by using a fall-arrest system properly worn, used, and tied off. The fall-arrest system should be worn while the worker is removing the guardrail, receiving the material, and replacing the guardrail. Too often, guardrails are removed to receive materials and then not replaced. Many workers have fallen because other workers have left unguarded openings on scaffold platforms.

Figure 5.6
GUARDRAILS





6 ERECTING AND DISMANTLING SCAFFOLDS

6.1 General

Scaffolds should always be erected under the supervision of a competent worker. Although scaffold systems vary between manufacturers, certain fundamental requirements are common to all scaffold systems. Frame scaffolds over 15 metres (50 feet) in height, and tube-and-clamp and systems scaffolds over 10 metres (33 feet), must be designed by a professional engineer. Supervisors must ensure that the scaffolds are constructed in accordance with that design.

6.1.1 Foundations and Support Surfaces

Scaffolds must be erected on surfaces that can adequately support all loads applied by the scaffold. To support scaffolds, backfilled soils must be well compacted and levelled. Mud and soft soil should be replaced with compacted gravel or crushed stone. Embankments that appear unstable or susceptible to erosion by rain must be contained. Otherwise, the scaffold must be set far enough back to avoid settlement or failure of the embankment.

Where mudsills must be placed on sloping ground, levelling the area should be done, wherever possible, by excavating rather than backfilling (Figure 6.1).

In some cases it may be necessary to use half-frames to accommodate grade changes. For these situations the side bracing is usually provided by using tube-and-clamp components.

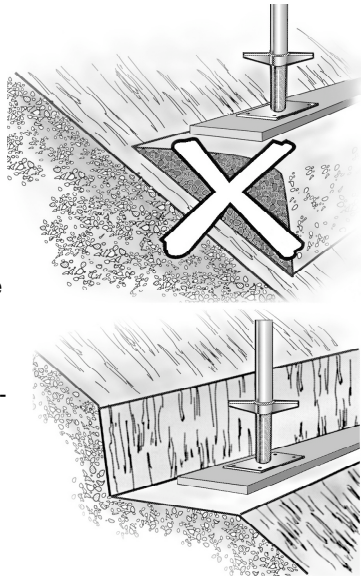


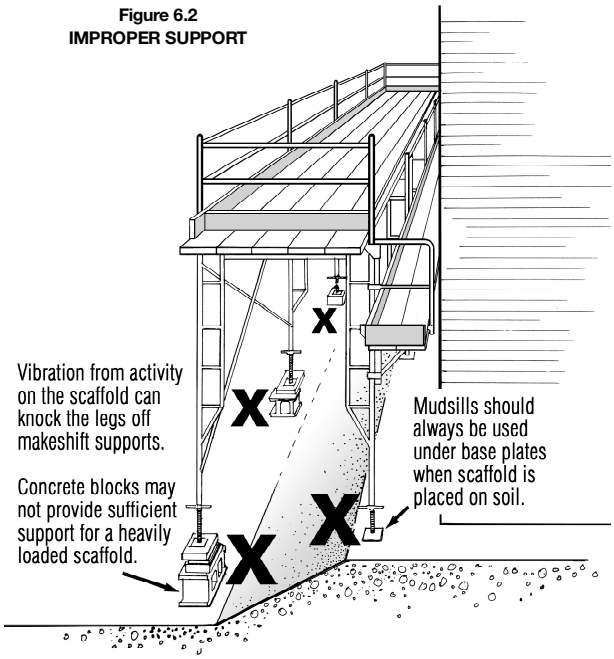
Figure 6.1
MUDSILL ON SLOPING GROUND

Floors are usually adequate to support scaffold loads of workers, tools, and light materials. As loads become greater, floors, especially the older wooden types, should be examined to ensure that they will support the anticipated loads. In some cases, shoring below the floor and directly under the scaffold legs may be necessary. In other situations, you may need sills that span the floor support structure.

Scaffolds erected on any type of soil should have a mudsill. At minimum the mudsill should be a 48 mm x 248 mm (2" x 10") plank (full size) and should be continuous under at least two consecutive supports. The scaffold feet should rest centrally on the mudsill and the sill should, where possible, project at least 300 mm (1 foot) beyond the scaffold foot at the ends. Mudsills may be placed either along the length or across the width of the frames.

Do not use blocking or packing such as bricks, short pieces of lumber, or other scrap materials either under scaffold feet or under mudsills (Figure 6.2). If the scaffold is subjected to heavy loading, bricks or blocks can break. Vibration can cause blocking to move or shift, leaving a scaffold leg unsupported. In such conditions the scaffold can topple when heavy loads are applied.

Figure 6.2
IMPROPER SUPPORT



Take particular care when erecting scaffolds on frozen ground. Thawing soil is often water-soaked, resulting in considerable loss of bearing capacity. You must take thawing into account when tarps or other covers will be placed around a scaffold and the enclosure will be heated.

If the scaffold is inside a building, preparing the foundation may mean

- clearing away debris or construction materials and equipment stored in the way
- using sills or placing shoring under old wooden floors.

For a scaffold on the outside of a building, preparing the foundation may include

- replacing mud and soft ground with gravel or crushed stone
- levelling and compacting loose backfill
- stabilizing or protecting embankments
- providing protection against erosion from rain or thawing
- using mudsills.

Foundation preparation is important with any scaffold. It is especially important when scaffolds will be heavily loaded, as in masonry work. Differential settlement may damage scaffold components even if no serious incident or collapse occurs.

6.1.2 Inspection

Scaffold materials should be inspected before use for

- damage to structural components
- damage to hooks on manufactured platforms
- splits, knots, and dry rot in planks
- delamination in laminated veneer lumber planks
- presence of all necessary components for the job
- compatibility of components.

Structural components which are bent, damaged, or severely rusted should not be used. Similarly, platforms with damaged hooks should not be used until properly repaired. Planks showing damage should be discarded and removed from the site so that they cannot be used for platform material.

6.1.3 Location

Before erecting a scaffold, check the location for

- ground conditions
- overhead wires
- obstructions
- variation in surface elevation
- tie-in locations and methods.

Checking the location thoroughly beforehand will eliminate many of the problems that develop during erection and will allow erection to proceed smoothly, efficiently, and safely.

6.1.4 Base Plates

Base plates and adjustable screw jacks should be used whether the scaffold is outside on rough ground or indoors on a smooth level surface. Base plates should be centred on the width of the sill and nailed securely after the first tier has been erected. Sills may run either across the width or along the length of the scaffold depending on grade conditions and other factors. Generally, bearing capacity will be increased by running sills longitudinally because the sill has more contact with the ground.

6.1.5 Plumb

When the first tier of scaffold has been erected it should be checked for plumb, alignment, and level. Where necessary, adjustments can be made using the screw jacks.

Settlement or slight variations in the fit of the components may require additional adjustments as tiers are added to the scaffold tower. Braces should fit easily if the scaffold tower is level. If braces do not fit easily it is an indication that the scaffold is out of plumb or out of alignment.

6.1.6 Hoisting Materials

Where scaffolds will be more than three frames high, a well wheel or “gin” wheel and a hoist arm or davit will make the hoisting of materials easier during erection (Figure 6.3).

While materials can be pulled up by rope without these devices, the well wheel and hoist arm allow the hoisting to be done by workers on the ground. This is much safer and eliminates the risk of workers falling from the scaffold platform as they pull materials up by rope. Loads lifted by a well wheel should normally be no more than 50 kg (100 lb.) unless special structural provisions are made.

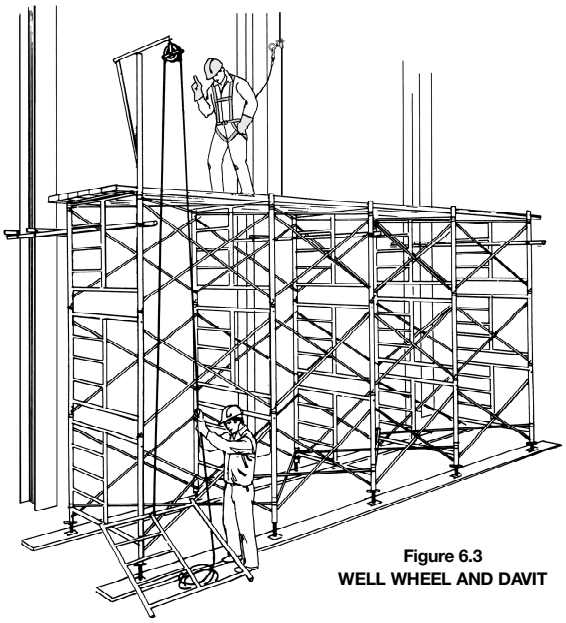


Figure 6.3
WELL WHEEL AND DAVIT

The use of forklifts or other mechanical means of hoisting scaffold materials has become more common particularly in masonry applications. The use of this type of equipment greatly reduces the potential for overexertion injuries due to lifting and pulling. However, extra precaution must be taken to prevent powerline contact and other potential hazards such as overloading.

6.1.7 Tie-ins

Scaffolds must be tied in to a structure or otherwise stabilized —in accordance with manufacturer’s instructions and the Construction Regulation—as erection progresses. Leaving such items as tie-ins or positive connections until the scaffold is completely erected will not save time if it results in an accident or injury. Moreover, in most jurisdictions it is prohibited. For further information on tie-in requirements see Section 7.6.

6.1.8 Fall Protection in Scaffold Erection

Providing practical fall protection for workers erecting and dismantling scaffold and shoring has been challenging for the construction industry.

In Ontario, revised fall protection requirements (Section 26 of the Construction Regulation) were introduced in June 2000 and require that workers erecting, using, or dismantling scaffolds must be protected from falling by using guardrails, travel restraint, fall-restricting systems, or fall-arrest systems.

For fall protection while workers are using a scaffold as a work platform, the safest solution is guardrails, provided they can be erected safely. Workers involved in erecting or dismantling scaffolds face a different challenge. Erecting guardrails and using fall-arrest equipment requires specialized procedures since normally there is nothing above the erector on which to anchor the fall protection system. See *Scaffolds in Construction* (DS023), from the Construction Safety Association of Ontario, for suggestions.

In all cases ensure that procedures comply with the regulations. You must use engineered design and procedures when required, and competent workers must review the installed scaffold before use. Pay special care and attention to anchorages.

A competent person must give adequate oral and written instructions to all workers using fall protection systems. Like all scaffolds, this equipment must be used under the supervision of a competent person.

6.2 ERECTING FRAME SCAFFOLDS

Frame scaffolds are the most common types of scaffolds used in Ontario. Too often they are erected by people who are inexperienced and do not know or recognize the potential hazards. Erectors must be aware of the potential dangers not only to themselves but also to the end user of the scaffold.

6.2.1 Fittings and Accessories

People are sometimes reluctant to install all the parts, fittings, and accessories required for a properly built frame scaffold. This poor practice continues because parts are frequently lost or otherwise not available at the site. Other times, it is due to haste, lack of training, or carelessness.

Always use base plates with adjustable screw jacks. They allow for minor adjustments to keep the scaffold plumb and level. Base plates usually have holes so you can nail them to mudsills. This is good practice and should be done as soon as the first tier is erected and plumbed with base plates centred on the sills.

You must brace in the vertical plane on both sides of every frame. Bracing in the horizontal plane should be done at the joint of every third tier of frames starting with the first tier. Horizontal bracing should coincide with the point at which the scaffold is tied to the building. Horizontal bracing is needed to maintain scaffold stability and full load-carrying capacity. The use of horizontal bracing on the first tier helps to square up the scaffold before nailing base plates to mudsills.

Every scaffold manufacturer provides coupling devices to connect scaffold frames together vertically. Figure 6.4 illustrates various types. Erectors often ignore these devices, believing that the bearing weight of the scaffold and its load will keep the frame above firmly connected to the frame below. This will probably hold true until the scaffold moves or sways. Then the joint may pull apart, causing a scaffold collapse. Coupling devices should always be used and installed properly on every leg of the scaffold, at every joint, as assembly proceeds.

If wheels or castors are used they should be securely attached to the scaffold and be equipped with brakes. Failure to attach wheels or castors properly to the frame has been the cause of many serious accidents and fatalities involving rolling scaffolds. Wheels or castors must have brakes which are well maintained and easily applied.

Scaffolds should always have guardrails. Unfortunately, people frequently leave them out, especially on scaffolds of low to moderate height. Workers have been seriously injured as a result.

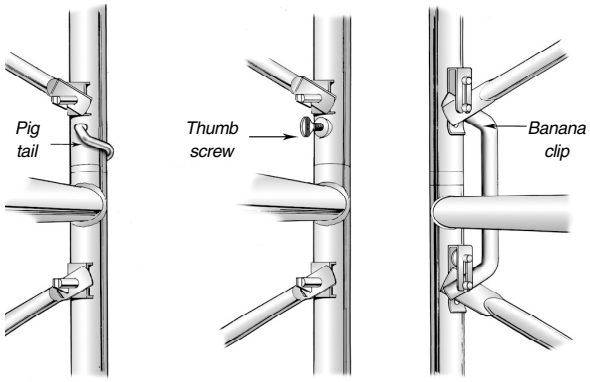


Figure 6.4
COUPLING DEVICES

6.2.2 Braces

Once you have fitted the adjustable base plates on the frames you must then attach the braces for each tower span. The braces should slide into place easily. If force is required, either the braces are bent or damaged or the frames are out of plumb or alignment.

Secure braces at each end. The erection crew must ensure that self-locking devices move freely and have fallen into place. Rust or slight damage can prevent some of these devices from working properly and they then require force to secure them in position. Maintain moving parts in good condition to prevent this situation from developing.

6.2.3 Platform Erection

Ensure that parts and fittings are in place and secure before placing platform components on a scaffold tier.

When proceeding with the next tier, workers should use platform sections or planks from the previous tier, leaving behind either one platform section or two planks. While this requires more material it speeds up erection because workers have platforms to stand on when erecting or dismantling the platform above. At heights above 3 metres (10 feet), all workers involved in the erection or dismantling of scaffolds must be protected by a guardrail or by other means of fall protection.

Frequently, low scaffolds one or two frames in height are not fully decked in. This can lead to accidents and serious injury. Many lost-time injuries occur each year in Ontario because platforms are inadequately decked.

6.2.4 Ladders

Where frames are not equipped with ladder rungs, ladders should be installed as the erection of each tier proceeds. Injuries involving scaffolds frequently occur when workers are climbing up or down the scaffold. Providing proper ladders will help prevent such injuries. See Section 5.3 (page 85) for more information on ladders.

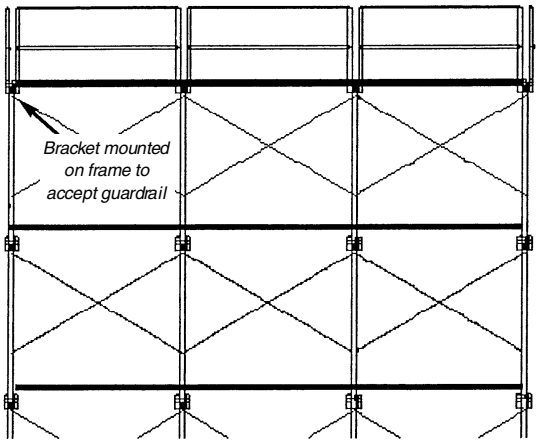
6.2.5 Guardrails

Guardrails must be installed at each working level as the scaffold is erected and also at the top level of the scaffold. This is recommended for all scaffolds regardless of height. Although you do not require guardrails until scaffolds are 2.4 metres (10 feet) high, a considerable number of severe injuries and even fatalities are due to falls from lower scaffolds.

Some manufacturers have recently introduced temporary guardrails workers can use when erecting scaffolds. A guardrail can be set in position from the previous level and can provide a protected work platform for the worker to install the next level of components. Each type of guardrail has a unique design and system of attachment to the scaffold.

Figure 6.5 shows one example of an "advanced guardrail" with the platform fully enclosed. The guardrail is positioned on a bracket which is mounted from below on the outside of the scaffold, and does not interfere with the placement of subsequent frames and braces. As the scaffold goes up the guardrail may be raised as well, or left in position to form the permanent guardrail. The erector must use another fall protection method—permanent guardrails or a full body harness with a lanyard attached to the scaffold—while moving either the platforms or the temporary guardrail.

Figure 6.5
ADVANCED TEMPORARY GUARDRAIL



6.3 ERECTING TUBE-and-CLAMP SCAFFOLDS

Most of the general rules that apply to frame scaffolding also apply to tube-and-clamp scaffolding. The requirements for mudsills, platforms, and guardrails are exactly the same for both types.

The most important difference between the two is the additional degree of skill and knowledge necessary to erect tube-and-clamp scaffolds safely and efficiently. Tube-and-clamp scaffolds should not be erected by an unskilled or inexperienced crew. Basic terms are identified in Figure 6.6.

6.3.1 General Requirements

Tube-and-clamp scaffolds are erected plumb and level like frame scaffolds but the erection system is quite different. The scaffold must start with a set of ledgers and transoms immediately above the base plates. This is necessary to hold the base plates in their proper position. The typical erection sequence for a simple tower is shown in Figure 6.6. Each vertical and horizontal member should be checked with a spirit level as erection proceeds.

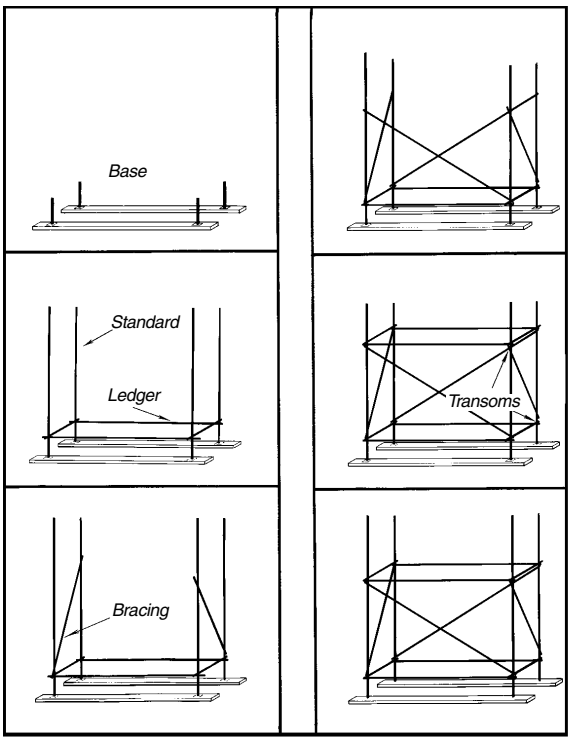


Figure 6.6
ERECTION OF TUBE-AND-CLAMP SCAFFOLD

6.3.2 Materials and Components

The tubing normally used for tube-and-clamp scaffolding in Ontario is schedule 40, 1.9" OD (1½ ID) aluminum pipe manufactured of either 6061 or 6063 alloys.

Clamps are usually made of steel and have a variety of configurations. Depending on the manufacturer, clamps can be fastened using wedges, bolts, or other methods. The following types are used.

- **Right-Angle Clamp**—a clamp used for connecting tubes at right angles. They maintain the right-angled orientation providing rigidity to the structure.
- **End-to-End Clamp**—an externally applied clamp to connect two tubes end-to-end.
- **Swivel Clamp**—a clamp used to connect two tubes when right-angle clamps cannot be used. They usually connect bracing.
- **Parallel Clamp**—a clamp used for lap jointing two tubes together. It can be used to connect short guardrail posts to the standards or legs of frame scaffolds.
- **Concrete Tie Clamp**—a clamp used to connect a tube to concrete or other surfaces using a bolt or concrete anchor.

These and other devices are shown in Figure 6.8 depicting a typical tube-and-clamp scaffold.

Before using clamps, check them carefully for damage to wedges or threads on bolts and distortion of the clamp body.

6.3.3 Spacing of Standards

The spacing of standards depends on the load-carrying requirements of the scaffold. Wherever possible, tube-and-clamp scaffolding should have bay and elevation spacing of about 2 metres (6'-6") longitudinally and vertically. This allows for the front sway bracing to be located at approximately 45° to the horizontal. It also facilitates the use of 5-metre (16-foot) planks with adequate overhang. The width of these platforms can vary but is usually approximately 1 metre (3 feet). This spacing allows the aluminum tubing specified earlier to carry normal construction loads adequately. An advantage of tube-and-clamp scaffolding is that the platform height can be easily adjusted to the most appropriate level for the work being done.

6.3.4 Ledgers and Transoms

Ledgers should be connected to standards using right-angle clamps. These clamps maintain a rigid 90° angle between members.

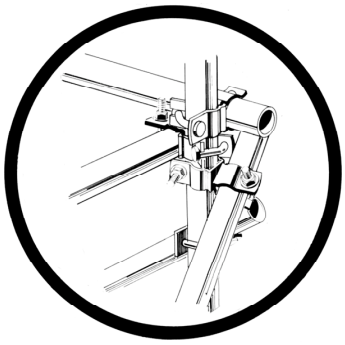
Transoms should be placed above the ledgers and both should be maintained in a horizontal position by levelling with a spirit level. Transoms may be connected to either standards or ledgers by using right-angle clamps.

6.3.5 Joints in Standards and Ledgers

Joints in standards and ledgers should be made with end-to-end clamps. These joints should be as close to the node points as the clamp arrangements will allow. Joints in vertically-adjacent ledgers should not occur in the same bay but should be staggered to provide rigidity.

A node point is the point at which the ledger-to-standard, transom-to-standard, and bracing-to-standard connections come together. An example of a node point is shown in Figure 4.7 and below.

Node point



6.3.6 Intermediate Transoms

You should install intermediate transoms when the scaffold will be supporting heavy loads. You can also use them to avoid lapping planks and the tripping hazard that comes with it.

6.3.7 Tie-ins

Tie-ins are required with tube-and-clamp scaffolding. They should be located at every second node vertically and every third standard horizontally. The tie-in tube should be connected to both standards or both ledgers, near the standard to provide rigidity. Connections should be made with right-angle clamps. Tie-ins should be capable of withstanding both tension (pull) and compression (push) forces (Figure 6.8).

6.3.8 Bracing

Internal bracing (Figure 6.8) is connected standard-to-standard using swivel clamps. It should be clamped as close to the node as possible. Internal bracing should normally be placed at every third standard. The location should coincide with tie-in points. You should also install bracing for tube-and-clamp scaffolding as erection progresses.

Face sway bracing should be installed to the full height of the scaffold. It may be located in a single bay or extend across several bays (Figure 6.7). Where the bracing is located in single bays it should be in the end bays and at least in every sixth bay longitudinally. In practice, it becomes difficult to get bracing close enough to the node points if it extends more than four bays in width (see ends of bracing in Figure 6.7).

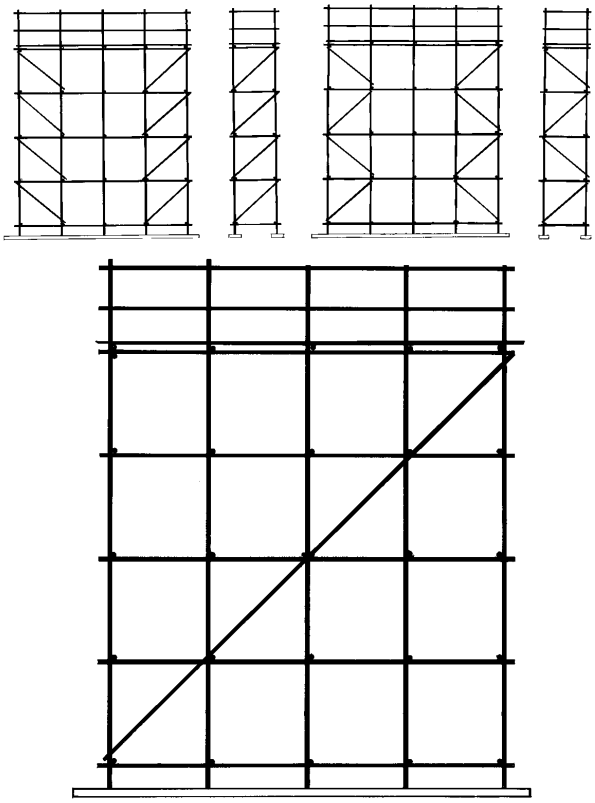
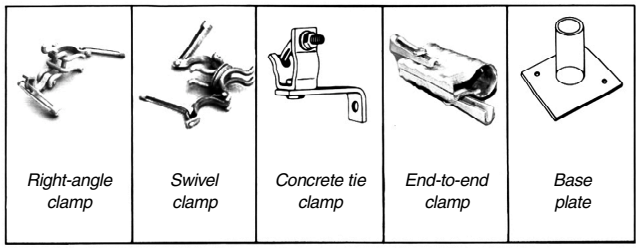


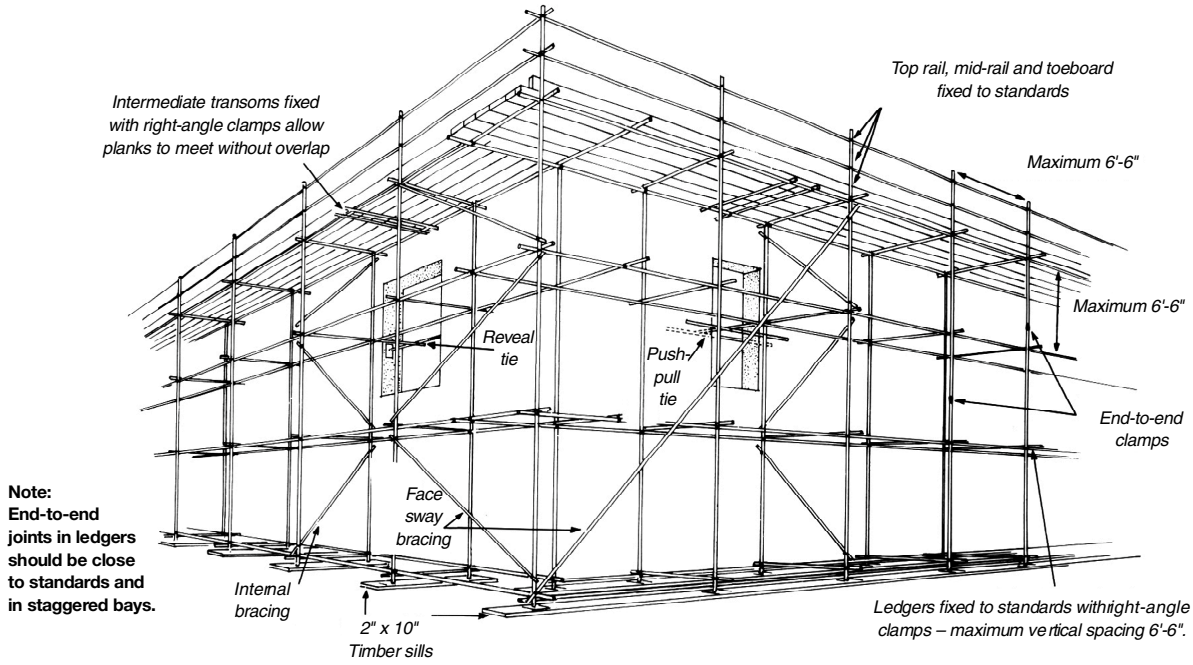
Figure 6.7
TUBE-AND-CLAMP BRACING

6.3.9 Drawings and Inspections

We strongly recommend that a sketch or drawing be prepared before erecting tube-and-clamp scaffolding. It is important that you place the standard to accommodate the anticipated loads adequately. Bracing must also be designed to provide stability and to transfer horizontal loads to tie-in points.

Figure 6.8
COMPLETED TUBE-AND-CLAMP SCAFFOLD





Where the platform will be more than 10 metres (33 feet) high or where unusual structures such as cantilevered platforms are involved, a professional engineer must design the scaffold. A professional engineer or a competent worker must inspect the scaffold before it is used to ensure that it is erected in accordance with the design drawings.

6.4 ERECTION of SYSTEMS SCAFFOLDS

Erection of systems scaffold is very similar to that of tube-and-clamp scaffold. The requirements for mudsills, platforms, and guardrails are the same as is the requirement for being built level and plumb. The main differences are the method of connecting individual members together and the fact that all the members are of a fixed length. As with tube-and-clamp scaffolds, all systems scaffolds above 10 metres (33 feet) must be designed by a professional engineer.

6.4.1 Components

Standards come in a variety of lengths and have a variety of built-in connection points at equal distances along their length. These connectors are normally between 450 and 500 mm (18 and 21 inches) apart depending on the manufacturer. Typical connections are shown in Figure 6.9, although others are available. An end-to-end connection, normally a spigot, is formed at one end to facilitate extension of the standard.

Starter Collars are short standards with one set of system rings or rosettes attached. They are convenient to use because they allow one person to put the first set of transoms and ledgers in place easily (Figure 6.10).

Ledgers or Runners for each system are available in varying lengths and have built-in connection devices for connecting to the standards. The connection is secured by wedging, bolting, or by other methods.

Transoms or Bearers are made wide enough for four or five planks. They normally have end connections similar to those of ledgers and connect directly to the standard. Normally transoms have a lip or groove—particular to the individual manufacturer—designed to accommodate the platform.

Braces are made in set lengths to fit the scaffold being constructed, with connections at both ends to fit directly onto the connection point on the standard.

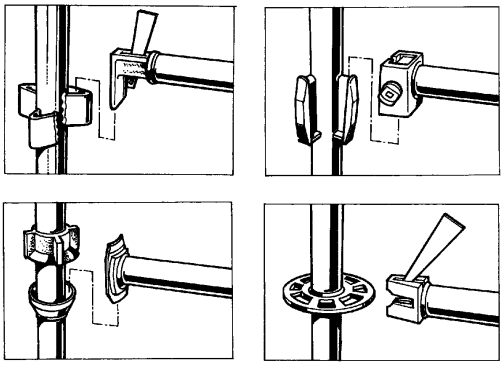


Figure 6.9
TYPICAL SYSTEMS SCAFFOLD CONNECTORS

Platform boards (also called staging) come in a variety of lengths and widths. They fit directly into the transoms and can be secured to prevent wind uplift. To facilitate climbing, some platforms have trap doors with built-in drop-down ladders.

6.4.2 Erection Procedure

The foundation for systems scaffolds should be prepared in the same way as other types of scaffolding, ensuring a firm level base, and using mudsills, base plates, and adjustable screw jacks.

The base plates should be laid out in what you estimate is the correct location. We recommend starter collars since they allow scaffolds to be laid out level and square.

The first level of transoms and ledgers should be placed on the starter collars and be levelled using the screw jacks.

When the scaffold is square and level you should tighten the connections and nail the base plates to the mudsills.

At this point set up an erection platform for installing the standards for the next lift. You now install the second level ledgers and transoms as well as the deck.

You must install ledger bracing at the ends of all system scaffolds and at intervals according to the manufacturers' recommendations. Each brace will be the correct length for the span being braced and should be connected to the attachment point on the standard.

You must install face or sway bracing according to manufacturers' instructions. Again, attachment points are set on the standards, and the braces come in specific lengths for the span of the scaffold being constructed. Normally, every third bay is braced for sway.

Figure 6.10 outlines the typical erection procedure for systems scaffold.

6.4.3 Tie-ins

Systems scaffolds must be tied in to structures using the 3-to-1 rule as with other scaffolds. Some manufacturers have special adjustable ties which connect directly into the standards, while others use a tube-and-clamp method to tie in to the structure. Anchors attached to the structure are the same as in frame or tube-and-clamp scaffolds.

6.4.4 Guardrails

Generally, guardrails are installed at all working levels. These guardrail components come in modular lengths and are made from lighter materials than the ledgers. They attach directly to the connection points on the standards.

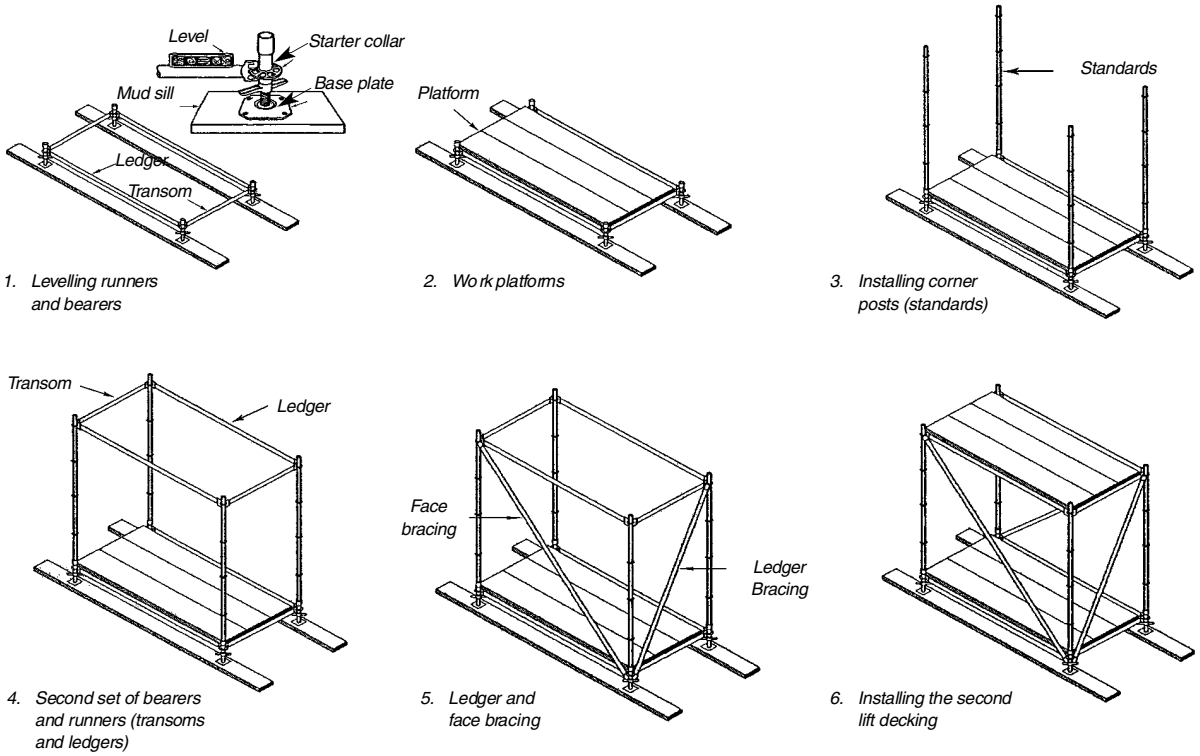


Figure 6.10
ERECTION SEQUENCE OF TYPICAL SYSTEMS SCAFFOLD

Certain manufacturers have developed advanced guardrail systems that can be installed for a level above the erector, providing fall protection for the worker accessing the next level.

The example shown in Figure 6.11 consists of a "T" shaped temporary guardrail which is attached to the permanent guardrails on the level underneath. When mounted, it extends the required distance past the deck above to form a guardrail. The erector can then work safely without being tied off and install the next level of standards, ledgers, and transoms.

6.5 DISMANTLING

Dismantling frame scaffolds is essentially erection in reverse. Each tier should be completely dismantled and the material lowered to the ground before beginning to dismantle the next tier.

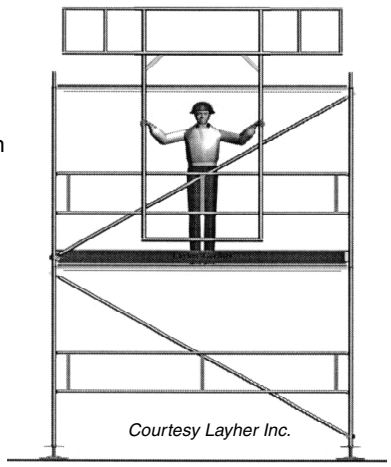
If platform sections or planks have been left at each level during erection, as suggested above, it should be relatively easy to lower platform materials from above and deck in the current working platform completely. Extra platform material can be lowered to the ground. Using this procedure, workers will be operating most of the time from a fully decked-in platform. This makes for easier removal of braces and frames.

Dismantled materials should be lowered using a well wheel and hoist arm or by mechanical means. Dropping materials not only causes damage and waste, but also endangers workers below—and is illegal in most jurisdictions.

When scaffolds have been in the same location for a long time, pins and other components frequently rust, braces become bent, and materials such as mortar or paint often build up on the scaffold parts. All of these can prevent components from separating easily. Removing jammed or rusted scaffold components can be very hazardous. Tugging or pulling on stuck components can cause you to lose your balance and fall. Workers should wear a full body harness and lanyard tied off to a scaffold frame or lifeline before attempting to loosen stuck or jammed parts.

Dismantling tube-and-clamp and systems scaffolding must proceed in reverse order to erection. Each tier should be completely dismantled as far as connections will allow before you begin dismantling the lower tier. You must dismantle them this way because the bracing for tube-and-clamp scaffold is not located in each bay as it is for frame scaffolding. The span or spans with front sway bracing should be the last to be dismantled on each tier.

Figure 6.11
ONE STYLE OF
ADVANCED GUARDRAIL SYSTEM



Courtesy Layher Inc.

7 SCAFFOLD STABILITY

7.1 Three-to-One Rule

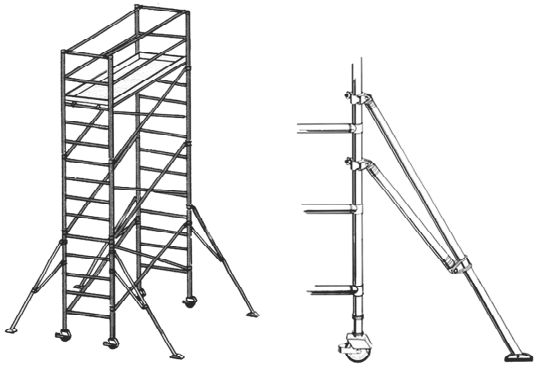
The ratio of height to least lateral dimension must not exceed 3 to 1 unless the scaffold is

- tied to a structure, as discussed in Section 7.6
- equipped with outrigger stabilizers (Figure 7.1) to maintain the ratio of 3 to 1
- equipped with suitable guy wires.

7.2 Outrigger Stabilizers

Scaffold manufacturers usually make outrigger stabilizers that can be attached to their equipment (Figure 7.1).

Figure 7.1
OUTRIGGER STABILIZERS



Rolling scaffold with outrigger stabilizers

Adjustable outrigger stabilizers

With devices of this type, ensure that the outrigger is adjusted so that vibration or dynamic loads on the platform will not move the stabilizer. Where stabilizers with castors are used the castors must rest firmly on a solid surface, with the brakes applied, and with the stabilizer secured in the extended position before workers use the platform (Figure 7.2). Many of these stabilizers fold up to allow movement through smaller openings and around obstructions (Figure 7.2).

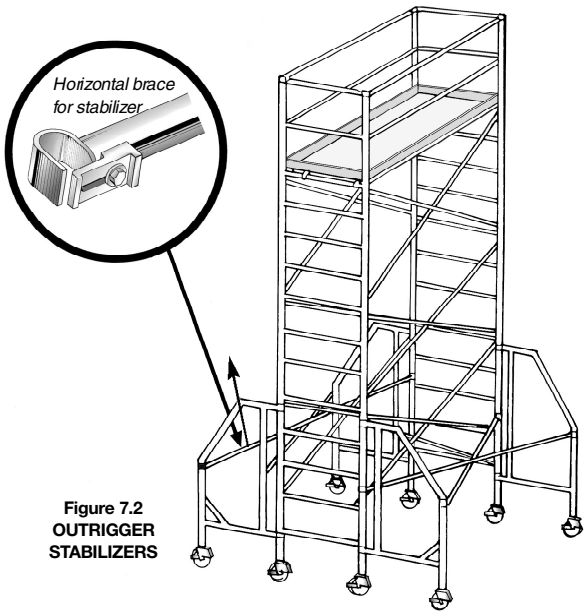


Figure 7.2
OUTRIGGER
STABILIZERS

7.3 Limitations to the Three-to-One Rule

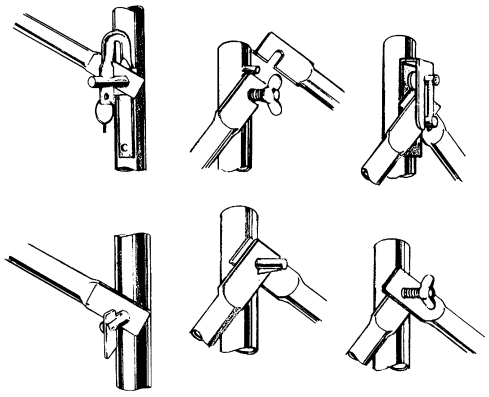
The 3-to-1 rule applies only to the extent that outriggers are extended symmetrically about the scaffold tower. If the outriggers are extended only on one side, you prevent toppling only in that direction.

7.4 Damage

Most bracing systems for tubular frame scaffolds are manufactured from light materials and are easily damaged.

Do not use braces with kinks, bends, or deformations. Such damage can weaken them significantly. The ends of braces are frequently damaged by dropping them on concrete or other hard surfaces during dismantling. Ends of braces are also frequently bent by forcing them onto the locking pin during erection. Constant bending can cause the ends to crack. You should inspect them before use and discard braces with cracked ends. You should maintain the locking device onto which the brace fits in good condition. It should move freely to accept and release the brace. Common securing devices are shown in Figure 7.3.

Figure 7.3
SECURING DEVICES FOR FRAME SCAFFOLD BRACES



7.5 Installation Problems and Symptoms

Ensure that bracing is secured in place. Otherwise, scaffold movement can dislodge the braces and reduce the stability of the scaffold. These devices must secure the braces in place but they must operate freely so that it is easy to erect and dismantle the scaffold. Many times a worker has lost balance and fallen when trying to release a jammed or rusted drop hook while dismantling a scaffold.

You should completely deck platforms used to install bracing. Trying to work from a platform one or two planks wide often results in a fall. In addition, it leads to greater damage to the ends of scaffold braces because they bend when they are not kept close to proper alignment during installation and removal.

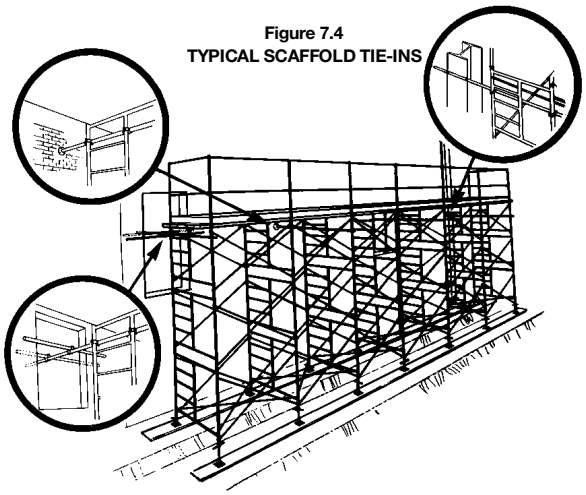
If a brace does not easily drop onto pins something is wrong. The brace may simply be bent and should be discarded. Often, however, it means the scaffold is twisted and out of plumb. Braces should not be forced or hammered onto the pin. The condition causing this difficulty should be corrected so that the brace slides onto the pin easily. Adjusting screw jacks slightly will often solve this problem. However, you need to take care to ensure the scaffold is not adjusted out of plumb.

7.6 Tie-in Requirements

Scaffolds which exceed the 3-to-1 rule of height to least lateral dimension must be tied in to a building or structure. Tie-ins should be applied at every third frame vertically second frame horizontally for tubular frame scaffolds. Tie-ins for tube-and-clamp scaffolds should be applied at every second node vertically and every third standard horizontally.

These tie-ins must be capable of sustaining lateral loads in both tension (pull) and compression (push). Examples are shown in Figure 7.4.

Figure 7.4
TYPICAL SCAFFOLD TIE-INS



Wind loads can affect tie-ins and bracing. These loads vary not only with speed but also with the exposure of the location and the height and shape of structures where the scaffold is erected. In addition, scaffolds which are going to be enclosed for winter construction or sandblasting will be subjected to significantly greater wind loads. If severe winds are expected it is recommended that a professional engineer be consulted for tie-in requirements

8 PLATFORMS

Before you select the platform material, you need to assess the weight of the workers, tools, and materials to be supported. You must also take into consideration the spans being used in the scaffold.

8.1 Typical Loads and Requirements

Minimum platform capacities vary from jurisdiction to jurisdiction. In Ontario, the minimum platform capacity is a uniformly distributed load of 2.4 kn/m^2 (50 lb./sq. ft.) for construction-related work. This is usually sufficient for workers, their tools and equipment, as well as a moderate amount of light materials. It is not sufficient for heavy loads such as those used in masonry construction.

For masonry construction where the scaffold will support large pallets of concrete blocks, minimum capacity should be at least a uniformly distributed load of 7.2 kn/m^2 (150 lb./sq. ft.). This means that scaffolds with spans of 2.1 metres (7 feet) should be at least double-planked. Aluminum/plywood platforms should also have a layer of scaffold planks on top.

Table 8.1

MAXIMUM LOADS ON PLANKS FOR SCAFFOLD PLATFORMS 5 FEET IN WIDTH

	Layers of Planks	5'-0"			7'-0"		
UNIFORM LOAD PER SQUARE FOOT	150 lbs.	No. 1				No. 1	
	100 lbs.	No. 1			SEL STR	No. 1	
	75 lbs.	No. 1			No. 1		
	50 lbs.	No. 1			No. 1		
4'X4' PALLET LOADS (POUNDS)	4000	SEL STR	No. 1			SEL STR	No. 1
	2900	No. 1				No. 1	
	2430	No. 1			SEL STR	No. 1	
	1760	No. 1			No. 1		
	1520	No. 1			No. 1		

Notes

1. Planks are **spruce-pine-fir species group (SPF)**.
2. Planks are at least $1\frac{7}{8}$" thick and at least $9\frac{3}{4}$" wide.
3. Grade is either number one (No. 1) or select structural (SEL STR).
4. Allowable stresses conform with CSA Standard CAN3-086-1984 "Engineering Design in Wood."
5. No stress increases are included for load sharing or load duration.
6. Scaffold platforms are 5' wide and fully decked in.
7. Loads indicated are **maximum** for grade and loading conditions. Shaded areas indicate that **no** SPF grades are capable of carrying the loads.

For weights of construction materials and allowable load-carrying capacities of planks at various spans, consult Table 8.1 and Table 9.1.

8.2 Aluminum/Plywood Platform Panels

Most manufacturers make their heavy-duty platforms capable of supporting a uniformly distributed load of 3.6 kn/m^2 (75 lb./sq. ft.) together with a concentrated load of 227 kg (500 lb.) spread over an area near the centre of the span. The load-carrying capacity of these platforms varies to some extent.

It is recommended that the rated load-carrying capacity be obtained from the supplier and marked on the platform panel if the manufacturer has not provided such information on the equipment already. The light-duty platforms available with much less capacity are not suitable for construction.

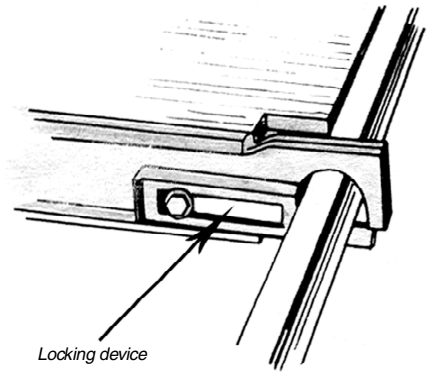


Figure 8.1
SECURING ALUMINUM/PLYWOOD PLATFORMS

The advantage of aluminum/plywood platform panels is that they are light and durable. Worn-out plywood can easily be replaced. However, they are expensive and the hooks on most models can be damaged if dropped from the scaffold repeatedly during dismantling. Check the platform hooks and fastening hardware regularly for looseness, cracking, and distortion. When used outdoors, these platforms should be secured to the scaffold frames using wind locks. Otherwise, when left unloaded, they can be blown off the scaffold by strong winds.

8.3 Laminated Veneer Lumber

This material is really a special type of exterior plywood with laminations oriented longitudinally rather than in two directions. The wood is usually spruce or Douglas fir, although other structural species can be used. The material is manufactured in large sheets of various thicknesses that can be sawn to the sizes required.

The use of laminated veneer lumber as a scaffold platform material is increasing. The strength varies from manufacturer to manufacturer depending on method of fabrication and species of wood used. Users of the material should ask suppliers to furnish rated working loads for the scaffold spans on which the lumber will be used. In general, the material will be stronger than sawn lumber scaffold planks of similar size and species. The strength is also more uniform than sawn lumber.

Like all lumber and plywood, laminated veneer lumber is subject to deterioration from weathering and rot. It must therefore be inspected periodically. Sections showing delamination, cracks, serious damage to several layers of lamination, fungi, or blisters should be discarded.

8.4 Sawn Lumber Planks

Rough sawn planks 48 mm x 248 mm (2 inches by 10 inches) or larger have been the standard scaffold platform material for many years. They are also the least expensive of the common platform materials. **Dressed lumber should never be used for scaffold platforms.**

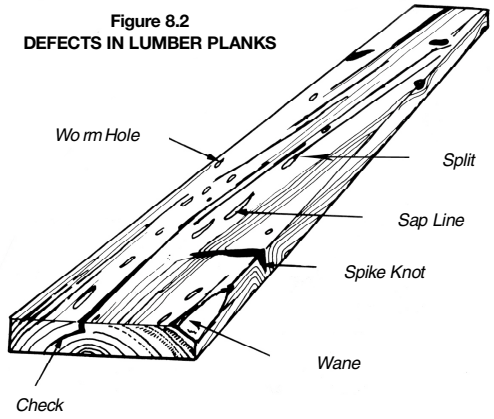
The proper use of planks on a scaffold or other work platform is governed by the Construction Regulation under Ontario's *Occupational Health and Safety Act*. The regulation specifies that wooden planks used on a scaffold must

- be number 1 grade spruce
- bear a legible stamp or be permanently identified as being number 1 grade spruce
- be at least 48 mm by 248 mm ($1\frac{7}{8}$" x $9\frac{3}{4}$")
- be arranged so their span does not exceed 2.1 metres (7 feet)
- overhang their supports by no less than 150 mm (6") and no more than 300 mm (12")
- be laid tightly side by side across the full width of the scaffold at the working level
- be cleated or otherwise secured against slipping
- be capable of carrying any load likely to be applied and as a minimum be capable of carrying 2.4 kilonewtons per square metre (50lb./sq. ft).

It is recommended that planks should meet or exceed the requirements for select structural grades of the species group used, which should be either spruce-pine-fir (SPF) or Douglas fir. Although the SPF group has less strength, it is usually lighter and therefore easier to handle than Douglas fir. Table 8.1 provides maximum loads based on unit stresses from Canadian Standards Association Standard 086.1-1994 "Engineering Design in Wood" for Number 1 and select structural SPF plank platforms. Sawn lumber planks must be stamped by the manufacturer identifying them as scaffold planks.

Since wood planks deteriorate they must be regraded and culled periodically. For most situations, visual grading is recommended. Scaffold planks must be inspected regularly because they deteriorate with use and age, and are subject to damage. Figure 8.2 illustrates defects to look for when inspecting planks. Cull out planks with large knots in the edge, spike knots, checks, wanes, worm holes, and steeply sloping grain patterns. Planks with these defects should not be used as scaffold material and should be destroyed. Scaffold planks can also be weakened by dry rot. It is not easy to notice this condition in its early stages, especially if the exterior of the planks is weathered. Planks substantially infected with dry rot are usually lighter than sound planks of similar size and species. For this reason do not use planks which feel lighter than normal.

Figure 8.2
DEFECTS IN LUMBER PLANKS



8.5 Reinforcing Wood Planks

Wood planks may be reinforced with metal nailer strips or plates. Research conducted by the Construction Safety Association of Ontario has indicated that the strength of weaker planks may be increased considerably by this technique but it should only be used to increase the strength of planks that are of the proper grade. Do not use this as a method of upgrading inferior grades for scaffold use.

The advantages of strengthening planks by this method are twofold:

- planks are not as likely to be cut up or used for purposes other than scaffold planks
- you have additional assurance that poorer quality planks undetected in the grading process will not break prematurely causing an accident.

WARNING: Nailer plates should not be placed over the portion of the plank resting on the scaffold support—unless cleats are used to prevent the plank from sliding—since there is little friction between the bearing surfaces.

Take care when handling planks reinforced in this way since sharp edges can cut your hands.

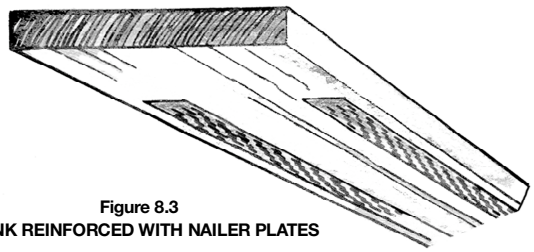


Figure 8.3
PLANK REINFORCED WITH NAILER PLATES

8.6 Securing Platforms to the Frame

Be sure to secure platforms against sliding or movement. Workers frequently fall from platforms because they did not first secure the platform materials. Aluminum/plywood combination platforms have hooks that prevent longitudinal movement but will slide sideways on the scaffold unless the platform is fully decked in.

Sawn lumber planks should be cleated on at least one end to prevent longitudinal movement (Figure 8.4). You can also prevent movement by wiring a plank (Figure 8.6). Unless you carefully apply it, the wire can present a tripping hazard on the platform. Again, the platform should be fully decked in to prevent sideways movement.

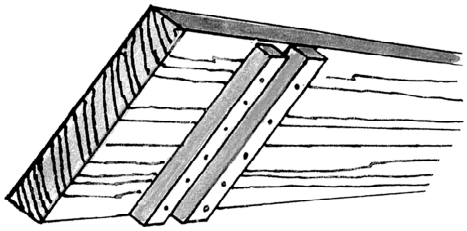
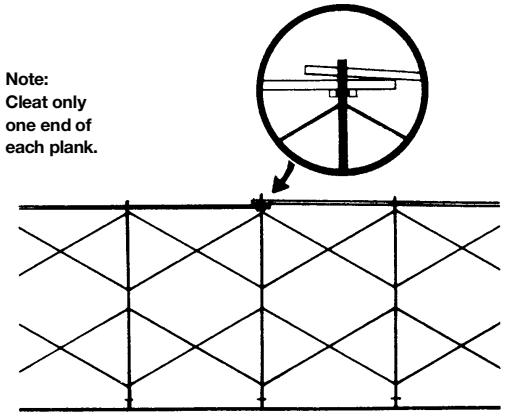


Figure 8.4
PLANK CLEATED TO PREVENT SLIDING

If you have overlapping planks, the cleated end should be resting on the scaffold support. Be aware that the overlapped section presents a tripping hazard (Figure 8.5).

Figure 8.5
OVERLAPPING PLANKS FOR MULTI-SPAN TOWERS

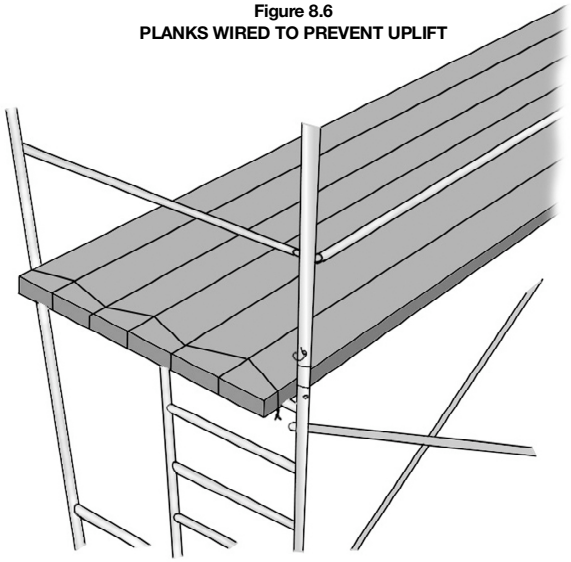


8.7 Wind Uplift

Wind can lift light platform materials from the scaffold if they are not secured. When you anticipate severe wind conditions or when you are using high scaffolds, you should secure platform materials such as aluminum/plywood panels to the scaffold. With some types of platform panels you can do this with wire or nails.

Others have a sliding locking device (Figure 8.1). These locking devices, however, can be easily damaged and are often difficult to apply and release.

Figure 8.6
PLANKS WIRED TO PREVENT UPLIFT



9 PROPER USE OF SCAFFOLDS

Much of this chapter deals with the erection and dismantling of various types of scaffolds. Frequently, the end user of the scaffold is not the person who erects it. In order for scaffolds to provide efficient access to work areas they must be used properly by all workers.

9.1 Ladders and Climbing

We discussed ladder access in Section 5.3. The ladder must be properly erected with rails projecting 1 metre (3 feet) above the platform of the scaffold. You should clear debris, extension cords, and tools away from areas around the top and bottom of ladders. Store materials away from these locations.

Falls often happen when workers are getting on or off the ladder at the platform level. Both hands must be free to hold guardrails or ladder rails. Do not carry tools or materials by hand when climbing ladders. Wear a tool belt and pouch and move material up or down by rope.

You should always place portable straight ladders with an adequate slope and secure them to the scaffold structure (Figure 5.5).

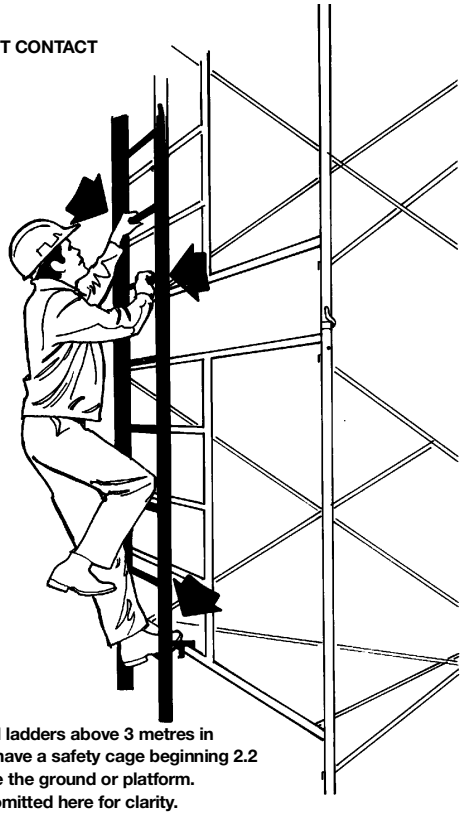
Always use three-point contact (Figure 9.1) when climbing ladders. This means using two hands and one foot, or two feet and one hand, to maintain contact with the ladder at all times. Always face the ladder when climbing and always keep your centre of gravity between the two ladder rails.

For more information, refer to the ladders section of this manual.

9.2 Guardrails Missing or Removed

There may be situations where scaffolds must be used without guardrails. If the scaffold is more than one frame or tier in height and there are no guardrails, personnel on the platform must tie off with a full body harness and

Figure 9.1
THREE-POINT CONTACT



Note: Vertical ladders above 3 metres in height must have a safety cage beginning 2.2 metres above the ground or platform. The cage is omitted here for clarity.

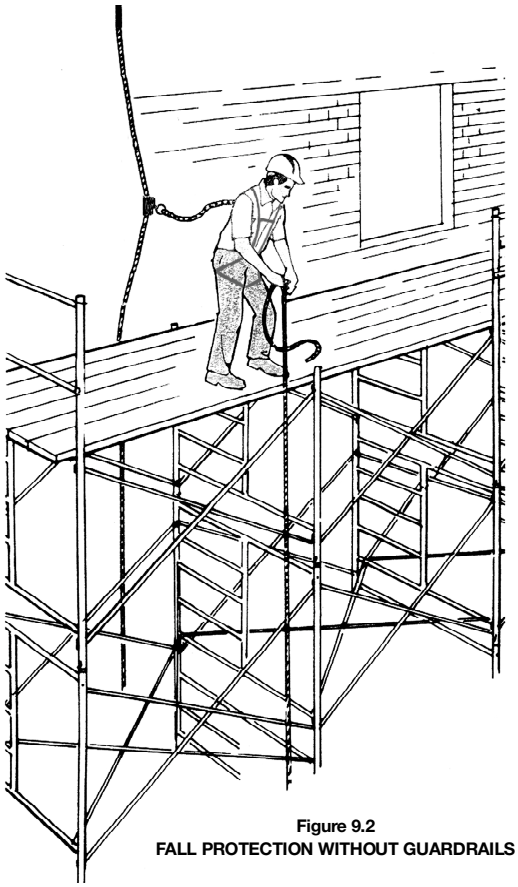


Figure 9.2
FALL PROTECTION WITHOUT GUARDRAILS

lanyard (Figure 9.2). Many falls and serious injuries occur when workers use platforms without guardrails. Any worker who removes a guardrail for any reason must replace it when the task is completed.

9.3 Standing on Objects Above the Platform

People working from the platform should have both feet on the platform. Standing on a barrel, box, stepladder, guardrail, or other object to gain extra height is extremely dangerous and is illegal in most jurisdictions, including Ontario. You should know the required height of the scaffold before erecting it, so you can obtain all the required material, including half frames when necessary.

9.4 Overloading

Overloading scaffold platforms in the masonry trades is one of the most frequent violations of good scaffold practice. Placing full pallets of bricks or concrete blocks on a single layer of 48 mm x 254 mm (2" x 10") scaffold planks is, in most cases, overloading the platform. You may have to double plank decks to support pallets of masonry materials. Place the pallets over the supports wherever possible. In addition, inspect planks used to support masonry materials for damage or for deterioration regularly and often. Table 8.1 indicates the load-carrying capacities of various grades of plank. Table 9.1 lists the approximate weights of common building materials. Bear in mind overloading may affect stability as well as load-carrying capacity.

Differential settlement is often a problem when you apply heavy loads to scaffolds resting on uncompacted soils. A scaffold tower 9 metres (30 feet) high that settles 25 millimetres (1 inch) on one side can move 150 millimetres (6 inches) at the top. Settlement puts stress on braces, tie-ins, and frame joints. Place heavy loads symmetrically on the platform to ensure that soil settlement is uniform.

Finally, the scaffold structure must be capable of carrying the load that you will apply. Both light-duty and heavy-duty frames are available on the market. Do not use light-duty frames where you have heavy loads. If you do not know the load-carrying capacity of the frames, consult the manufacturer or supplier. The load-carrying capacity of frames usually varies with the height of the towers.

9.5 Debris on Scaffold Decks

Scaffold decks are small, narrow, and confined. Store tools and materials in an orderly fashion. Do not allow debris and waste materials to collect on the platform. Put them in a container or remove them from the platform immediately. Set up a plan for dealing with waste materials. Simply throwing garbage off the scaffold is extremely dangerous—don't do it. If work on the scaffold is likely to result in debris falling, such as in masonry work, then cordon off the scaffold to prevent workers from entering the area.

Waste pieces of lumber, pipe, wire, miscellaneous metal, and small tools are tripping hazards which have caused