CHAPTER 19

PERSONAL FALL PROTECTION

19 PERSONAL FALL PROTECTION

Falls are the number one cause of critical injuries and deaths of Ontario workers on construction sites. Most fall-related incidents are the result of fall protection methods and equipment being used improperly or not at all.

This chapter provides practical compliance information on fall protection for the construction industry as a whole. However, since each construction project is unique and can pose hazards not covered in this chapter, consult the regulations relevant to your workplace to make sure additional precautions are not required.

Regulations

In 2015, Ontario introduced a new Working at Heights (WAH) Training Standard and made changes to the health and safety legislation in order to reduce the number of fall-related injuries and fatalities. Minimum requirements for fall protection are set out in Section 26 of the Construction Projects regulation (213/91). New training requirements for WAH came into effect with the Occupational Health and Safety Awareness and Training regulation (287/13).

Fall protection must be used where a worker may be exposed to any of the following hazards (O. Reg. 213/91, s. 26):  
1. Falling more than 3 metres (10 feet)
2. Falling more than 1.2 m (4 ft) if the work area is used as a path for a wheelbarrow or similar equipment
3. Falling into operating machinery
4. Falling into water or another liquid
5. Falling into or onto a hazardous substance or object
6. Falling though an opening on a work surface.

Workers who may be exposed to a fall of 2.4 m (8 ft) or more and have access to the perimeter or an open side of any of the work surfaces listed above must be protected by a guardrail system (O. Reg. 213/91, s. 26.3(1)):  
1. Floor, including the floor of a mezzanine or balcony
2. The surface of a bridge
3. A roof while formwork is in place
4. A scaffold platform, work platform, runway or ramp.

If it is not practical to install guardrails, workers who may be exposed to a fall hazard must be protected by the highest-ranked method of fall protection that is practical (O. Reg. 213/91, s. 26.1(2)). These methods are:

1. Travel restraint system
2. Fall restricting system
3. Fall arrest system
4. Safety net.

See Figure 19-29 at the end of this chapter for a helpful illustration on the methods of fall protection and their ranking.

Mandatory WAH Training

Employers must ensure that workers on a construction project who may use one of the four methods of fall protection listed above have completed a working at heights training course. This course must have been approved by the Chief Prevention Officer (CPO) of Ontario (O. Reg. 287/13, s. 6-7).

The CPO (under the Ministry of Labour) must approve not only the WAH training course but also the WAH training provider. The employer must keep a record of this training. They must also ensure workers complete a WAH refresher course every three years.

In addition, employers must ensure that their workers receive the following:

• Site-specific training on the fall hazards they will encounter
• Site-specific training on the fall protection equipment and procedures they will use
• Adequate oral and written instructions by a competent person on site.

To meet this requirement, employers should ensure that the site supervisor conducts a Job Safety Analysis/Hazard Assessment and develops a Fall Protection Work Plan. The supervisor should review the results of the JSA/JHA and the requirements of the FPWP with workers on the site. (See Appendix A for more information.)
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For more information on these requirements and templates to help you develop these resources, visit the Fall Prevention and Working at Heights topic page on the ihsa.ca website.

Definitions and Terminology

It’s important for workers and employers to know the definitions of the following terms that relate to fall protection. These can be found in section 1 of the Construction Projects regulation (213/91).

“Fall arrest system” means an assembly of components joined together so that when the assembly is connected to a fixed support, it is capable of arresting a worker’s fall.

“Fall restricting system” means a type of fall arrest system that has been designed to limit a worker’s fall to a specified distance.

“Fixed support” means a permanent or temporary structure or a component of such a structure that can withstand all loads and forces the structure or component is intended to support or resist and is sufficient to protect a worker’s health and safety, and includes equipment or devices that are securely fastened to the structure or component.

“Full-body harness” means a device that can arrest an accidental vertical or near vertical fall of a worker and which can guide and distribute the impact forces of the fall by means of leg and shoulder strap supports and an upper dorsal suspension assembly which, after the arrest, will not by itself permit the release or further lowering of the worker.

“Safety net” means a safety net that complies with section 26.8 of the regulation, and is located and supported in such a way that it arrests the fall of a worker who may fall into it without endangering the worker.

“Travel restraint system” means an assembly of components capable of restricting a worker’s movement on a work surface and preventing the worker from reaching a location from which he or she could fall.

Types of Fall Protection

The best way to protect workers from a fall injury or fatality is to prevent the fall from happening. This is known as fall prevention. It includes devices such as guardrails, covers over floor openings, warning barriers, and travel restraint.

If fall prevention is not possible, the next best option is to use a fall protection system that prevents the worker from hitting the ground or an object below if they were to fall. This is known as fall arrest because it is designed to arrest (i.e., stop) the fall of a worker who is already falling. It includes fall restricting systems, fall arrest systems, and safety nets.

Fall Prevention

Fall prevention systems are devices or controls that eliminate or minimize the possibility of a fall by a worker while they are performing various activities. In addition to devices such as guardrails, protective covers, and warning barriers, fall prevention can include engineering controls that eliminate or minimize the fall hazard by changing work processes. For example, building a roof on the ground and hoisting it into place—if roofers do not work at heights, they cannot fall from heights.

To be effective, fall prevention must be planned in advance. Ideally, the planning should take place at the design stage. In many cases, anchors and other parts of a fall prevention system can be installed at the fabrication stage, before the equipment arrives on the jobsite.

The type of fall prevention system used often depends on the kind of work being done. Regardless of which type is used, every fall prevention system in Ontario construction must comply with the relevant provincial legislation (e.g., OHSA, construction regulations) and applicable national standards (e.g., CSA, ANSI).

The best option to prevent falls is to install guardrails. (See Chapter 18: Guardrails in this manual for more information.) Note that before guardrails are in place, or if they have to be removed temporarily, workers must be protected by another means of fall protection (Figure 19-1).

Figure 19-1: Worker Wearing Fall Protection While Installing a Guardrail

If it is not practicable to install guardrails, the next best option is to use travel restraint.

Travel Restraint System

Travel restraint lets a worker travel just far enough to reach the edge but not far enough to fall over. A typical travel restraint system consists of the following CSA-approved equipment attached to adequate anchorage:
• Full-body harness
• Lanyard
• Lifeline
• Rope grab to attach harness or lanyard to lifeline.

Adequate anchorage for a travel restraint system means that it is capable of supporting a static load of 2 kilonewtons (kN) (450 lb) with a recommended safety factor of at least 2 (i.e., 4 kN or 900 lb). Two methods of travel restraint are commonly used in construction.

1. Connect an adequately anchored lifeline directly to the D-ring of the worker’s full-body harness. To use this method, the length of the lifeline—measured from the anchor point—must be short enough to restrain the worker from any fall hazard.

2. Attach a lanyard from the D-ring of the worker’s full-body harness to a rope grab on an adequately anchored lifeline. To use this method, there must be some way of preventing the rope grab from sliding along the lifeline to a point where the worker is no longer restrained from falling (e.g., a positive stopping device or a loose knot on the lifeline).

Regardless of which method 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 (Figure 19-2).

To implement a travel restraint system, arrangements must be planned thoroughly. Every fall hazard in the proposed work area must be identified and careful consideration must be given to the selection of appropriate components and the location of adequate anchor points. Here are some things to consider:

• When identifying the fall hazards, pay special attention to areas with irregular-shaped perimeters, floor openings, or locations near corners.
• When selecting an anchor point, choose one that is as close as possible to the centre of the work area and perpendicular to the unprotected edge.

• When choosing components, be aware that 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.

Fall Arrest

If it’s not practicable to use guardrails or travel restraint to prevent workers from falling, the next best option is to use a system that arrests or stops the worker fall before they hit the ground or an object below. Ranked in order, these methods are:

1. Fall restricting system
2. Fall arrest system

Before using any of these methods of fall arrest, the employer must develop written procedures for rescuing a worker whose fall has been arrested. See the section on Fall Arrest Rescue Procedures at the end of this chapter.

Fall Restricting System

A fall restricting system is designed to limit a worker’s free-fall distance to 0.6 m (2 ft). This means that less force will be exerted on the body when the fall is arrested. It also means there is less chance that the person will hit the ground or an object below.

Temporary fixed supports used for anchorage with a fall restricting system must support at least 6 kN (1,350 lb) without exceeding the allowable unit stress for each material used. A safety factor of two should be applied (i.e., 12 kN or 2,700 lb).

The components described under fall arrest systems can be used for fall restricting systems. However, the harness is generally connected at the front (sternum) rather than at the D-ring on the back. This sternal connection is then fastened to a wire rope grab or fixed ridged rail system used for climbing ladders (Figure 19-3).
**Fall Arrest System**

A fall arrest system must prevent a falling worker from hitting the ground or any object or level below the work. It must include the following:

- A CSA-approved full-body harness
- A lanyard equipped with an energy absorber (unless the energy absorber could cause a falling worker to hit the ground or an object below)
- An adequate fixed support

Figure 19-4 shows the type of equipment used in a fall arrest system. It is similar to the equipment used for travel restraint except that there is an energy absorber attached to the lanyard. This device absorbs some of the force exerted on the body when a fall is arrested.

Safety nets can be used in many places including around building edges, below formwork operations, and on bridge work. It is important to note that a plan to rescue a worker whose fall has been arrested is still required.

**Fall Protection Standards**

The components of any fall protection system must meet the requirement of the Canadian standards. Canadian fall protection standards are regularly updated to incorporate the most current changes to fall protection systems. For the most current standards, go to www.csa.ca

The following is a list of standards that are referenced in the most current (2018) version of the Construction Projects regulation (O. Reg. 213/91, s. 26.1(3)):

2. CAN/CSA-Z259.2.5-12: Fall Arresters and Vertical Lifelines.
4. CAN/CSA-Z259.2.3-99 (R2004): Descent Control Devices.
5. CAN/CSA-Z259.10-06: Full Body Harnesses.

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 an energy absorber. IHSA does not recommend the use of a fall arrest system without an energy absorber unless the deployment of the energy absorber will create a hazard of hitting a level or object below.

In systems without energy absorbers, all components—including lifeline and lifeline anchorage—must be able to support a static load of at least 8 kN (1,800 lb) without exceeding the allowable unit stress of the materials used for each component. A safety factor of at least two should be applied to the minimum static load capacity (i.e., 16 kN or 3,600 lb).

In systems with energy absorbers, all components—including lifeline and lifeline anchorage—must be able to support a static load of 6 kN (1,350 lb) without exceeding the allowable unit stress of the materials with a safety factor of at least two (12 kN or 2,700 lb).
Anchorage

A fall protection system must be attached to appropriate anchorage. There are three basic types of anchor systems used for fall protection:

1. **Designed fixed supports** are load-rated anchors specifically designed and permanently installed for fall protection purposes as an integral part of the building or structure. An example is roof anchors on high-rise buildings (Figure 19-5).

2. **Temporary fixed supports** are anchor systems designed to be connected to the structure using specific installation instructions. An example is nail-on anchors used by shinglers (Figure 19-6).

3. **Existing structural features or equipment** are not intended as anchor points but are verified by a professional engineer or competent person as having adequate capacity to serve as anchor points. Examples are rooftop mechanical rooms, structural steel, or reinforced concrete columns (Figure 19-7).

Designed fixed supports 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 Ontario Building Code and it is safe and practical to use.

A temporary fixed support can be used as anchorage if it meets the following conditions:

- It can support at least 8 kN (1,800 lb) without exceeding the allowable unit stress for each material used.

- When used with a fall arrest system incorporating an energy absorber, it can support at least 6 kN (1,350 lb) without exceeding the allowable unit stress for each material used.

- When used with a travel restraint system, it can support at least 2 kN (450 lb) 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.

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 (Figure 19-8).
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Lifelines

Lifelines are the part of a fall protection system that connects to an anchor on one end. On the other end, they connect to the user through a rope grab (fall arrester) and lanyard, which connects to the full-body harness. In some cases, especially in travel restraint systems, they can be attached directly to the full-body harness.

There are three basic types:

1. **Vertical lifelines**
2. **Horizontal lifelines**
3. **Self-retractable lifelines (SRLs)**

**Vertical Lifelines**

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

- Each vertical lifeline can be used by only one person at a time (Figure 19-10).
- A vertical lifeline must reach the ground or a level above the ground where the worker can safely exit after the fall has been arrested.
- A vertical lifeline must have a manufactured termination (e.g., a self-closing and self-locking snap hook or carabiner) at one end. At the other end, it must have a positive stop that prevents the fall arrester (rope grab) from running off the end. This positive stop can be a stopping device or a knot that does not damage the rope.
- Vertical lifelines are usually made of synthetic rope that is 16 mm (5/8 in) in diameter. An example would be a three-strand twisted rope made from a polypropylene/polyethylene blend (Figure 19-11). However, a polypropylene utility rope is NOT approved to be used as a lifeline (Figure 19-12). A general rule of thumb is that an approved lifeline will have different-coloured strands.
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Figure 19-11: A Polypropylene Blend Rope is an Approved Lifeline

Figure 19-12: Polypropylene Utility Rope is NOT an Approved Lifeline

**Inspection**

Vertical lifelines must be inspected before each use. Check for the following:

- Cuts, burns, or frayed strands
- Broken or loose strands inside the rope
- Strands that are different sizes or shapes
- Abrasions, tears, and other defects or signs of damage
- An accumulation of powder or dirt inside the rope
- Discolouration and brittleness indicating heat or chemical exposure.

**Horizontal Lifelines**

A horizontal lifeline system must be designed by a professional engineer according to good engineering practices (Figure 19-13). The design can be a standard design or specifically engineered for the site.

The design for a horizontal lifeline system must meet the requirements listed below. It 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.

**Inspection**

A horizontal lifeline 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:** Knots or splices along the length of a horizontal or vertical lifeline can reduce its strength by as much as 50%, which is why they are not permitted.

**Self-Retracting Lifelines**

Self-retracting lifelines (SRLs), sometimes referred to as self-retracting devices (SRDs), are widely used in construction to provide fall protection, especially where workers must move about to handle or install materials (Figure 19-14). The devices let the user move the full length of the line, but they will stop and lock at any sudden pull. This type of device is designed for fall arrest not, as some people think, for travel restraint.
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Self-Retracting Lifelines (SRLs) consist of a lifeline spooled on a retracting device attached to adequate anchorage. In general, SRLs have the following characteristics:

- They are usually designed to be anchored above the worker (i.e., vertically). If it is being used horizontally, check with the manufacturer to ensure that it is designed for that type of use.
- They employ a locking mechanism that lets the line wind off the drum under the slight tension caused by a user’s normal movements.
- They automatically retract when tension is removed, thereby preventing slack in the line.
- They lock up when a quick movement, such as the movement caused by a fall, is applied.
- They are designed to minimize fall distance and the forces exerted on a worker’s body by fall arrest.

There are several different types of SRLs. Their classification depends on when they were manufactured (i.e., which CSA standard they were designed to meet). After 2014, they were classified as follows:

- **SRL**: A self-retracting device that is suitable for applications where, during use, the device is mounted or anchored overhead and possible free-fall is limited to 2 ft (0.6 m) or less. Before 2014, this type was called a Type 1 or Type 2 SRL.

- **SRL-R**: This type has “integral rescue capability”, which is an integral means for assisted rescue via raising or lowering the rescue subject. Previously this type was called a Type 3 SRL.

- **SRL-LE**: This type has “leading edge capability”. It is suitable for applications where, during use, the device is not mounted or anchored overhead and may be at foot level and where the possible free-fall is up to 1.5 m (5 ft). That includes integral means to withstand impact loading of the line constituent with a sharp or abrasive edge during fall arrest and for controlling fall arrest forces on the user. This type had no previous classification.

**Inspection**

The inspection requirements for SRLs are based on which CSA standard they were designed to meet. Table 19-1 below outlines the different inspection requirements.

<table>
<thead>
<tr>
<th>CSA Standard</th>
<th>Revalidation and Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Manufacturer should provide guidance information with their product.</td>
</tr>
<tr>
<td></td>
<td>• <strong>Infrequent to Light Use</strong>: Revalidation by the manufacturer at least every five years, but not at intervals less than those required by the manufacturer.</td>
</tr>
<tr>
<td></td>
<td>• <strong>Moderate to Heavy Use</strong>: Revalidation by the manufacturer at least every two years, but not at intervals less than those required by the manufacturer.</td>
</tr>
<tr>
<td>CAN/CSA-Z259.2.2-98 (2009): Self-Retracting Devices for Personal Fall Arrest Systems</td>
<td>• Based on time.</td>
</tr>
<tr>
<td></td>
<td>• Manufacturer should provide guidance information with their product.</td>
</tr>
<tr>
<td></td>
<td>• <strong>For Type 2 and Type 3 SRLs</strong>: SRLs must returned to the manufacturer (or an approved service agent) no more than two years after the date of the manufacture for inspection and maintenance and then once a year thereafter. (NOTE: This requirement is not changed in the 2014 CSA Standard.)</td>
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</tbody>
</table>

**Markings**

The markings are essentially the same but will have the new CSA Standard number and new classification.
Rope Grab

The rope grab, also known as a fall arrester, is a device used to connect the lanyard to the lifeline (Figure 19-15). This device will move smoothly up and down the lifeline when a steady force is applied, but it will lock when a sharp tug or pull is applied, such as when a person falls. It will remain locked on the lifeline until the applied force is released (i.e., the person is recued).

![Figure 19-15: Rope Grab](image)

There are many different styles rope grabs but only of two classifications in the CSA Standard:

1. Fall arrester
   - It engages a vertical lifeline or rigid rail in the vertical or sloped plane.
   - It accepts a connecting linkage.
   - It can be moved along the lifeline or rail in accordance with the position of the worker.
   - It automatically engages on the lifeline or rail in the event of a fall in order to arrest the fall.

2. Manual fall arrester
   - It is locked on a synthetic lifeline line.
   - It requires a manual action by the worker to displace it along the line.
   - It is connected to the dorsal attachment point of a harness as described in CAN/CSA-Z259.10.
   - It remains engaged on the lifeline if released or held beyond its non-engaged position (i.e., the “panic grab feature”).

The main difference between them is that the manual robe grab requires the user to move it with them to do at position that is suitable for the work and a rope grab with follow the worker without requiring action by the user.

Each rope grab is designed and manufactured for use with a specific diameter (size) and type of lifeline. **NOTE: The rope grab and lifeline must be compatible.** Specifications are usually listed in the manufacturer’s instructions or on the housing (Figure 19-16).

![Figure 19-16: Rope Grab Specifications](image)

**CAUTION:** If you are involved in a fall, DO NOT grab the fall arrester (rope grab). If you do, it may not work properly and you risk being seriously injured or even killed.

Make sure that the rope grab is attached to the lifeline in the correct direction—not upside down. On most rope grabs, an arrow on the side or top of the housing indicates the proper direction. The arrow must point in the direction of the anchorage.

**Inspection**

Rope grabs, as well as all other connecting components (e.g., snap hooks, carabiners), must be inspected before each use. Look for the following:

- Damage, cracking, dents, bends, or signs of deformation
- Connecting rings centred—not bent to one side or otherwise deformed
- Rust or sharp edges
- Moving parts that don’t work smoothly
- Signs of wear or metal fatigue.

**Lanyard**

The lanyard connects a full-body harness to the rope grab on the lifeline or directly to the anchor. The point where it attaches to the anchorage should be higher than waist level and kept as short as possible to reduce fall distance. Lanyards can come with or without an energy absorber (Figure 19-17). However, an energy absorber will increase lanyard length by as much as 1.1 m (42 in).
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Figure 19-17: Lanyard with Energy Absorber

Follow these best practices:

- Use manufactured (i.e., store-bought) lanyards only. They can be made of wire rope, synthetic fibre rope, or synthetic webbing.
- Lanyards are manufactured to specific lengths. Try to use one that is as short as possible for the work you are doing without interfering with your ability to do the work. This will reduce the likelihood that you will fall over the edge or fall too far. However, never try to shorten a lanyard by tying knots in it. This is prohibited by law because it can reduce its rated strength considerably.
- Never store lanyards around chemicals, sharp objects, or in wet places. Never leave them exposed for long periods to direct sunlight.
- Most manufacturers do not permit two lanyards connected to the same D-ring. If you have to move from one lifeline to another, use a Y lanyard (Figure 19-18). It has two attachment points, so it will allow you to be tied off at all times.

Inspection

All lanyards must be inspected before each use. Check for the following:

- Webbing that is cut, frayed, or kinked
- Loose or broken stitching
- Burns or signs of chemical damage
- Rust, cracks, or damage to the lanyard hardware.

If any part is damaged, remove it from service, tag it, and use another one.

Energy Absorber

The energy absorber is the part of a fall protection system that will limit the amount of force a person feels if they are involved in a fall. It is generally integrated into or part of the lanyard that is attached to the full-body harness and the lifeline or anchorage. It can also be purchased on its own and used in a fall arrest system.

Energy absorbers come in two classifications:

1. Class E4 is for workers weighing at least 45 kg (100 lb), but not more than 115 kg (254 lb)
2. Class E6 is for workers weighing at least 90 kg (200 lb), but not more than 175 kg (386 lb).

One end of the energy absorber must be connected to the D-ring on the full-body harness (Figure 19-19). The other end connects to the lanyard or is part of the lanyard and connects directly to the anchorage (e.g., the rope grab on the lifeline). In most cases, the energy-absorbing component is enclosed in a snug-fitting jacket to protect it from damage.

Using a lanyard with an energy absorber (commonly called a shock absorber) to absorb some of the energy exerted on the body after a fall has been arrested could save a person’s life.

Figure 19-18: Y-Lanyard

Figure 19-19: Energy Absorber Attached to D-Ring
Inspection
Before each use, check the cover jacket for stress or tearing (Figure 19-20). Many energy absorbers have a tag on the jacket that tears if the unit has been exposed to a shock load—make sure this tag is intact. Otherwise, remove it from service and use another one.

Figure 19-20: Check Jacket for Stress or Tearing

Full-Body Harness
The full-body harness is attached to the fall protection system and then to a proper anchor. It can be used for both fall prevention (i.e., travel restraint) and for fall arrest.

Full-body harnesses are fully adjustable and available in different sizes. Some types are specially designed for women. Proper fit of the harness is important, especially when it is being used for fall arrest. Always refer to manufacturer’s instructions for proper use and fit of a full-body harness.

Here are some general recommendations for proper fit:

1. Adjust the chest strap so that it is snug and located near the middle of your chest (Figure 19-21). A general rule is above the sternum, just below the armpits. If you fall, a properly adjusted chest strap will prevent you from coming out of the harness.

Figure 19-21: Adjusting the Chest Strap

2. Adjust the leg straps so that your fist can fit snugly between the strap and your leg (Figure 19-22).

Figure 19-22: Adjusting the Leg Straps

3. Adjust the shoulder straps so that the back D-ring rests between your shoulder blades (Figure 19-23). A properly positioned D-ring will keep you upright after a fall.

Figure 19-23: Positioning the D-Ring Between the Shoulder Blades

Inspection
Inspect your harness before each use. Look for things such as:

- Burns, cuts, frayed material, and loose or broken stitching
- Signs of heat or chemical damage
- Hardware and straps that are intact and undamaged
- D-ring and keeper pads that are free from distortion and signs of wear or damage
- Grommets and buckles that are free of damage, distortion, or sharp edges
- Moving parts that are moving freely through their full range of motion.

Make sure to check the fall arrest indicator to confirm that it hasn’t been deployed.

CAUTION: If any part of a fall protection system has been used to arrest a fall, it must be removed from service.
Fall Arrest Hazards
Before deciding to use a fall arrest system, the employer should assess the hazards the workers may be exposed to in case of a fall. As mentioned earlier in this chapter, the preferred method of fall protection is fall prevention. Fall arrest should only be used when all other means of fall prevention such as guardrails, travel restraint, and engineering controls (e.g., using an elevated work platform) have been ruled out.

Fall arrest hazards include the following:
1. Bottoming out
2. Pendulum effect or swing fall
3. Suspension trauma

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 (Figure 19-24). This occurs when the Total Fall Distance is greater than the distance from the work surface to the next surface below.

Fall arrest systems must be planned, designed, and installed to prevent any risk of bottoming out. See the next section on calculating Total Fall Distance for more information.

Figure 19-24: Bottoming Out

Pendulum Effect
The pendulum effect, also known as a swing fall, occurs when a worker whose fall has been arrested swings from side to side, possibly striking equipment, material, or a structure (Figure 19-25).

Figure 19-25: Pendulum Effect

The farther you move sideways (not perpendicular) from your anchor point, the greater the chance of swinging if you fall. And the more you swing, the harder 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.

To minimize the pendulum effect, workers should keep their lanyard or lifeline perpendicular from the edge to the 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.

Suspension Trauma
A person who is involved in a fall arrest may experience suspension trauma, also known as orthostatic intolerance. Suspension trauma can occur if a person is suspended in the harness for a period of time. Being suspended in an upright position can cause blood to pool in the legs, depriving the brain of oxygen. This can lead to loss of consciousness, serious injury, or even death.
The best protection against suspension trauma is an effective rescue plan and timely rescue. However, using suspension trauma relief straps or tying a loop for a foothold in the lifeline can help by allowing a conscious worker to relieve the pressure and increase blood circulation (Figure 19-26).

**Calculating Total Fall Distance**

Preventing a falling worker from hitting the ground or an object below requires knowing the Fall Clearance Distance (Figure 19-27). This is the distance from the ground (or object below) to the connection point where the worker attaches their lanyard to the anchor or lifeline.

Once a worker knows the length of the lanyard and length of the deployed energy absorber used in their fall protection system, they can calculate their Fall Clearance Distance and adjust their fall protection system to prevent “bottoming out”.

The calculation for Fall Clearance Distance is:

\[
\text{Fall Clearance Distance} = \text{Length of Lanyard} + \text{Length of Deployed Energy Absorber} + \text{Height of Worker} + \text{Safety Factor}
\]

In Figure 19-28, the worker’s connection point to the anchor needs to be at least 5.5 m (18.2 ft) from the ground or bottom level.

**Fall Arrest Rescue Procedures**

Section 26.1 (4) of the Construction Projects 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.

See the section on Emergency Procedures for Fall Rescue in Chapter 2.
Summary
This chapter 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. Each workplace party is responsible for reducing or eliminating falls in construction.

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.

For an easy way to remember the methods of fall protection and the ranking that must be followed before choosing a method that is most practicable for your site and circumstances, follow the illustration (Figure 19-29).

Hazard Elimination
Changing the work process so the hazard no longer exists (e.g., building a roof on the ground and hoisting it into place)

Guardrails, Protective Covers, and Warning Barriers
Prevents a fall from unprotected edges or openings at heights.

Travel Restraint System
Allows a worker to reach the edge of a fall hazard but not fall over it.

Fall Restricting System
Designed to limit a fall distance to 0.6 m (2 ft).

Fall Arrest System
Designed to stop the fall of a worker before they hit the ground or objects below.

Safety Net
Designed to catch a falling worker before they hit the ground or objects below.

Figure 19-29: Fall Protection Methods Ranked in Order