

# Module 9: Cranes, Derricks, Hoists, Elevators & Conveyors

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## Lesson Summary

- Employers should assign attendants to monitor confined spaces. These attendants must know the relevant hazards, recognize the signs of exposure, maintain a count of authorized entrants in the space, and remain outside the space during entry operations.
- An attendant must summon rescue and other emergency services as soon as she or he determines that authorized entrants may need assistance to escape from permit space hazards.
- Whether using their own on-site rescue team (consisting of its own or another contractor's employees) or an off-site team, such as a local fire department or other rescue service, the employer must make certain that the rescue team is able to respond in time to enable the injured worker to receive whatever medical attention is needed.
- Authorized entrants must know the hazards that may be faced during entry, properly use equipment as required, communicate with the attendant as necessary, and exit the space immediately if acceptable entry conditions cannot be maintained.
- Atmospheric testing of the confined space must be conducted regularly, and the results must be posted. If the confined space meets the requirements of a permit space, the necessary additional precautions must be taken.

## Module 9: Cranes, Derricks, Hoists, Elevators and Conveyors

### Module Description

This module is intended for workers who want to learn more about cranes, derricks, hoists, elevators, and/or conveyors. We will discuss the topics of cranes and derricks, helicopters, base-mounted drum hoists, overhead hoists, conveyors, and aerial lifts in detail in this module along with the safety measures required when handling such machinery. This module will also cover the topics included in OSHA 29 CFR 1926 Subparts N and CC.

### Module Learning Objectives

At the conclusion of this module, students will be able to:

- Distinguish between the different types of cranes
- Name the procedures for proper inspection and maintenance
- Summarize guidelines for proper equipment testing and load rating capacities
- Discuss the proper procedures for crane operators and co-workers
- Outline regulations for load handling and handling equipment



## Lesson 1: General Standards

### Lesson Focus

At the end of this lesson, students will be able to:

- Define key personnel required for crane operations
- Identify the hazards associated with crane operations
- Describe common accidents resulting from crane operations

### Definitions of Key Personnel

- **Competent Person:** Someone who is capable of identifying working conditions that are unsanitary, hazardous, or dangerous to employees and who has the authorization to take prompt corrective measures to eliminate such hazards. The employer should designate a competent person to inspect all of the machinery and equipment before and during use to ensure that they are within safe working parameters. All deficiencies must be promptly repaired and defective parts replaced before the machine can be used.
- **Qualified Person:** This is a person who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience, successfully demonstrated the ability to solve/resolve problems relating to the subject matter, the work, or the project.
- **Assembly/Disassembly Director:** The assembly/disassembly director, or A/D director, oversees and directs all crane assembly and disassembly operations. The A/D director must be both a “competent person” and a “qualified person,” or must be a “competent person” assisted by one or more “qualified persons.”
- **Signal Person:** A signal person maintains continuous communication with the crane operator during all crane movements where the point of operation is not in full view of the operator, or the crane operator’s view is obstructed in the direction of where the equipment or load is traveling. The employer must ensure the signal person is qualified for the task prior to giving any signals.

### Hazards Associated with Crane Operations

OSHA's analysis of crane accidents in general industry and construction identified an average of 71 fatalities per year. A study conducted by OSHA showed that nearly 30 percent of work-related electrocutions involved cranes.

Although mechanical failures represent only 11 percent of the causes of crane accidents, they may result in major accidents involving injuries, fatalities, substantial material costs, and negative media coverage. Studies and analyses show that



mechanical failures are frequently due to the result of a lack of preventive maintenance or adequate training, and/or experience on the part of the personnel involved.

Cranes and associated rigging equipment must be inspected regularly to identify any existing or potentially unsafe conditions. Regular inspections should be conducted before and during use. If there are problems, necessary repairs must be made before continuing work. Preventive maintenance must also be performed according to the crane manufacturer and/or the supplier specifications.

Windows in the crane cab must be made of safety glass that prevents distortion, which could interfere with the safe operation of the crane.

### **Crane Hazards**

The following are some common examples of crane hazards:

- Improper load rating
- Excessive speeds
- No, unclear, or improper hand signals
- Inadequate inspection and maintenance
- Unguarded parts
- Unguarded swing radius
- Working too close to power lines
- Improper exhaust system
- Shattered windows
- No steps/guardrails walkways
- No boom angle indicator
- Not using outriggers

### **Planning before Start-Up**

Adequate ground conditions are essential for safe crane operations because the crane's capacity and stability depend on having the proper foundation on which to work. If, for example, the ground is muddy or otherwise unstable, a crane could overturn even if operated within the load limits specified by the manufacturer. You must not assemble or use a crane unless the ground is firm, drained, and graded to a sufficient extent that, with the use of supporting materials such as blocking, mats, or cribbing, adequate support is provided.

The proper assembly and disassembly of lattice-boom and tower cranes, and the set-up of hydraulic-boom cranes, including outriggers, are critical to safe crane operations. When assembling or disassembling a crane, you must comply with either the manufacturer's procedures, or your own procedures, which must be developed by a qualified person.

Before the operation begins, the A/D director must ensure that the crew members understand their tasks, any hazards associated with their tasks and any hazardous positions/locations they need to avoid.





Follow the listed safety guidelines before initial start-up:

- Level the crane and ensure support surface is firm and able to support the load.
- Contact power line owners and determine precautions. Know the location and voltage of overhead power lines. No part of the crane, load, or load line should get closer than 20 feet to a power line; if so, additional precautions are required.
- Know the basic crane capacities, limitations, and job site restrictions, such as the location of power lines, unstable soil, or high winds.
- Ensure outriggers or stabilizers are properly deployed when the load to be handled and the operating radius require them.
- Make other personnel aware of hoisting activities.
- Barricade areas within the swing radius.
- Ensure proper maintenance and inspections.
- Determine safe areas to store materials and place machinery.

Follow the listed safety guidelines during operation:

- Comply with all manufacturer procedures that apply to the operational functions of equipment, including its use with attachments.
- Do not engage in any practice or activity that diverts attention while engaged in operating the equipment.
- Do not leave the controls while the load is suspended, unless all of the following are met:
  - The operator remains adjacent to the equipment and is not engaged in any other duties.
  - The competent person determines that it is safe to do so.
  - Barricades or caution lines, and notices, are erected to prevent all employees from entering the fall zone.
- Comply with the rated capacity. Equipment must not be operated in excess of its rated capacity.

Maintain continuous contact with the signal person when one is assigned. If communication is disrupted, stop all crane movements until communication is restored.

## Accidents

OSHA has identified the major causes of crane accidents to be:

- Boom or crane contact with energized power lines
- Overturned cranes
- Dropped loads
- Boom collapse
- Crushing by the counterweight
- Outrigger use



- Falls
- Rigging failures

### How Do Accidents Occur?

Accidents generally occur due to one of the following factors:

- Instability: unsecured load, load capacity exceeded, or ground not level or too soft
- Lack of communication: the point of operation is at a distance from the crane operator or not in full view of the operator
- Lack of training: untrained crane operators are likely to have accidents
- Inadequate maintenance or inspection: cranes or other heavy machinery must not be operated without proper inspection and regular maintenance

### Lesson Summary

- Key personnel who may be needed around crane operations include a competent person, a qualified person, an assembly/disassembly (A/D) director, and a signal person.
- Cranes and associated rigging equipment must be inspected regularly to identify any existing or potentially unsafe conditions. Regular inspections should be conducted before and during use. If there are problems, necessary repairs must be completed before continuing work. Preventive maintenance must also be performed according to the crane manufacturer and/or the supplier specifications.
- Mechanical failures are frequently due to the result of a lack of preventive maintenance or adequate training, and/or experience on the part of the personnel involved.
- Common hazards encountered during crane operation include excessive speeds, unclear hand signals, unguarded parts or swing radius, or no boom angle indicator.
- Common accidents that result from crane operation include contact with power lines, dropped loads, and crushing and falling injuries.

## Lesson 2: Cranes

### Lesson Focus

At the end of this lesson, students will be able to:

- List types of cranes
- Explain the requirements relating to a crane's load
- Explain proper guarding techniques
- Describe the necessary inspections related to cranes



## Types of Cranes

Among the most commonly used cranes are:

- Truck-mounted cranes, of both the lattice and hydraulic types
- Crawler cranes, of both the lattice and hydraulic types
- Tower cranes

There are several significant differences between these cranes, primarily in boom hoist and load line controls. The somewhat smooth operation of the boom control adjustments on hydraulic cranes may falsely suggest that they are simple to operate. The lattice boom crane's movement, in its boom or in its adjustment in load position, tends to extend and retract less smoothly and may require additional experience to operate smoothly.

Other types of cranes

- Mobile
- Hydraulic
- Overhead
- Gantry
- Tower

The differences between cranes are significant enough to require specific training on each type of crane and with each specific model. It may be unrealistic to expect that every crane operator has the requisite knowledge and proficiency to safely and efficiently operate all of the many diverse types of cranes available today. Furthermore, they cannot be expected to move from one type of crane to another without adequate education and training on the specifics of each piece of equipment.

## Load

All equipment must have the recommended operating speeds, rated load capacities, and special hazard warnings conspicuously posted. Instructions and/or warnings shall be posted in such a manner that they are visible to operators when they are at their control stations.

### Load Limits and Indicators

Overloading is responsible for a relatively small portion of mobile crane accidents. Load and load-moment indicators used properly help to ensure that cranes will not be overloaded. In practice, however, they must not be relied upon without the requisite operator skills and experience for these reasons:

- The device can be turned off or malfunction.
- The device may be out of calibration.



- Operating conditions (such as wind or operating speeds) may be beyond the published rating information.

The presence of a load limit device is not adequate to assure safe crane operation. These devices are not fail-safe devices. They are indicators to advise the crane operator of load parameters to support logical operating decisions. Crane operators must know the load limits of the crane and the approximate weight of the load about to be lifted. Load weights can often be determined by referring to shipping documentation that accompanies the load. The weight of working gear, such as slings, spreader bars, and other rigging equipment, should be considered when it may have an impact the capacity of the equipment. Once the load weight is known, the operator must verify lift calculations and determine if the load is within the load rating of the crane.

The operator must also take into consideration certain conditions that may limit the load rating of a crane. The following are some examples:

- The crane is not placed upon a level ground.
- There are adverse wind conditions at the time.
- Side loads may destabilize the crane.
- Lifting over the side, which places the load at an angle to the center of gravity, may lead to lessened stability.
- Extensions, jibs, or other attachments are in use.
- The weight limits of wire ropes, slings, and other lifting devices.

There are four basic lifting principles that govern a crane's mobility and safety during lifting operations: center of gravity, leverage, stability, and structural integrity.

### **Center of Gravity**

Generally, the center of gravity refers to the point in an object around which its weight is evenly distributed. The location of the center of gravity of a mobile crane depends primarily on the weight and location of its components (boom, carrier, upper-works, and counterweight).

### **Leverage**

Leverage refers to the use of a lever and a fulcrum to exert force on an object. Cranes use leverage to lift loads. The rotation of the upper works (cab, boom, counterweight, and load) changes the location of the center of gravity, known as the leverage point or fulcrum.

### **Stability**

Stability refers to the relationship between the load weight, the angle of the boom, the boom's radius (the distance from the crane's center of rotation to the center of the load), and the center of gravity of the load. Stability may also be affected by the support on which the crane is resting. A crane's load rating is generally developed for operations under ideal conditions, i.e., a level firm surface. Unsteady surfaces or soft ground,





therefore, must be avoided. In areas where soft ground poses a support problem, mats and/or blocking should be used to distribute a crane's load and to maintain a level stable condition.

### Structural Integrity

The crane's main frame, crawler track, and/or outrigger supports, boom sections, and attachments are all considered to contribute to the structural integrity of lifting. In addition, all wire ropes, including stationary supports or attachment points, help determine lifting capacity and are part of the overall structural integrity determining a crane's lifting capacity.

These elements may also affect structural integrity:

- The load chart capacity in relationship to stability
- The boom angle limitations that affect stability and capacity
- The length of boom and radius in determining capacity

### Guarding

Rotating and other moving parts such as gears, shafts, pulleys, sprockets, spindles, drums, fly wheels, and chains must be guarded if they are exposed to employee contact.

- **Swing Radius:** It is advised that all employees stay out of the swing radius, or tailswing, of the crane. A practical method of making sure that the swing radius is clearly visible is to erect barriers. OSHA determined that the preferred way to protect employees in these situations is to completely barricade the entire swing radius of the equipment and prevent employee access to the area.
- **Guardrails:** Runways and steps need to have guardrails, handholds, and slip-resistant surfaces.
- **Boom Angle Indicator:** A boom angle indicator must be located on the crane in a position where it will be clearly visible to the operator.
- **Supporting Surface:** The crane must be uniformly level within one percent of level grade and located on firm footing or operated within the manufacturer's guidelines.

### Sheaves

Sheaves are wheels with open grooves that ropes or cables fit around. It should be smooth and free from surface defects which could cause rope damage. All sheave bearings shall be provided with means for lubrication. Permanently lubricated bearings are acceptable. The boom hoisting sheave must have pitch diameters of no less than 18 times the nominal diameter of the rope used.



## Inspections

### Annual Inspections

A thoroughly documented inspection of hoisting machinery must be carried out by a competent person on at least an annual basis. In addition to the annual documented inspection, the OSHA standards require a visual inspection before and during each shift and an additional inspection at least once a month. The employer must maintain a record of these inspections and their results.

The following must be inspected/identified on a regular basis:

- Air pressure
- Possible leaks
- Tire pressure
- Clearance for rotating superstructure
- Wear on wire rope
- Any physical damage to the crane
- Loose or missing hardware, nuts, or bolts
- Fluid leaks

Wire rope used as a load line must be inspected as part of the shift, monthly, and annual inspections. During shift and monthly inspections all rope that is visible must be inspected. During the annual inspection, the entire length of the rope must be inspected.

### Remove from Use

Immediately remove damaged or defective wire rope from use. Wire ropes should not be used if any of the following conditions are observed:

- In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay
- Wear of one-third the original diameter of outside individual wires with kinking, crushing, bird caging, or any other damage resulting in distortion of the rope structure
- Evidence of any heat damage from any cause
- In standing ropes, more than two broken wires in one lay in sections beyond end connections or more than one broken wire at an end connection

## Lesson Summary

- Operators must always account for the four basic lifting principles that govern a crane's mobility and safety during lifting operations: center of gravity, leverage, stability, and structural integrity.



- Rotating and other moving parts of cranes, such as gears, shafts, pulleys, sprockets, spindles, drums, fly wheels, and chains, must be guarded if they are otherwise exposed to employee contact.
- All employees should stay out of the swing radius of a crane. A practical method of making sure that the swing radius is clearly visible is to erect barriers.
- Crane operators must know the load limits of the crane and the approximate weight of the load to be lifted. Load weights can often be determined by referring to shipping documentation that accompanies the load, and once the load weight is known, the operator must verify lift calculations to determine if the load is within the load rating of the crane.
- While load and load-moment indicators can be helpful for crane operators, they are not always reliable. The device can be turned off or malfunction or be out of calibration. Operating conditions might be so far from ideal that the published rating is insufficient to prevent failure.
- Cranes must be inspected annually and removed from use if any deficiencies are found.

The somewhat smooth operation of the boom control adjustments on hydraulic cranes may falsely suggest that they are simple to operate.

## Lesson 3: Cranes and Rigging

### Lesson Focus

At the end of this lesson, students will be able to:

- Describe safety requirements pertaining to floating cranes and derricks
- Describe the safe use of personnel platforms, including platform specifications and rigging procedures
- Describe platform-related work practices

### Floating Cranes and Derricks

Always make sure that the rated load of the crane does not exceed the original capacity specified by the crane's manufacturer. To avoid accidents, a load rating chart with clearly visible letters and figures should be provided with each crane, and it should be fixed at a location where the chart can easily be read by the operator of the crane. In addition, on barges, always secure mobile cranes positively.

**Note:** Do not forget to provide the load rating charts to the operators.

When installing cranes and derricks permanently on a barge, make sure their capacity and limitations of use are in compliance with current design criteria.



Cranes and derricks that have variable angle booms should be equipped with a boom angle indicator. The indicators must be placed where they can be easily seen by the operators. Cranes having telescoping booms must be equipped with an indicator. The indicator should be visible to the operator.

The maximum allowable list and trim while operating a floating crane or derrick are specified in the following table. List refers to how far a vessel leans to one side or the other. Trim refers to how much one end or the other (aft and stern, or front and back) sits more deeply in the water.

Rated capacity	Maximum allowable list (degrees)	Maximum allowable trim (degrees)
<i>Equipment designed for marine use by permanent attachment (other than derricks):</i>		
25 tons or less	5	5
Over 25 tons	7	7
<i>Derricks designed for marine use by permanent attachment:</i>		
Any rated capacity	10	10

## Personnel Platforms

Employers and employees should know that using a derrick or crane to hoist workers on a personnel platform is prohibited in most circumstances. The primary exception is when the conventional means of reaching a worksite, such as a ladder, stairway, personnel hoist, scaffold, aerial lift, or elevating platform would be more dangerous, or the design of the structure does not allow employees to access the area. In such exceptions, a personnel platform may be used. This restriction varies for work completed under OSHA 1926, Subpart R, Steel Erection. Also, specific exemptions exist for some work related to drill shafts, pile driving, marine worksites, storage tanks, and chimney operations.

It is important that the suspension system and the personnel platform are designed by a qualified engineer or by a competent person qualified in structural design. A suspension system should be designed to minimize tipping the platform due to the movement of workers on it. Moreover, the personnel platform should be capable of supporting its own weight and at least five times the maximum intended load without any failure.

The activity of hoisting a personnel platform should be performed in a controlled, slow, and cautious manner. Personnel platforms, wire rope, shackles, and other rigging hardware must not exceed 50 percent of the rated capacity for the radius and configuration of the equipment. Locking devices (pawls or dogs), load and boom hoist drum brakes, and swing brakes must be engaged when the occupied worker's platform is in a stationary position.





The following manufacturer's specifications should be met when cranes are used for lifting personnel:

- Always make sure that the total weight of the loaded personnel platform and related rigging does not exceed 50 percent of the manufacturer's rated capacity for the configuration and radius of the crane or derrick.
- The load line hoist drum must have a system, other than the load line hoist brake, which regulates the lowering rate of speed of the hoist mechanism. This system or device must be used when hoisting personnel.

### **Guardrail and Grab-Rail Systems**

A guardrail system must be placed on each personnel platform. The guardrail system should meet the requirements of Subpart M. In addition, the guardrail system must be enclosed from the toe-board to mid-rail with expanded metal having openings no greater than 0.5 inch. The installation of a grab rail inside the entire perimeter of the personnel platform is very important, as it provides something to hold onto should the platform shift unexpectedly.

### **Access Gates**

If access gates are installed in the area, make sure that they do not swing outward during hoisting. In addition, to prevent accidents, the gates must be equipped with a restraining device.

### **Headroom on the Platforms**

In order to stand upright on the platform, headroom should be provided for the employees. Furthermore, hard hats must be provided to the employees working on the personnel platform to protect their heads from falling objects.

### **Rough Edges, Welding and Markings**

Always make sure that all rough edges are smoothed or surfaced as they could injure employees who come into contact with them. Only a qualified welder who is familiar with the weld types, material, and grades is allowed to perform all welding of the personnel platform. The personnel platforms should have a plate or other permanent markings that indicate the platform's rated load capacity or maximum intended load and the weight of the platform.

### **Occupancy of the Platform**

Only necessary employees (employees required to perform the work) can occupy the personnel platform. The platform can only be used for employee tools and materials necessary to perform the work. When employees are not being hoisted, the personnel platform should not be used for hoisting tools and materials.



## Rigging Platforms

If you are using a wire rope bridle to connect the personnel platform to the load line, always make sure that each bridle leg is connected to the shackle or master link and that the load is equally divided among the bridle legs. Master links, shackles, wire rope, and all other rigging hardware must be capable of supporting at least five times the maximum intended load without failure. Furthermore, when using rotation resistant rope, the slings must be capable of supporting at least ten times the maximum intended load without failure. Bridles and associated rigging for attaching the personnel platform to the hoist line can only be used for the platform, necessary employees, their tools, and the materials necessary for work. When bridles and associated rigging are not hoisting personnel, they should not be used for other purposes.

## Personnel Platform-Related Work Practices

When a platform is being raised, lowered, and positioned, it is vital that employees keep all parts of the body inside, as doing otherwise could lead to an accident. When possible, ensure that the platform is secured to the structure where the work is to be performed. If a hoisted platform is not secured, employees should not leave or enter the platform. In addition, when the crane engine is running and the platform is occupied, the crane or derrick operator should remain at the controls at all times.

## Dangerous Conditions

Do not hoist employees if weather conditions are bad, or if any other indication of impending danger exists. If employees are hoisted and a dangerous situation arises, they should be grounded immediately and safely. Always remember, when employees are suspended on a platform, not to lift anything on another of the crane's or derrick's load lines as it could lead to an emergency situation.

## Rigging Equipment for Material Handling

It is important that workers involved with hoisting and rigging activities are trained in both safety and operating procedures. Hoisting and rigging equipment should be operated only by trained personnel. Training and experience enable riggers to recognize hazards that can have an impact on a hoisting and rigging operation. Riggers must be familiar with the proper inspection and use of slings and other rigging hardware. Most rigging accidents can be prevented by field personnel following basic safe hoisting and rigging practices.

Employers must ensure that rigging equipment used for material handling has permanently affixed and legible identification markings as prescribed by the manufacturer that indicate the recommended safe working load. Equipment should not be used without affixed, legible identification markings. Rigging equipment must not be loaded in excess of its safe working load limit identified by the manufacturer.



Slings and all fastenings and attachments shall be inspected for damage or defects by a competent person before being used. Damaged or defective slings or other rigging equipment shall be immediately removed from service.

Rigging equipment must be removed from the immediate work area when not in use so it does not pose a hazard to employees.

## Lesson Summary

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- Floating cranes and derricks should never exceed the original capacity specified by the manufacturer. List and trim should be kept within acceptable limits when using a floating crane.
- Only necessary employees should occupy a personnel platform, and the platform must only be used for employee tools and materials necessary to perform the work. When employees are not being hoisted, the personnel platform should not be used for hoisting tools and materials.
- A suspension system should be designed to minimize tipping the platform due to the movement of workers. Moreover, the personnel platform should be capable of supporting its own weight and at least five times the maximum intended load without any failure. The activity of hoisting a personnel platform should be performed in a controlled, slow, and cautious manner.
- Personnel platforms should be equipped with guardrails and grab-rails with no rough edges.
- When the crane engine is running and the platform is occupied, the crane or derrick operator should remain at the controls at all times. When a platform is being raised, lowered, and positioned, it is vital that employees keep all parts of the body inside, as doing otherwise could lead to an accident.
- Employers and employees should know that using a derrick or crane to hoist workers on a personnel platform is normally prohibited. The primary exception is when the conventional means of reaching a worksite such as a ladder, stairway, personnel hoist, scaffold, aerial lift, or elevating platform would be more dangerous, or the design of the structure does not allow employees to access the area. In such exceptions, a personnel platform may be used. Additional exceptions related to specific operations also exist.
- Never hoist employees if the weather is bad or other adverse conditions exist at the worksite.

## Module 10: Ergonomics

### Module Description

