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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, you should be able to:

- Identify the OSHA regulations which provide the information for this course.
- 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

This lesson focuses on the following topics:

- Definition of Competent Person
- Hazards Associated with Crane Operations
- Accidents

Definition of Competent Person

A competent person is defined as being one who is capable of identifying working conditions which are unsanitary, hazardous, or dangerous to employees and who has the authorization to take prompt corrective measures to eliminate such hazards.

> **Note:** 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.

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 examples of various 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

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
- Know the basic crane capacities, limitations, and job site restrictions, such as the location of power lines, unstable soil, or high winds.
- 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

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 counter weight
- Outrigger use
- Falls
- Rigging failures

How Do Accidents Occur

Accidents generally occur due to:

- 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

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. 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.

Lesson 2: Cranes

Lesson Focus

This lesson focuses on the following topics:

- Types of Cranes
- Load
- Guarding
- Sheaves
- Inspection

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.

Overturning Accidents

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 are not fail safe and 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) beyond the published rating information.

The existence of a device alone 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. 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 crane is not placed upon a level ground.
- Wind conditions at the time.
- The existence of side loads which may destabilize the crane.
- Lifting over the side, which places the load at an angle to the center of gravity—this may lead to lessened stability.
- The use of extensions, jibs, and other attachments.
- 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

This is the point in the 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

Cranes use leverage to lift loads. 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

Relationship of the load weight, angle of the boom, and its radius (distance from the crane's center of rotation to the center of the load) to 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 grounds, 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 part of 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 otherwise exposed to employee contact.

Swing Radius

It is advised that all employees stay out of the swing radius 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

Sheave grooves shall 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 15 times the nominal diameter of the rope used.

Inspection

Annual Inspections

A thorough 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 on a regular basis:

- Correct air pressure and no leaks
- Tires properly inflated
- Clearance for rotating superstructure

- Wire rope wear
- Physical damage to crane
- Loose or missing hardware, nuts, or bolts
- Fluid leaks

Remove from Use

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

- In running ropes, with 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.

Training

All operators must be certifiably qualified to operate a specific type of crane before they are allowed to do so. Furthermore, all operators must undergo a period of on-the-job training, so as to familiarize them with any conditions specific to the workplace. Also, there must always be a competent supervisor present at all times.

Lesson Summary

Rotating and other moving parts such as gears, shafts, pulleys, sprockets, spindles, drums, fly wheels, and chains must be guarded if they are otherwise exposed to employee contact. Additionally, it is advised that all employees 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.

In concept, load and load-moment indicators are an ideal means of ensuring that cranes will not be overloaded. In practice, however, they may fall short. The reasons that load or load-moment indicators are not necessarily reliable are:

- The device can be turned off or malfunction.
- The device may be out of calibration.
- Operating conditions might be so far from ideal that the published rating is insufficient to prevent failure.

Also, the somewhat smooth operation of the boom control adjustments on hydraulic cranes may falsely suggest that they are simple to operate. In short, one must 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.

Lesson 3: Cranes and Rigging

Lesson Focus

This lesson focuses on the following topics:

- Cranes and Derricks
- Floating Cranes and Derricks
- Personnel Platforms
- Platform Specifications
- Rigging
- Platform-Related Work Practices

Cranes and Derricks

A machine with a long projecting arm, which is used to move heavy objects from one place to another, is called a crane.

A derrick is a lifting device composed at minimum of a one guyed mast, as in a gin pole, which may be articulated over a load by adjusting its guys.

Floating Cranes and Derricks

Mobile Cranes Mounted on Barges

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 shall 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.

Permanently Mounted Floating Cranes and Derricks

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

The Provision

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.

Operational Criteria

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.

Instruments and Components

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.

Personnel Platforms

It is important that the suspension system and the personnel platform is 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.

Platform Specifications

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.

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

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.

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.

Lesson Summary

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.

Additionally, 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.

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.

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