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A Guide to Crane Safety

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Acknowledgments

A *Guide to Crane Safety* was originally prepared by David V. MacCollum, president of David V. MacCollum, Ltd., of Sierra Vista, Ariz. This edition was revised and updated by Sydney Cheryl Sutton, safety compliance officer, Division of Occupational Safety and Health, N.C. Department of Labor. Recognized also for their assistance with much appreciation are contributing organizations that offered and supplied material and information used in this edition. Table 1 information format provided by Construction Safety Council, Hillside, Ill., ***Pocket Reference Guide for Power Line Clearance; Wire Rope Slings pocket reference guide***, extracts or similar information shown in Chapter 11 of the PDF version of this document are provided on behalf of union ironworkers and their employers by the Institute of the Ironworking Industry. Bobby Davis, series editor, incorporated these documents into this edition, including information from the U.S. Department of Energy (DOE) Hoisting and Rigging Standard, DOE-STD-1090-2001.

Figures 12 and 13 were provided courtesy of Award Services Crane Safety Systems, a division of Ronald M. Ward & Associates Inc. of Orlando, Fla. Mr. Ward also reviewed the manuscript.

This guide is intended to be consistent with all existing OSHA standards; therefore, if an area is considered by the reader to be inconsistent with a standard, then the OSHA standard should be followed.

To obtain additional copies of this book, or if you have questions about North Carolina occupational safety and health standards or rules, please contact:

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Additional sources of information are listed on the inside back cover of this book.

The projected cost of the OSHNC program for federal fiscal year 2002–2003 is \$13,130,589. Federal funding provides approximately 37 percent (\$4,920,000) of this total.



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Foreword

Construction cranes are a common sight on North Carolina city skylines. People watch in amazement as stacks of material and loads of concrete become our newest buildings. But the very power and size of cranes can pose many dangers to the employees who work in and around them.

A Guide to Crane Safety examines the hazards and describes safety measures the reader can take when implementing a crane safety program for a company. The guide also lists the main Occupational Safety and Health Act (OSHA) requirements that a crane owner or operator must follow to stay in OSHA compliance.

In North Carolina, N.C. Department of Labor inspectors enforce federal OSHA laws. The NCDOL's Division of Occupational Safety and Health enforces current OSHA standards. NCDOL offers many educational programs to the public and produces publications, including this guide, to help inform people about their rights and responsibilities regarding OSHA.

As you look through this guide, please remember that the NCDOL's mission is greater than just enforcement. An equally important goal is to help citizens find ways to create safe and healthy workplaces. Everyone profits when managers and employees work together for safety.

Reading and understanding *A Guide to Crane Safety* will help you form a sound occupational safety and health policy where you work.

Cherie K. Berry
Commissioner of Labor

Reasons for Crane Accidents and Preventive Measures

In our highly mechanized world, cranes are the workhorses that have increased productivity and economic growth in construction, mining, logging, maritime operations, and maintenance of production and service facilities. It is not unusual in large metropolitan areas to see several crane booms outlined against the skyline within a few blocks of each other and in rural areas to see cranes performing a great variety of jobs.

Statistics show, however, that there are inherent hazards that occur during normal working circumstances. A crane can be a very dangerous piece of equipment. Most crippling injuries and deaths from crane accidents can be attributed to several basic hazards.

Those supervising the use of cranes can greatly improve workplace safety by targeting the craning hazards that cause the most injury and death. Basic hazard prevention measures can be taken to eliminate these hazards. It is important to ensure the safety of all personnel who may be in the immediate areas where cranes are being operated, not just the riggers, signalers and operators.

Workplace safety is more than complying with a few safety rules. Everyone must be involved—management, supervisors and the work crew. Each has specific safety responsibilities, and a mutual understanding of who is responsible for what is essential. A fact that is often overlooked is that hazards are the primary cause of most accidents, so hazard prevention is what brings about a safe workplace. But, what is a hazard? How can a hazard be controlled?

As it relates to cranes, a hazard may be thought of as any unsafe condition. Hazards may be present in three forms:

- **Dormant:** A dormant hazard is an undetected hazard created either by design or crane use.
- **Armed:** An armed hazard is a dormant hazard that has become armed and ready to cause harm during certain work circumstances.
- **Active:** An active hazard is an armed hazard triggered into action by the right combination of factors. At this point it is too late to take any preventive action to escape injury or avoid death.

To change the design of a crane on a jobsite to make it safer is almost impossible, but there are measures within the control of every crane owner or user that can be taken to prevent a hazard from becoming armed and active. In decreasing order of importance, the most effective ways to control hazards are:

1. *Eliminate or minimize the hazard.* The major effort during the planning phase of any project must be to select appropriate work methods for cranes to eliminate hazards created by particular work circumstances.

2. *Guard the hazard.* Hazards that cannot be totally eliminated through planning must be reduced to an acceptable level of risk by the use of appropriate safety devices to guard, isolate or otherwise render the hazard effectively inert or inaccessible. If this cannot be done, then nearby personnel should be protected from the hazard. For example, the employer should ask the manufacturer to assist in installing guards to provide physical protection against moving parts. Listed below are other methods of guarding particular hazards or the danger zone they create.

- a. Install screens or covers over moving parts.
- b. To prevent electrocution when cranes are to be used in the vicinity of overhead energized power lines, have the local electric utility install line guards or covers on the lines. Use an insulated link on the hoist line to prevent the passage of electric current from the hook through the load to the person guiding the load on the ground.
- c. Install fences, guardrails or other barriers to prevent entry into the danger zone created by the rotating crane cab.
- d. Ask the manufacturer to install a crush-resistant cab and restraint system that encloses the operator in a protective frame to give the operator a place of safety if upset occurs.

3. *Give warning.* When a hazard cannot be controlled by applying either the first or second method, an active! intercessory warning device should be installed that detects a hazard and emits a timely, audible and/or visual warning signal. Examples are alarms, horns and flashing lights. Warning systems must emit the standard variety of sounds or flashes so the meaning of the warning will be understood. Some hazard detection systems not only give audible or visual warnings

but are wired to stop or prohibit movement. On cranes, this is especially important so the boom can be stopped before it reaches a hazardous position. There are numerous suppliers of such items.

Signs and labels are passive warnings. They must be very explicit and state what the hazard is, what harm will result, and how to avoid the hazard. The signs for life-threatening hazards should be pictorial if possible, with the word DANGER written in white letters on an oval red background with a black border. Signs and labels are not substitutes for eliminating or guarding the hazard. Rather, warnings are best used to make users aware of a specific change of circumstances that can create a hazardous situation or of a dormant hazard that could not be totally eliminated or controlled. Warnings should also inform users as to why the specified safeguard must be used.

Requirements for signs and labels are set forth in Occupational Safety and Health Administration (OSHA) standards, "Specifications for Accident Prevention Signs and Tags," 29 CFR 1910.145; "Signs, Signals, and Barricades," 29 CFR 1926.200; and Society of Automotive Engineers Recommended Practices (SAE) J115, "Safety Signs."

4. Special procedures and training. When a hazard cannot be eliminated or its risk reduced by any of the first three methods, then planning, special operating procedures, training and audits must be employed to guarantee that a viable, continuing regimen will effect avoidance of the hazard.

5. Personal protective equipment. Use of gloves, taglines to guide the load, hard hats, safety shoes, aprons, goggles, safety glasses, lifelines, life jackets and other protective equipment at all appropriate times will also protect users from injury.

Often a network of several of these five preventive measures is necessary to control a life-threatening hazard.

Safety Considerations for Lifting Personnel

Using cranes or derricks to hoist personnel poses a significant risk to employees being lifted. To help prevent employee injury or death, the Occupational Safety and Health Administration (OSHA) regulation 1926.550 limits the use of personnel hoisting in the construction industry and prescribes the proper safety measures for these operations. Personnel platforms that are suspended from the load line and used in construction are covered by 29 CFR 1926.550(g). In addition, there is no specific provision for suspended personnel platforms in Part 1910. The governing provision, therefore, is general provision 1910.180(h)(3)(v), which prohibits traveling hoisting, lowering, swinging or traveling while anyone is on the load or hook.

Federal OSHA has determined, however, that when the use of a conventional means of access to any elevated worksite would be impossible or more hazardous, a violation of 1910.180(h)(3)(v) will be treated as "de minimis" if the employer has complied with provisions set forth in 1926.550(g)(3), (4), (5), (6), (7) and (8). De minimis violations are those where the standard has been technically violated but where the violation does not constitute a danger to employees.

North Carolina's state plan does not include de minimis violations; however, the North Carolina Operations Manual requires the identification of a hazard and employees exposed to that hazard for the issuance of a citation. The OSHA rule for hoisting personnel is written in performance-oriented language that allows employers flexibility in deciding how to provide the best protection for their employees against the hazards associated with hoisting operations and how to bring their work sites into compliance with the requirements of the standard.

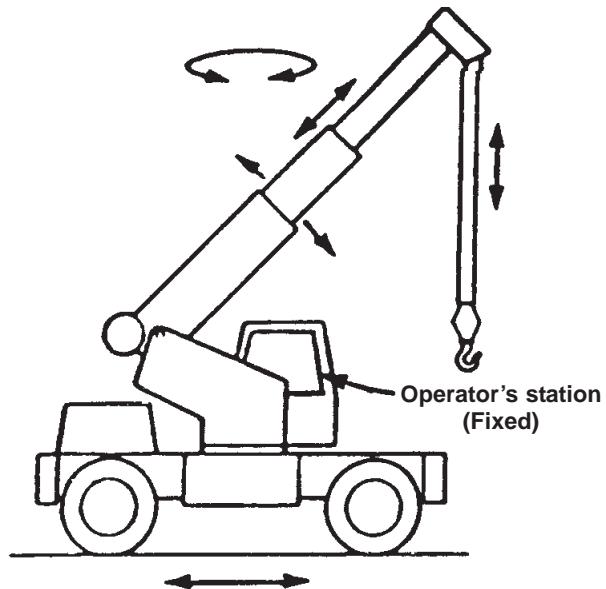
Types of Cranes Generally Used in the Workplace

Mobile Hydraulic Cranes

Rough Terrain and Wheel-Mounted Telescoping Boom

Figure 1

Wheel-Mounted Crane—Telescoping Boom (Single Control Station)

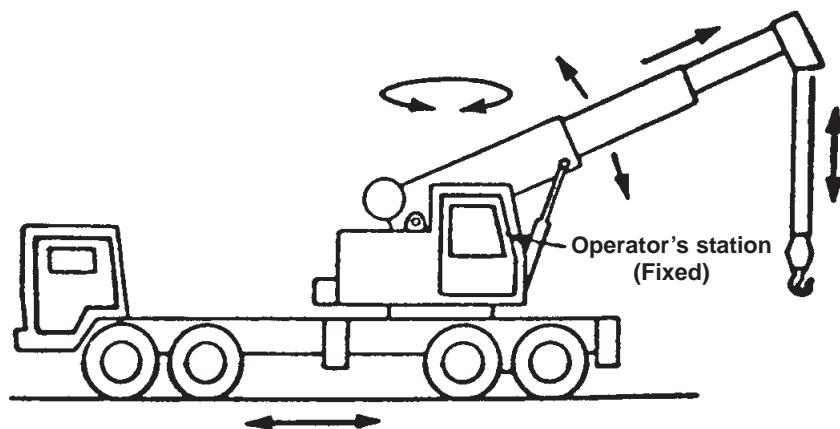


Truck-Mounted Cranes

Hydraulic Boom

Figure 2

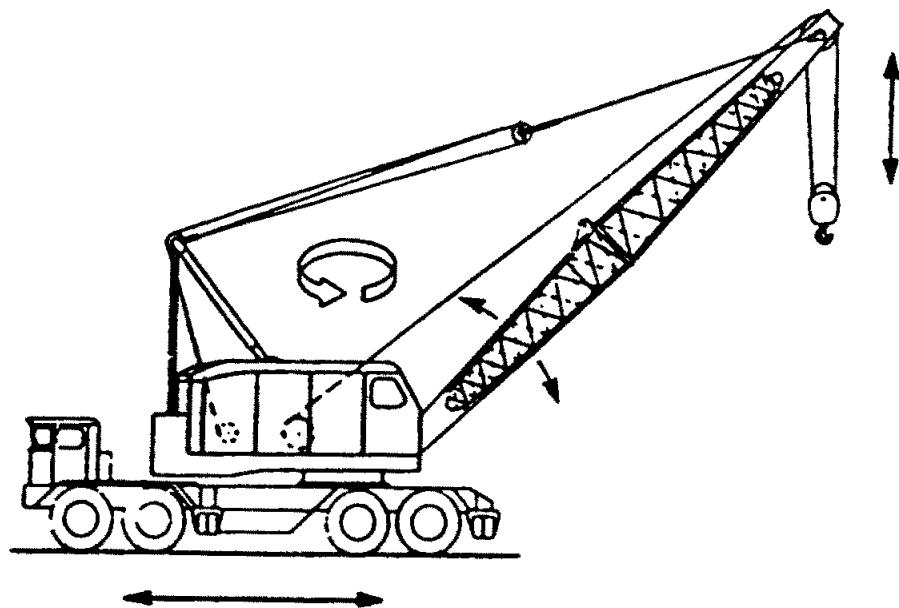
Wheel-Mounted Crane—Telescoping Boom (Multiple Control Station)



Latticework Boom

Figure 3

Wheel-Mounted Crane (Multiple Control Station)

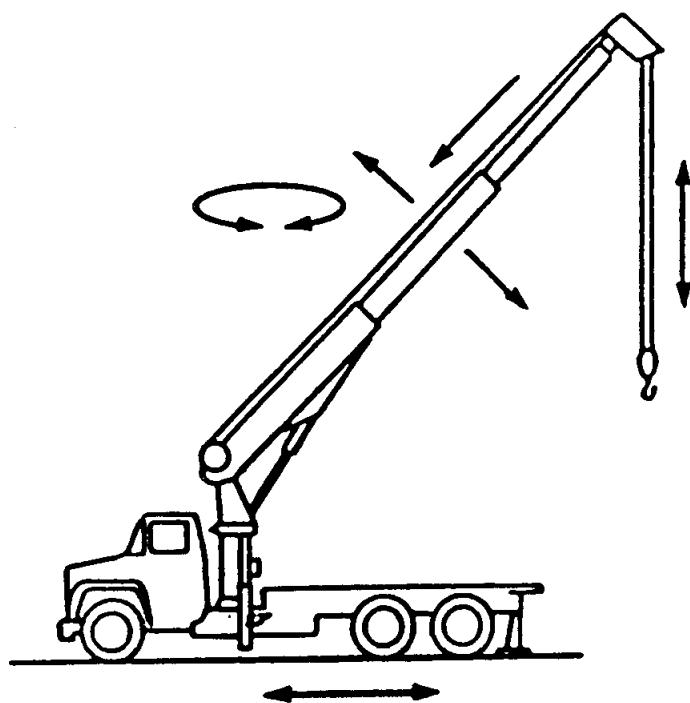


Flatbed Truck-Mounted Cranes

Hydraulic Boom

Figure 4

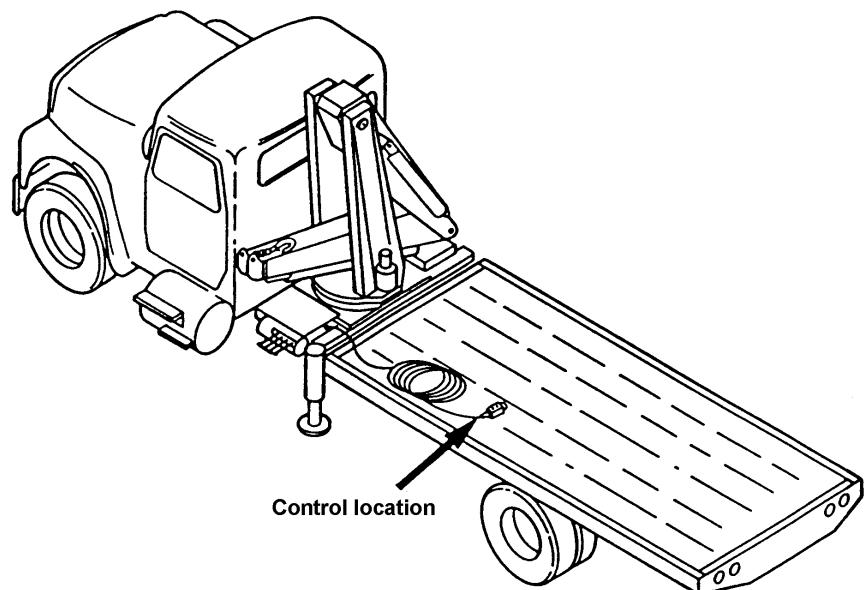
Commercial Truck-Mounted Crane—Telescoping Boom



Articulated Boom

Figure 5

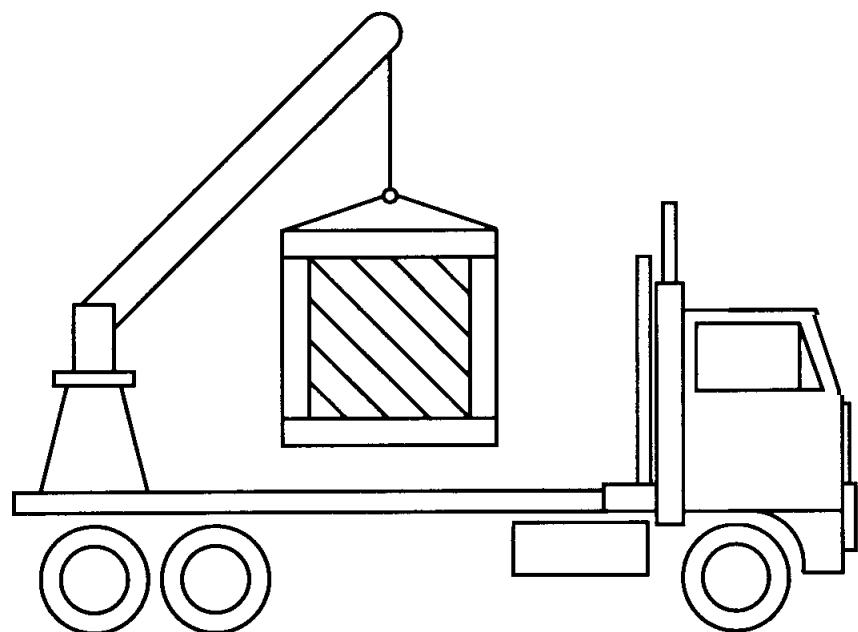
Commercial Truck-Mounted Remote Control



Trolley Boom

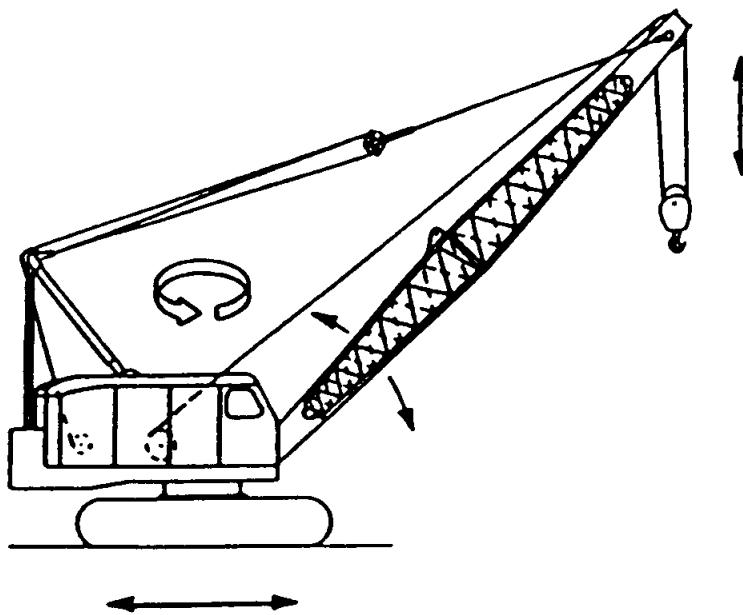
Figure 6

Trolley Boom Crane



Crawler-Mounted Latticework Boom Cranes

Figure 7
Crawler Crane



Requirements for 1926.550(g)(3), (4), (5), (6), (7) and (8)

Crane and Derrick Operations—1926.550(g)(3)

Where conventional means (e.g., scaffolds, ladders) of access would not be considered safe, personnel hoisting operations, which comply with the terms of this standard, would be authorized. OSHA stresses that employee safety—not practicability or convenience—must be the basis for the employer's choice of method.

Cranes and derricks used to hoist personnel must be placed on a firm foundation, and the crane or derrick must be uniformly level within 1 percent of level grade.

The crane operator must always be at the controls when the crane engine is running and the personnel platform is occupied. The crane operator also must have full control over the movement of the personnel platform. Any movement of the personnel platform must be performed slowly and cautiously without any sudden jerking of the crane, derrick or the platform. Wire rope used for personnel lifting must have a minimum safety factor of seven. (This means it must be capable of supporting seven times the maximum intended load.) Rotation resistant rope must have a minimum safety factor of 10.

When the occupied personnel platform is in a stationary position, all brakes and locking devices on the crane or derrick must be set.

The combined weight of the loaded personnel platform and its rigging must not exceed 50 percent of the rated capacity of the crane or derrick for the radius and configuration of the crane or derrick.

Instruments and Components—1926.550(g)(3)(ii)

Cranes and derricks with variable angle booms must have a boom angle indicator that is visible to the operator. Cranes with telescoping booms must be equipped with a device to clearly indicate the boom's extended length, or an accurate determination of the load radius to be used during the lift must be made prior to hoisting personnel. Cranes and derricks also must be equipped with an anti-two-blocking device that prevents contact between the load block and overhaul ball and the boom tip or a two-block damage-prevention feature that deactivates the hoisting action before damage occurs.

Personnel Platforms—1926.550(g)(4)

Platforms used for lifting personnel must be designed with a minimum safety factor of five and designed by a qualified engineer or a qualified person competent in structural design. The suspension system must be designed to minimize tipping due to personnel movement on the platform.

Each personnel platform must be provided with a standard guardrail system that is enclosed from the toeboard to the mid-rail to keep tools, materials and equipment from falling on employees below. The platform also must have an inside grab rail, adequate headroom for employees, and a plate or other permanent marking that clearly indicates the platform's weight and rated load capacity or maximum intended load. When personnel are exposed to falling objects, overhead protection on the platform and the use of hard hats are required.

An access gate, if provided, must not swing outward during hoisting and must have a restraining device to prevent accidental opening.

All rough edges on the platform must be ground smooth to prevent injuries to employees.

All welding on the personnel platform and its components must be performed by a qualified welder who is familiar with weld grades, types and materials specified in the platform design.

Loading—1926.550(g)(4)(iii)

The personnel platform must not be loaded in excess of its rated load capacity or its maximum intended load as indicated on permanent markings. Only personnel instructed in the requirements of the standard and the task to be performed—along with their tools, equipment and materials needed for the job—are allowed on the platform. Materials and tools must be secured and evenly distributed to balance the load while the platform is in motion.

Rigging—1926.550(g)(4)(iv)

When a wire rope bridle is used to connect the platform to the load line, the bridle legs must be connected to a master link or shackle so that the load is evenly positioned among the bridle legs. Bridles and associated rigging for attaching the personnel platform to the hoist line must not be used for any other purpose.

Attachment assemblies such as hooks must be closed and locked to eliminate the hook throat opening; an alloy anchor-type shackle with a bolt, nut and retaining pin may be used as an alternative. “Mousing” (wrapping wire around a hook to cover the hook opening) is not permitted.

Inspecting and Testing—1926.550(g)(5)

A trial lift of the unoccupied personnel platform must be made before any employees are allowed to be hoisted. During the trial lift, the personnel platform must be loaded at least to its anticipated lift weight. The lift must start at ground level or at the location where employees will enter the platform and proceed to each location where the personnel platform is to be hoisted and positioned. The trial lift must be performed immediately prior to placing personnel on the platform.

The crane or derrick operator must check all systems, controls and safety devices to ensure the following:

- They are functioning properly.
- There are no interferences.
- All boom or hoisting configurations necessary to reach work locations will allow the operator to remain within the 50-percent load limit of the hoist's rated capacity.

If a crane or derrick is moved to a new location or returned to a previously used one, the trial lift must be repeated before hoisting personnel.

After the trial lift, the personnel platform must be hoisted a few inches and inspected to ensure that it remains secured and is properly balanced.

Before employees are hoisted, a check must be made to ensure the following:

- Hoist ropes are free of kinks.
- Multiple part lines are not twisted around each other.

- The primary attachment is centered over the platform.
- There is no slack in the wire rope.
- All ropes are properly seated on drums and in sheaves.

Immediately after the trial lift, a thorough visual inspection of the crane or derrick, the personnel platform, and the crane or derrick base support or ground must be conducted by a competent person to determine if the lift test exposed any defects or produced any adverse effects on any component or structure. Any defects found during inspections must be corrected before hoisting personnel. A competent person is one who can identify existing and predictable hazards in the workplace and is authorized to correct them (see 29 CFR 1926.32(f)).

When initially brought to the jobsite and after any repair or modification, and prior to hoisting personnel, the platform and rigging must be proof tested to 125 percent of the platform's rated capacity. This is achieved by holding the loaded platform—with the load evenly distributed—in a suspended position for five minutes. Then a competent person must inspect the platform and rigging for defects. If any problems are detected, they must be corrected and another proof test must be conducted. Personnel hoisting must not be conducted until the proof testing requirements are satisfied.

Safe Work Practices—1926.550(g)(6)

Employees also can contribute to safe personnel hoisting operations and help to reduce the number of accidents and injuries associated with personnel hoisting operations. Employees must follow these safe work practices:

- Use tag lines unless their use creates an unsafe condition.
- Keep all body parts inside the platform during raising, lowering and positioning.
- Make sure a platform is secured to the structure where work is to be performed before entering or exiting it, unless such securing would create an unsafe condition.
- Wear a body belt or body harness system with a lanyard. The lanyard must be attached to the lower load block or overhaul ball or to a structural member within the personnel platform. If the hoisting operation is performed over water, the requirements 29 CFR 1926.106—Working over or near water—must apply.
- Stay in view of, or in direct communication with, the operator or signal person.

Crane and derrick operators must follow these safe work practices:

- Never leave crane or derrick controls when the engine is running or when the platform is occupied.
- Stop all hoisting operations if there are indications of any dangerous weather conditions or other impending danger.
- Do not make any lifts on another load line of a crane or derrick that is being used to hoist personnel.

Movement of Cranes—1926.550(g)(7)

Personnel hoisting is prohibited while the crane is traveling except when the employer demonstrates that this is the least hazardous way to accomplish the task or when portal, tower or locomotive cranes are used.

When cranes are moving while hoisting personnel, the following rules apply:

- Travel must be restricted to a fixed track or runway.
- Travel also must be limited to the radius of the boom during the lift.
- The boom must be parallel to the direction of travel.
- There must be a complete trial run before employees occupy the platform.
- If the crane has rubber tires, the condition and air pressure of the tires must be checked and the chart capacity for lifts must be applied to remain under the 50-percent limit of the hoist's rated capacity. Outriggers may be partially retracted as necessary for travel.

Pre-lift Meeting—1926.550(g)(8)

The employer must hold a meeting with all employees involved in personnel hoisting operations (crane or derrick operator, signal person(s), employees to be lifted, and the person responsible for the hoisting operation) to review the OSHA requirements (1926.550(g)) and the procedures to be followed before any lift operations are performed.

This meeting must be held before the trial lift at each new worksite and must be repeated for any employees newly assigned to the operation.

Compliance with the common sense requirements of the OSHA standard and the determination that no other safe method is available should greatly reduce or eliminate the injuries and accidents that occur too frequently during personnel hoisting operations.

Analysis of Eight Hazards Common to Most Cranes

This part analyzes eight hazards common to most cranes. Each analysis includes a definition, description, risks presented by the hazard, reasons why the hazard occurs, preventive measures and any applicable OSHA requirements.

The lack of qualifications on the part of crane operators figures prominently into these hazards. The crane owner and job supervisor must ensure that their crane operators are qualified and competent, not only in machine operations but in load capacity calculations as well. Minimum competent personnel requirements are included in part 4.

Power Line Contact

Definition

Power line contact is the inadvertent contact of any metal part of a crane with a high-voltage power line.

Description

Most power line contacts occur when a crane is moving materials adjacent to or under energized power lines and the hoist line or boom touches a power line. Contact also frequently occurs during pick-and-carry operations when loads are being transported under energized power lines. Sometimes the person who is electrocuted is touching the crane or getting on or off of it when the hoist line or boom inadvertently comes into contact with an energized power line.

In some circumstances, when a crane comes into contact with a power line and sufficient ground fault is created, the electric utility's distribution system is automatically deenergized by a reclosure switch to avoid the blowing of intervening fuses. Many times people assume that the power line is deenergized when the sparks stop at the point of contact. But this can be very misleading, because the circuit is automatically reenergized several seconds later, so there usually is not enough time given by this type of deenergization to keep someone from being shocked again. *The best hazard prevention method to avoid such an occurrence is to position the crane to keep a 10-foot clearance so the boom or hoist line cannot reach the power lines.*

Risks Presented by Power Line Contact

Power line contact is the greatest risk to be found in craning operations. A single contact can result in multiple deaths and/or crippling injuries. Each year approximately 150 to 160 people are killed by power line contact, and about three times that number are seriously injured. On an average, eight out of 10 of the victims were guiding the load at the time of contact.

Why Crane Power Line Contacts Occur

Power line contact usually occurs because no one considered the need for specific hazard prevention measures to avoid using cranes near power lines. All too often no prejob safety planning is done, so when the crane arrives at the worksite, the workers are placed in a hurried set of circumstances that burdens them with unreasonably dangerous tasks.

Preventive Measures

The key to avoiding power line contact is prejob safety planning. *Planning is one of the greatest accident deterrents available in the workplace.* Because of the large number of employers involved in controlling the workplace—landowner, construction management, prime contractor, subcontractors crane rental firms, electric utilities—planning is necessary to establish the person in charge.

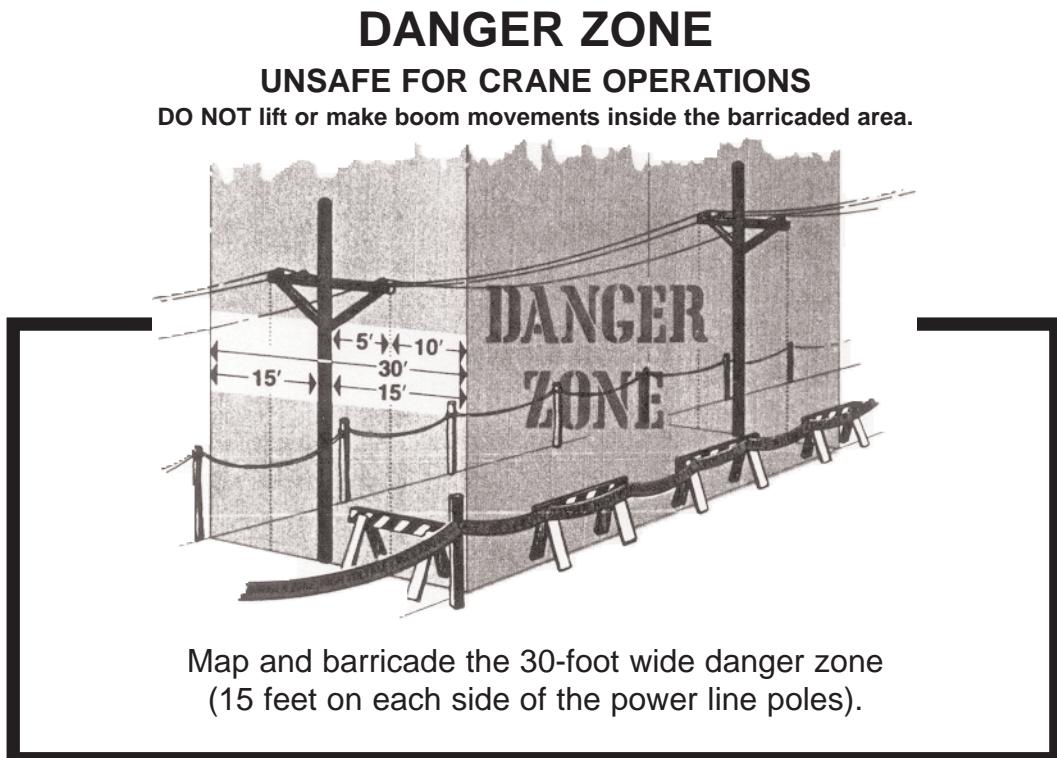
A single individual should have overall supervision and coordination of the project and must initiate positive direction to ensure that prejob safety planning is done before any cranes arrive at the worksite.

Cranes and power lines should not occupy the same work area. In too many instances, work areas encompass existing power lines that have clearances acceptable for normal roadway traffic but not for cranes. The crane operator, those guiding the load and those closely involved in the particular craning operation need visual guidance from the ground so they are made aware of the danger zone and can conduct all of their work outside of this dangerous area. The area within a

radius of 10 feet in any direction from power lines is an unsafe work area and must be clearly marked off on the ground by marker tape, fences, barriers, etc. That way, everyone at the worksite has the visual clues to ensure that the crane is positioned so that the boom and hoist line cannot intrude into the danger zone created by the power lines. Figure 8 shows how to map this danger zone surrounding power lines so it is impossible for the boom in any position or the hoist line to come closer than 10 feet and intrude into the danger zone. If the danger zone can be penetrated by a crane boom, the electric utility must be notified to deenergize, relocate, bury or insulate the lines while the crane is operating in that location.

Figure 8

Power Lines Properly Guarded to Prevent Contact With a Crane



ALWAYS notify the power company before you begin crane operations near power lines.

It is extremely difficult for a crane operator to:

- Judge accurately clearances between a crane and power lines simply through the use of vision.
- See more than one visual target at a time.
- Overcome the camouflaging characteristics that trees, buildings and other objects have upon power lines.

Sometimes a crane operator cannot judge the clearance of the boom from the power line because the boom blocks the operator's view to the right. Sole reliance upon the performance of crane operators, riggers and signalers, without any planning to separate cranes from power lines has resulted in many deaths.

Pick-and-carry operations with mobile cranes often result in power line contact, even though the same route had been taken previously. Cage-type boom guards, insulated links and proximity warning devices provide safety backups for operators, but such devices are not substitutes for maintaining the 10-foot clearance, which is most important. Use of these devices must be consistent with the product manufacturer's recommendations.

Truck-mounted trolleys or articulated crane booms that utilize an electrical remote control system to load or unload bricks, cement block, trusses and other building supplies have also caused many injuries and deaths. In the event the boom contacts a power line, the individual holding the control box at the end of the electrical control cable is usually electrocuted instantly. Such equipment should never be used near power lines. A safer purchase choice would be non-conductive, pneumatic-powered or remote radio control systems.

Controls for flatbed-mounted cranes that are located where they can be operated by an individual standing on the ground leaves the operator vulnerable to the initial fault current path in the event the boom strikes a power line.

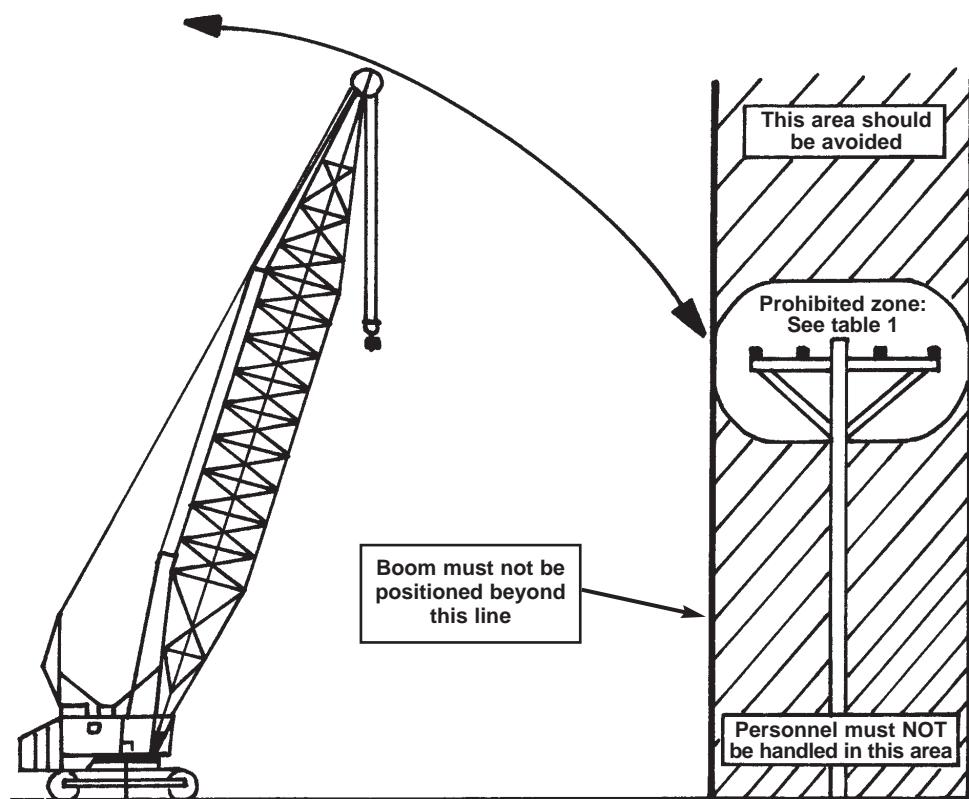
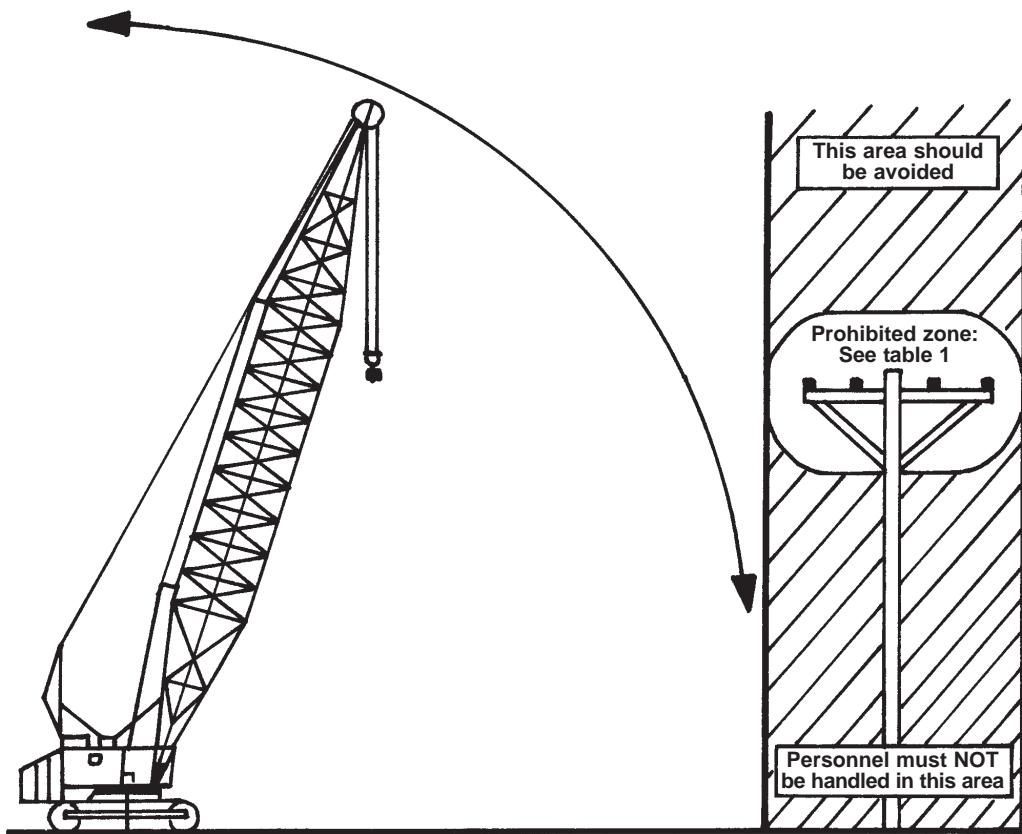
Table 1 shows the safe working distance from power lines. Figure 9 illustrates the prohibited zone around a power line.

Table 1
Safe Working Distances From Power Lines

a. When operating near high-voltage power lines	
Normal Voltage (phase to phase)	Minimum required clearance
to 0.50 kv	10 ft. (3.1 m)
Over 50 to 200 kv	15 ft. (4.6 m)
Over 200 to 350 kv	20 ft. (6.1 m)
Over 350 to 500 kv	25 ft. (7.6 m)
Over 500 to 750 kv	35 ft. (10.7 m)
Over 750 to 1000 kv	45 ft. (13.7 m)

b. While in transit with no load and boom or mast lowered	
Normal Voltage (Phase to Phase)	Minimum Required Clearance
to 0.75 kv	4 ft. (1.2 m)
Over 0.75 to 50 kv	6 ft. (1.3 m)
Over 50 to 345 kv	10 ft. (3.5 m)
Over 34 to 700 kv	16 ft. (4.9 m)
Over 750 to 1000 kv	20 ft. (6.1 m)

Figure 9
Danger Zone for Cranes and Lifting Personnel Near Electrical Transmission Line



OSHA Requirements

- 29 CFR 1910.180(b)—Crawler locomotive and truck cranes—General requirements
- 29 CFR 1910.180(j)—Crawler locomotive and truck cranes—Operations near overhead lines
- 29 CFR 1910.333(c)(3)—Selection and use of work practices—Working on or near exposed energized parts—Overhead lines
- 29 CFR 1926.550(a)(15)—Cranes and derricks—General requirements—Electrical distribution and transmission lines

Working Around Power Lines: Stay Away

Always Do	Never Do
<ul style="list-style-type: none">• ALWAYS keep a safe distance of at least 10 feet between you and your equipment from the power lines.• ALWAYS survey the site for overhead power lines. LOOK UP!• ALWAYS, when using crane and/or equipment near energized power lines of 50,000 volts (50kV) or more, make sure the minimum distance between the lines and any part of the crane is 10 feet plus 4 inches for each 10kV over 50kV.• ALWAYS request an observer to assist you where it is difficult to maintain the desired clearance by visible means.• ALWAYS require that the only job of the observer is to help the operator maintain the safe clearance.• ALWAYS treat overhead power lines as if they were energized.• ALWAYS, when in doubt, call the electric company to find out what voltage is on the lines.• ALWAYS ask the electric company to either de-energize and ground the lines or install insulation while you are working near them.• ALWAYS make sure ladders and tools are non-conductive.	<ul style="list-style-type: none">• NEVER get closer than 10 feet to an overhead power line!• NEVER work at a site without checking for power lines. LOOK UP!• NEVER, when using cranes and/or equipment near energized power lines of 50,000 volts (50kV) or more, get closer than 10 feet plus 4 inches for each 10kV over 50kV.• NEVER use cranes and/or alone where it is difficult by visible means to maintain the desirable clearance.• NEVER forget that overhead power lines could be energized.• NEVER allow the observer to perform another job while helping the operator to maintain a safe clearance.• NEVER take a chance without consulting first with the electric company to find out what voltage the lines carry.• NEVER work near power lines until you are certain that they have been de-energized and grounded or insulated by the electric company.• NEVER work with ladders and tools if they have not been rated nonconductive.

Overloading

Definition

Overloading occurs when the rated capacity of a crane is exceeded while a load is being lifted and maneuvered, resulting in upset or structural failure.

Description

Cranes can easily upset from overloading. On some models the weight of a boom without a load can create an imbalance and cause some high-reach hydraulic cranes to upset when the boom is positioned at a low angle. This has occurred even with outriggers extended.

Today's crane operator is confronted with a number of variables that affect lifting capacity:

1. The ability to lower a boom increases the radius and reduces its capacity.
2. The ability to extend a hydraulic boom increases the radius and reduces lifting capacity.

3. The ability to lower a boom while extending a boom quickly reduces lifting capacity.
4. The crane's tipping capacity can vary when the boom is positioned at the various points of the compass or clock in relation to its particular carrier frame.
5. The operator may neglect to extend the outriggers and affect the crane's stability.
6. The operator may mistakenly rely upon perception, instinct or experience to determine whether the load is too heavy and may not respond fast enough when the crane begins to feel light. (Fundamental to a lift are prelift determinations of the weight of the load and the net capacity of the crane—29 CFR 1926.550(a)(1).)

All of these variables create conditions that lead to operators inadvertently exceeding the rated capacity, tipping the load and upsetting the crane. The variables may also lead to structural failure of the crane. That is, under certain loads and at particular configurations, the crane may break before it tips.

Risks Presented by Overloading

It is estimated that one crane upset occurs during every 10,000 hours of crane use. Approximately 3 percent of upsets result in death, 8 percent in lost time, and 20 percent in damage to property other than the crane. Nearly 80 percent of these upsets can be attributed to predictable human error when the operator inadvertently exceeds the crane's lifting capacity. This is why employers must ensure their operators' competence (see table 2).

Table 2
Analysis of 1,000 Crane Upset Occurrences During a 20-Year Period

Approximately

15%	In travel mode
39%	Making swing with outriggers retracted
15%	Making a pick with outriggers retracted
14%	Making a pick or swing with outriggers extended
6%	Making a pick or swing; use of outriggers unknown
7%	Outrigger failure
4%	Other activity

Also reported:

3%	Deaths
8%	Lost-time injuries
20%	Significant property damage other than the crane

Why Overloading Occurs

Overloading occurs when poorly trained personnel are allowed to operate cranes. The operator must always know the weight of the load.

Preventive Measures

During the last 30 years much progress has been made in the availability of systems to prevent crane upset due to overloading. Crane operation is no longer a "seat-of-the-pants" skill but requires both planning and training in the use of the latest technologies such as load-measuring systems.

With the advent of solid-state micro-processing electronics, load-measuring systems evolved. Such systems can sense the actual load as related to boom angle and length, warn the operator as rated capacity is approached, and stop further movement. Load-measuring systems automatically prevent exceeding the rated capacity at any boom angle, length or radius. Today most U.S. crane manufacturers are promoting the sale of load-measuring systems as standard equipment on new cranes. There are after-market suppliers of these devices for older model cranes.

For years, the only control to avoid upset from overload has been reliance upon an operator's performance and the use of load charts. However, such charts are complex. Optimally, formal training should be provided for all crane operators, to ensure a working knowledge of crane load charts. However, on-the-job training can be adequate if the trainer is qualified.

OSHA Requirements

- NC. Gen. Stat. §95-129(1)—the general duty clause
- 29 CFR 1910.179(b)(5)—Overhead and gantry cranes—Rated load marking
- 29 CFR 1910.180(c)—Crawler locomotive and truck cranes—Load ratings
- 29 CFR 1910.180(h)(3)—Crawler locomotive and truck cranes—Moving the load
- 29 CFR 1926.550(a)(1)—Cranes and derricks—General requirements
- 29 CFR 1926.550(b)(2)—Cranes and derricks—Crawler, locomotive, and truck cranes

Failure to Use Outriggers; Soft Ground and Structural Failure

Definition

Crane upset can occur when an operator does not extend the outriggers or when a crane is positioned on soft ground.

Description

Many cranes upset because the use of outriggers is left to the discretion of the operator. For example, sometimes an operator cannot extend the outriggers because of insufficient space or a work circumstance that arises when planning is not done. Or outrigger pads may be too small to support the crane even on hard ground. However, the use of outriggers is not voluntary. Load capacity charts are based either on the use of fully extended outriggers or on “rubber,” for rubber-tired cranes. If circumstances are such that outriggers cannot be fully extended, then capacities in the on-rubber chart must be used.

Outriggers have collapsed because they were overloaded, defective or located on inadequate foundation. (When outriggers are being used, carrier tires must not be supporting weight. They must be clear of the ground. Outrigger pads must be positively attached to the connecting cylinder.)

Risks Presented by the Failure to Use Outriggers

An analysis of some 1,000 crane accidents (see table 2) has shown that half of the incidents involving outriggers occurred when the crane operator was either swinging the cab or extending or lowering a telescoping boom without outriggers extended. These actions rapidly increase the lifting radius so upset occurs quickly.

Why Outriggers Are Not Used

Supervisors and managers may unjustifiably rely upon their operators' knowledge of the need for outriggers. Management should assure itself that every crane operator is competent. Determining the load weight is generally viewed as the responsibility of the site supervisor, who must inform the operator before the lift is made. The operator must still be able to determine or estimate load weights, to evaluate and verify the weight provided. Based on the load weight, the operator knows if it is necessary to use outriggers. Management may also fail to insist that equipment brought onto the project be equipped with available safeguards, such as interlocks to restrict boom movement when outriggers are retracted.

Preventive Measures

Since such a high proportion of accidents occur when outriggers are not extended, design changes to overcome this hazard are needed. The surest way to avoid an accident is to make the machine inoperable until the operator activates necessary safeguards. Some aerial basket designs include limit switches to prevent boom movement until outriggers are extended and in place to avert upset. The newer aerial basket trucks have hydraulic systems with interlocks that preclude boom operation until outriggers are fully extended and fully supporting the crane, with wheels completely off the ground.

Soil failure occurs because the ground is too soft or the outrigger pads are not big enough. Soils range from wet sand that can only support 2,000 pounds per square foot to dry hard clay that can support 4,000 pounds per square foot to well-cemented hardpan that can support as much as 10,000 pounds per square foot. When poor soil is encountered, or the outriggers have inadequate floats or pads, well-designed blocking or cribbing is needed under the outriggers. On all types of cranes where floats are used OSHA requires that they be securely attached. It also requires that blocking used to support outriggers be strong enough to prevent crushing, be free of defects and be of sufficient width and length to prevent shifting or toppling under load.

OSHA Requirements

- 29 CFR 1910.180(h)(3)(ix)—Crawler locomotive and truck cranes—Handling the load
- 29 CFR 1926.550(b)(2)—Cranes and derricks—Crawler, locomotive, and truck cranes

Two-Blocking

Definition

Two-blocking occurs when the hoist block or hook assembly comes into contact with the boom tip, causing the hoist line to break and the hook and load to fall, endangering workers below.

Description

Both latticework and hydraulic boom cranes are prone to two-blocking. When two-blocking occurs on latticework booms, the hoist line picks up the weight of the boom and lets the pendant guys go slack. Often a whip action is created when a crawler crane with a long boom without a load is “walking” and the headache ball and empty chokers can drift up to the boom tip. Ordinarily, while the operator is busy watching the pathway of travel to avoid any rough ground that can violently jerk the crane, he or she does not watch the boom tip. When a hoist line two-blocks, it assumes the weight of the boom and relieves the pin-up guys of the load. Then, if the crane crawler goes over a rock or bump, the flypole action of a long boom is sufficient to break the hoist line. The weight of the load plus the weight of the boom on a latticework boom (when combined with a little extra stress when lifting a load) can cause the hoist line to break if two-blocking occurs.

The power of the hydraulic rams that extend hydraulic booms is often sufficient to break the hoist line if the line two-blocks. An operator can forget to release (pay out) the load line when extending the boom. When this occurs, the hoist line can be inadvertently broken. If the load line breaks while supporting a worker on a boatswain's chair or several workers on a floating scaffold or a load above people, a catastrophe can result. When an operator must use two controls, one for the hoist and one for the hydraulic boom extension, the chance of error is increased.

In many circumstances, both latticework and hydraulic boom cranes will two-block when the hook is near the tip and the boom is lowered. Two-blocking incidents can also occur without resulting in actual failure, but causing damage which will result in failure at a later time.

Risks Presented by Two-Blocking

Hundreds of deaths and crippling injuries have resulted from two-blocking occurrences. Over the years, there have probably been thousands of two-blocking occurrences that have broken the hoist line. Most occurrences probably went unrecorded because no one was injured when the hoist line failed and dropped the hook and/or load.

Why Two-Blocking Occurs

Two-blocking occurs because the crane operator is often visually overtaxed. He or she is unable to watch the load and headache ball or hook simultaneously.

Preventive Measures

Anti-two-blocking devices have long been available, but industry acceptance of these devices as a preventive measure has lagged. OSHA now requires an anti-two-blocking device or a two block damage prevention feature where cranes are used to hoist personnel.

There are several ways to prevent two-blocking:

1. An anti-two-blocking device can be used. This device is a weighted ring around the hoist line that is suspended on a chain from a limit switch attached to the boom tip. When the hoist block or headache ball touches the suspended, weighted ring, the limit switch opens and an alarm warns the operator. It can also be wired to intercede and stop the hoisting. The circuitry is no more complex than an electric door bell.
2. On hydraulic cranes the hydraulic valving can be sequenced to pay out the hoist line when the boom is being extended, thus avoiding two-blocking.

3. Adequate boom length can be ensured to accommodate both the boom angle and sufficient space for rigging, such as slings, spreader bars and straps. To avoid bringing the hook and headache ball into contact with the boom tip, a boom length of 150 percent of the intended lift is required for a boom angle of 45 degrees or more.

Anti-two-blocking devices should be standard equipment on all cranes. Currently, most new mobile hydraulic cranes are being equipped with these systems.

OSHA Requirements

- 29 CFR 1910.179(g)(5)(iv)—Overhead and gantry cranes—Switches
- 29 CFR 1910.179(n)(4)(I)—Overhead and gantry cranes—Handling the load—Hoist limit switch
- 29 CFR 1926.550(g)(3)(ii)(C)—Cranes and derricks—Instruments and components

Pinchpoints

Definition

There are two types of crane pinchpoints:

1. Within the swinging radius of the rotating superstructure of a crane in areas in which people may be working, is a pinchpoint where people can be crushed or squeezed between the carrier frame and the crane cab, or the crane cab and an adjacent wall or other structure.
2. Many unguarded gears, belts, rotating shafts, etc., within the crane are pinchpoints to which employees may be exposed.

Description

A pinchpoint is created by the narrow clearance between the rotating superstructure (cab) of a crane and the stationary carrier frame. When a crane must be used in a confined space, another dangerous pinchpoint is the close clearance between the rotating cab/counterweight and a wall, post or other stationary object. This hazard is inherent in rough terrain cranes, truck-mounted cranes, crawler cranes and other mobile cranes. Many people, especially oilers, have been crushed by such pinchpoints.

Analysis of such occurrences shows that the victims usually entered the danger zone to access:

- the water jug
- the tool box
- the outrigger controls
- an area to perform maintenance
- an area for storage of rigging materials

In all of the known cases where someone entered the danger zone and was caught in a pinchpoint, the danger zone was outside the crane operator's vision. Survivors have stated that they believed the crane operator was not going to rotate or slew the boom at that particular moment.

Many unguarded moving parts are found inside the crane cab, which serves as a shelter for the engine and hoist system.

Risks Presented by Pinchpoints

Many deaths or serious injuries have been recorded as a result of being crushed between the cab and carrier frame. Many amputations have been caused by unguarded moving parts within the crane.

Why Workers Are Crushed by the Rotating Cab

Workers have been crushed by the rotating cab because management failed to ensure that the crane was adequately barricaded and that all incentives to enter the swing zone were removed. Crane cabs are usually used for storage of lunch buckets, tools and supplies. The machinery that runs the crane requires oiling, adjustment and maintenance from time to time. Workers are, therefore, exposed to the hazard of the rotating cab and the hazard created by the many unguarded moving parts of the crane.

Preventive Measures

The swing area of the crane cab and counterweight must be barricaded against entry into the danger zone.

The removal of water jugs, tool boxes and rigging materials from crane cabs would reduce the incentive to enter the danger zone.

The installation of rear view mirrors for the crane operator provides an added safeguard so the operator can see into the turning area of the cab and counterweight.

OSHA Requirements

- 29 CFR 1926.550(a)(9)—Cranes and derricks—General requirements
- 29 CFR 1910.180(I)(6)—Crawler locomotive and truck cranes—Swinging locomotive cranes
- Numerous OSHA standards address machine guarding and the guarding of moving parts

Obstruction of Vision

Definition

Safe use of a crane is compromised when the vision of an operator, rigger or signaler is blocked, and employees cannot see what the others are doing.

Description

There are two general categories for obstructions of operators' vision:

- obstruction by the crane's own bulk
- obstruction by the work environment

The crane size alone limits the operator's range of vision and creates many blind spots, preventing the rigger, signaler, oiler and others affected by the crane's movement from having direct eye contact with the crane operator. When a cab-controlled mobile crane is moved or travels back and forth, the operator must contend with many blind spots on the right side of the crane.

Many situations arise in craning activities that can almost instantaneously turn a simple lift into a life-taking catastrophe:

1. In many instances the work environment requires that loads be lifted to or from an area that is outside of the view of the operator. The crane boom may obstruct the operator's range of vision on the right side.
2. Often a load is lifted several stories high, and the crane operator must rely upon others to ensure safe movement of the load being handled.
3. Many people are affected by a crane's movement. Welders with their hoods on, carpenters, ironworkers or other workers may be working in the immediate vicinity of a crane, preoccupied with their tasks and unaware of the activity of the crane. They also may be out of the range of vision of the crane operator. Both the lack of awareness on the part of others and the obstructed vision of the crane operator contribute to craning accidents.

Risks Presented by Obstruction of Vision

When operators, riggers, signalers, oilers and others cannot see each other or the suspended load, the risk of accident becomes very high.

Why People Are Injured by Movement of the Load or the Crane

People are injured during craning when management fails to provide an effective communication system for the crane operator and signalers to ensure that all are aware of any changes in circumstances. Often signalers have not been adequately trained to perform their important task.

Preventive Measures

The key to a safe craning operation is the planning of all activities, starting with prejob conferences and continuing with daily planning to address any changes that need to be made.

To overcome the hazard of blind spots while loads are being lifted, the use of radios and telephones is much more effective than relying upon several signalers to relay messages by line of sight.

The use of automatic travel alarms is an effective way to warn those in the immediate vicinity of crane travel movement in pick-and-carry functions.

It should also be recognized that OSHA requires the windows of cranes to be made of safety glass or the equivalent, which does not introduce visible distortion that will interfere with the safe operation of the crane.

OSHA Requirements

- 29 CFR 1910.179(I)—Overhead and gantry cranes—Warning device
- 29 CFR 1926.16(a)—Rules of construction
- 29 CFR 1926.201(b)—Signaling—Crane and hoist signals
- 29 CFR 1926.550(a)(1)—Cranes and derricks—General requirements
- 29 CFR 1926.550(d)(3)—Cranes and derricks—Overhead and gantry cranes

Travel Upset in Mobile Hydraulic Cranes (Rough-Terrain and Wheel-Mounted Telescoping Boom)

Definition

Because of a high center of gravity, a mobile hydraulic crane can easily upset and crush the operator between the boom and the ground.

Description

This type of crane is easily overturned on road shoulders or other embankments during travel from one location to another.

Risks Presented by Travel Upsets

Numerous travel upsets have been recorded. When the mobile hydraulic crane upsets on the left side where the operator's cab is located, the lightweight sheet metal cab is easily crushed, usually trapping the operator before escape is possible. Crawler tractors can remain stable up to a 57 degree side slope. Mobile hydraulic cranes, however, are rarely stable on side slopes beyond 35 degrees. Because of their versatility with four-wheel drive and four-wheel steer, rough-terrain cranes do encounter slopes of over 35 degrees that could cause upset.

The lightweight sheet metal cab on almost all types of cranes is also vulnerable to crushing during upset from overloading as discussed in "Overloading," and the operator has no safe sanctuary in this type of cab to prevent serious injury.

Why Crane Operators Are Crushed When a Crane Upsets

Crush-resistant cabs are not routinely installed on cranes.

Preventive Measures

In the 1950s it was recognized that protective canopies that would resist the crushing effect of rollover could be designed and fabricated for heavy crawler-type bulldozers. Beginning in the late 1960s, rollover protection system (ROPS) standards were developed by the Society of Automotive Engineers (SAE) for tractors (both crawler and wheel), loaders, graders, compactors, scrapers, water wagons, rear dumps, bottom dumps, fifth wheel attachments, and various other pieces of equipment. Death and crippling injuries from rollover and falling objects have been substantially reduced because of ROPS. The same technology could be applied to mobile hydraulic cranes so operators would have the protection of a crush-resistant cab in the event of upset. The crane manufacturer or an after-market supplier should be contacted for installation of a crush-resistant cab and seatbelt.

Boom Disassembly on Latticework Boom Cranes

Definition

If a boom is not blocked, improper disassembly can cause it to collapse upon those who are removing pins under the boom while the boom is suspended.

Description

Latticework booms are disassembled for shortening, lengthening or transporting. Boom collapse occurs on truck- or crawler-mounted cranes when the boom is lowered to a horizontal position and suspended from the boom tip with pendant guys, but the boom is not blocked. If the lower pins connecting boom sections are knocked out by workers who are under the boom, the boom can collapse upon them, resulting in death or serious injuries.

Risks Presented by Boom Disassembly

There are at least three circumstances that lead to accidents when latticework boom sections are being dismantled:

1. Workers are unfamiliar with the equipment.
2. A poor location is chosen for dismantling.
3. Not enough time is allotted to meet the task deadline.

Why Workers Are Crushed by Latticework Booms During Disassembly

Workers are crushed during disassembly of latticework booms when there is a lack of supervision to ensure that the manufacturer's disassembly procedures are followed.

Preventive Measures

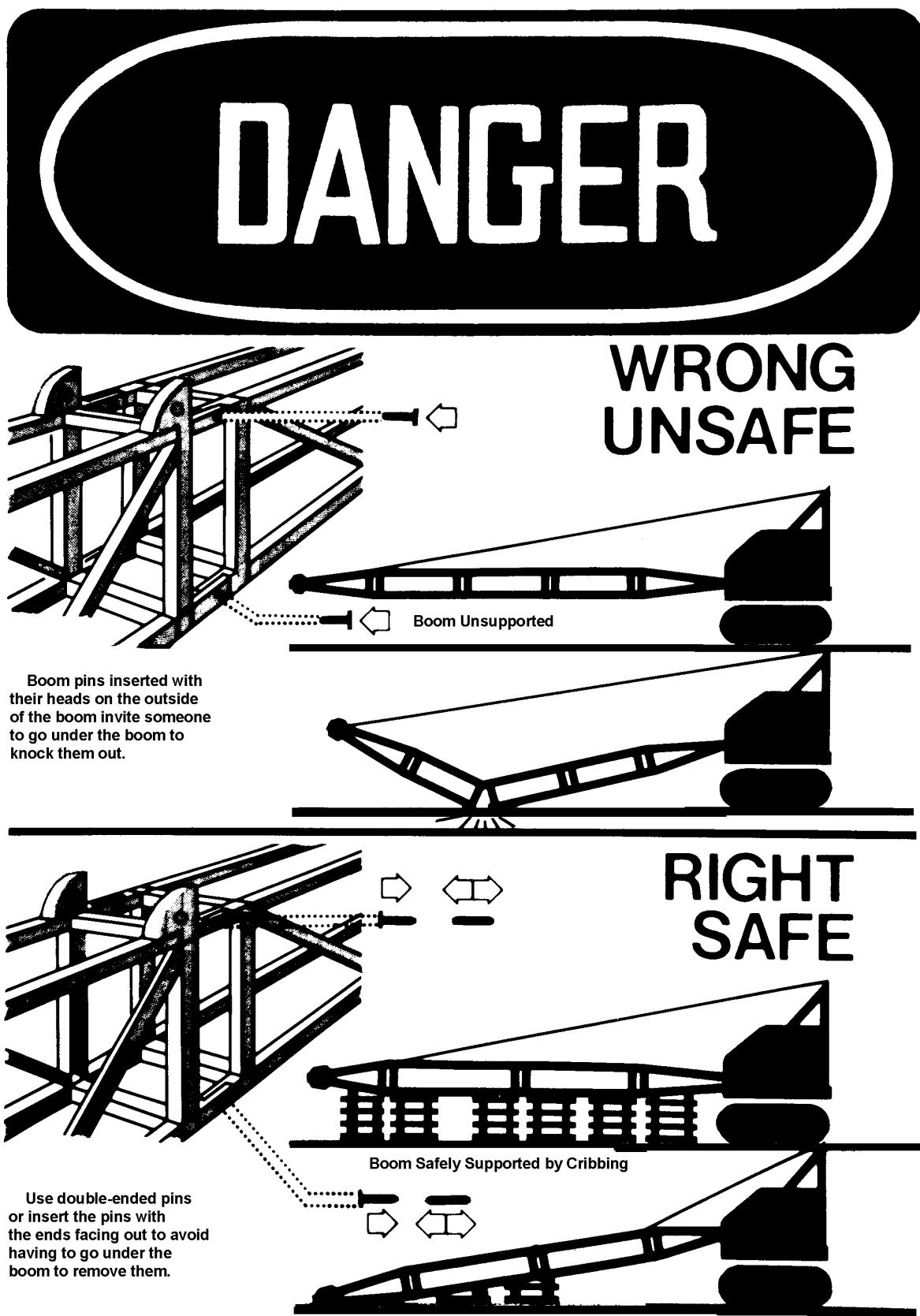
1. Plan boom disassembly location and procedures which are consistent with the manufacturer's instructions.
2. Use blocking or cribbing on each boom section. Figure 10 should be posted in the crane cab and figure 11 should be attached to each boom section.
3. Use one of several types of pins that substantially reduce the risk of crushing, such as:
 - a. Double-ended pins that can be removed while one is standing beside the boom by driving the pin in from the outside. (See Dickie, D.E., Crane Handbook, figure 3.41 at 78.)
 - b. Step pins that can only be inserted from inside facing out, and can only be removed by driving from the outside in. (See Dickie, D.E., Crane Handbook, figure 3.39 at 78.)
 - c. Welded lugs that prevent pins from being entered the wrong way. This requires the pin to be inserted inside facing out, and can only be removed by driving it from the outside in. (See Dickie, D.E., Crane Handbook, figure 3.40 at 78).
 - d. Screw pins with threads that insert or retract the pin.
4. Post warnings at pin connections. Be sure that comprehensive text warning of this hazard and informing of ways to avoid it is contained in operators' manuals.

OSHA Requirements

- 29 CFR 1926.550(a)—Cranes and derricks—General Requirements

Figure 10

Unsafe (Upper) and Safe (Lower) Way to Block a Boom Section



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Figure 11
Sign to Be Attached on Each Boom Section

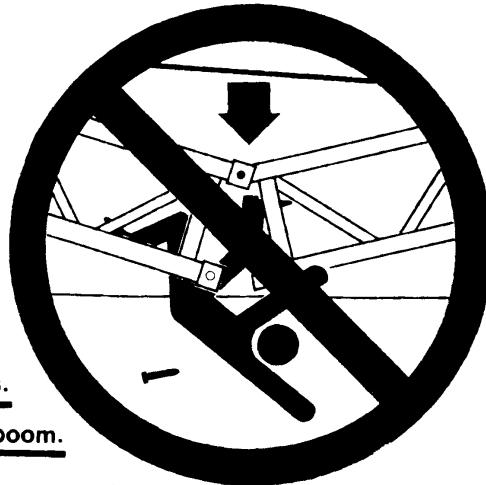


You will be Killed or Maimed when
you disassemble an unsupported boom.

NEVER go under an unsupported boom to remove pins.

NEVER remove connecting pins from an unsupported boom.

SEE INSTRUCTIONS ON CRANE CAB



Crane Safety Programs

Competent Personnel Requirements

Operators

In the past, if the lifting capacity of a crane were to be increased, a new design would call for a heavier and bulkier crane. Now, with the advent of new technology and metal alloys, manufacturers are able to increase lifting capacities yet maintain the relatively small size and light weight of the equipment. The contemporary crane can be compared to an airplane, not simply in terms of cost, but in its complexity of operation, as well.

Because cranes have become more sophisticated and are able to lift heavier loads, higher, further and faster, crane operators must be well trained. The day of total reliance upon “seat-of-the-pants” operator skills is gone. Today's operator must have a clear understanding of load dynamics (see figure 12), lifting capacities at various configurations, and the conditions under which such lifting capacities are valid. In a sentence, today's crane is complex. (See figure 13.) The lifting capacity charts and related notes are also complex. They require operators who are able to interpret the information properly if the lift is to be safe and successful. Management is responsible for the operator's training.

Effective licensing programs for crane operators consider minimum requirements for:

1. Education level.
2. Apprenticeship (hands-on) training and work experience. ANSI B30.5—1994, Section 5-3.1.2, requires a “practical operating examination.”
3. Classroom training on crane safety.
4. Thorough knowledge of crane safety references.
5. Physical qualification:
 - a. Age (mature and intelligent).
 - b. Emotional stability.
 - c. Absence of addictions.
 - d. Vision. ANSI/ASME B30.5, Mobile and Locomotive Cranes, Section 5-3.1.2(a)(1), requires: “Vision of at least 20/30 Snellen in one eye and 20/50 in the other, with or without corrective lenses.” Section 5-3.1.2(a)(2) requires: “Ability to distinguish colors, regardless of position, if color differentiation is required for operation. ...”
 - e. Hearing. ANSI/ASME.5, Mobile and Locomotive Cranes, Section 5-3.1.2(a)(3), requires: “Adequate hearing, with or without hearing aid, for the specific operation. ...”
 - f. Physical stamina.
 - g. Good coordination, reaction and tested skill level.
 - h. No history of heart problems or other ailments that produce seizures.

Riggers, Signalers and Others

Riggers, signalers and others who work with cranes should have qualifications similar to those of the operator. Just as an unqualified operator can make a life-threatening error during lifting operations, the inappropriate actions of an inexperienced rigger, signaler or anyone else involved in lifting operations can cause an accident.

Hazard Prevention Requirements

Preconstruction Planning

Most crane accidents could have been easily prevented if basic considerations had been given to the safe use of cranes and had such considerations been incorporated at the preconstruction planning meeting. The planning stage meeting is the

best time to address hazard avoidance. There, hazards inherent to power lines, blind lifts requiring communication, necessary lifting capacity, use of cranes and derricks on barges, and special circumstances requiring two or more cranes to lift a single load can be discussed and preventive measures can be taken. Planning before actual crane operations begin can eliminate major craning hazards from the jobsite and make operations more efficient.

Job Hazard Analysis

Before actual craning operations are begun at the jobsite, a specific job hazard analysis should be conducted to ensure that preconstruction planning is adequate. When prejob planning has been neglected, this on-site job hazard analysis is necessary to ensure that craning operations can be done safely.

Hand Signals

Before any lifts are commenced, all parties, including the crane operator, signalers, riggers and others involved, must re-familiarize themselves with appropriate hand signals. Often signals vary from job to job and region to region. It is best to ensure that everyone is familiar with the hand signals outlined in ANSI/ASME B30.5, Mobile and Locomotive Cranes (see figure 14). OSHA standard 29 CFR 1926.550(a)(4) states that “Hand signals to crane and derrick operators shall be those prescribed by the applicable ANSI standard for the type of crane in use. An illustration of the signals shall be posted at the job site.”

Signaling Devices

On lifts where the signalers are outside the direct view of the operator due to elevation or in blind areas, either a telephone or radio is necessary. Modes of communication must be agreed upon in preconstruction planning and in the job hazard analysis.

Lifting Capabilities

During preconstruction planning, lifting requirements should be analyzed by an engineer competent to establish whether the crane to be used has adequate lifting capability. The job hazard analysis should also verify that the crane to be used has sufficient boom length for the lift.

Rigging Practices

The requirements for slings to support loads are well defined in OSHA standards 29 CFR 1910.184, and the requirements for rigging equipment are defined in 29 CFR 1926.251.

Controlling the Load

The use of tag lines to control movement of the load is very important. Normally, when a load is being hoisted, the lay or twist in wire rope causes rotation when the load becomes suspended. OSHA standard 29 CFR 1910.180(h)(3)(xvi) states: “... A tag or restraint line shall be used when rotation of the load is hazardous.”

Wire Rope Requirements

It is very important to comply with the crane manufacturer's recommendations for the type of wire rope to be used for various hoist lines or pendants.

Annual Inspections

A number of business firms are certified to perform annual crane inspections. A notice of the current inspection should be posted in the crane. Cranes that cannot be certified must be removed from service until all necessary repairs are made and the equipment is re-inspected. OSHA standards 29 CFR 1910.179(j), 29 CFR 1910.180(d), 29 CFR 1910.181(d) and 29 CFR 1926.550(a)(6) require an annual crane inspection.

Preventive Maintenance

Cranes require ongoing service and preventive maintenance. Preventive maintenance programs should be documented according to the crane manufacturer's recommendations.

Figure 12
Dynamics of Setting Up a Crane

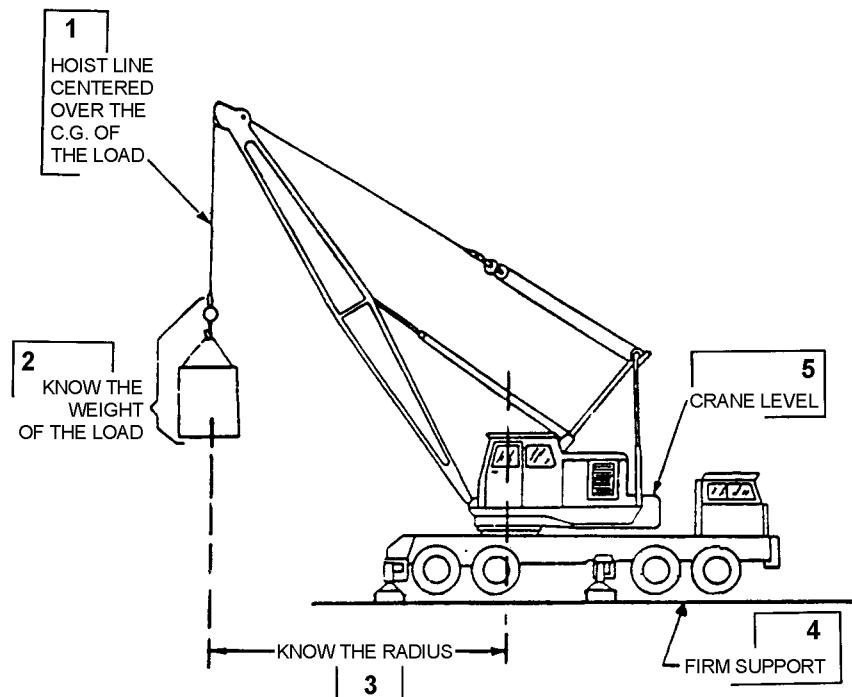


Figure 13
Crane nomenclature

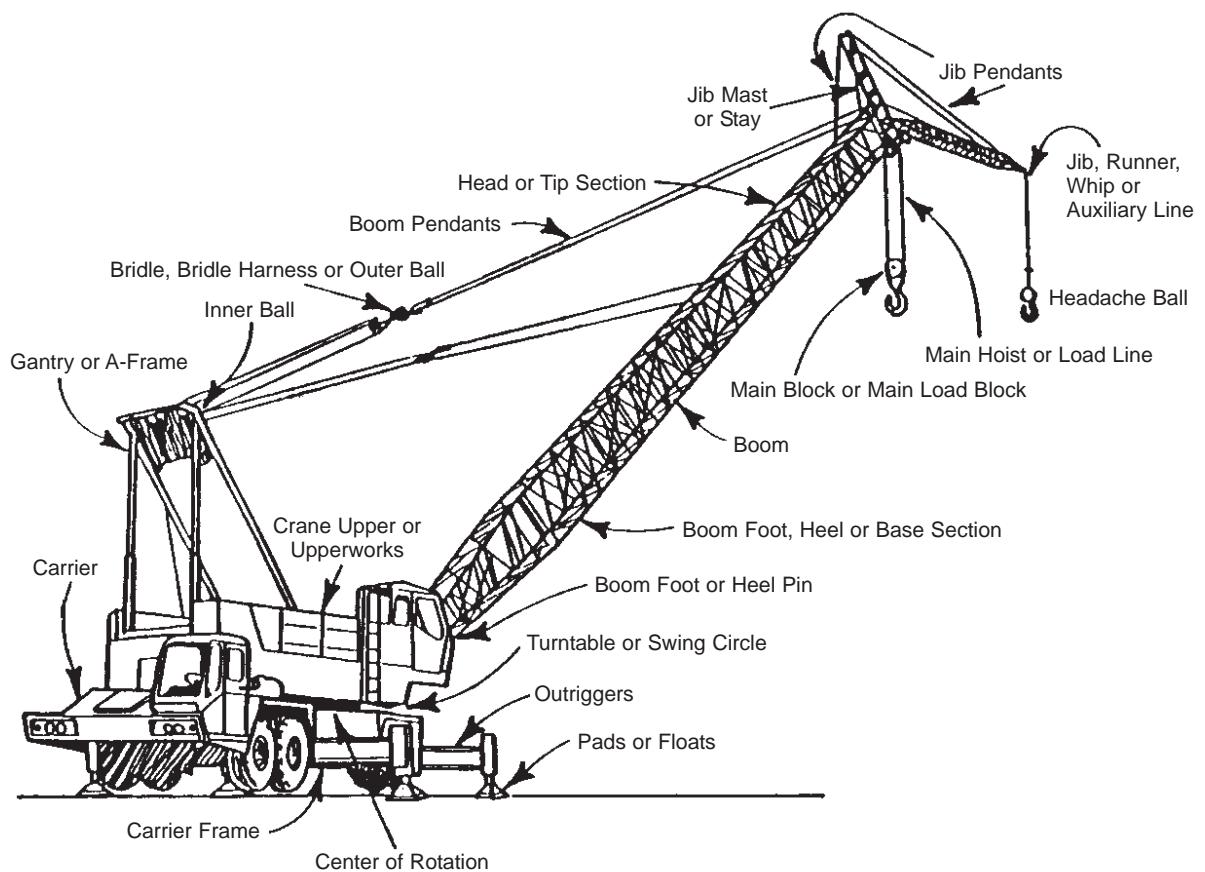
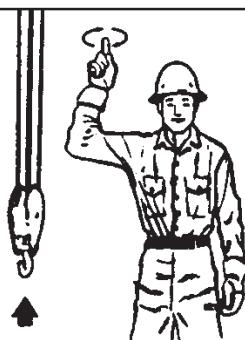
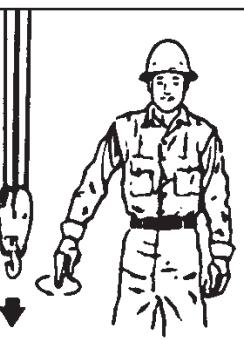
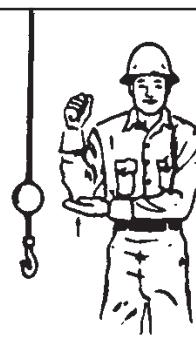
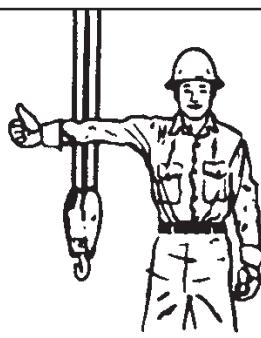
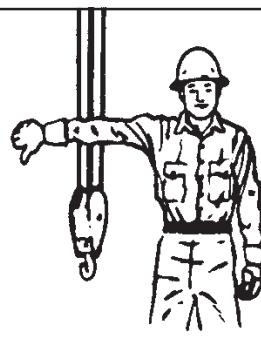
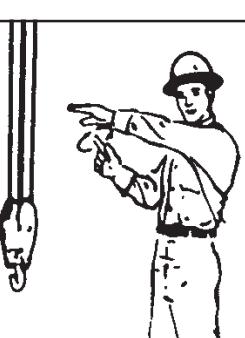
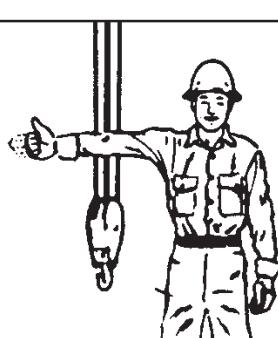
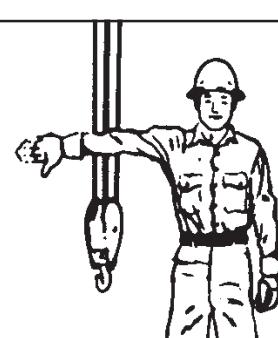
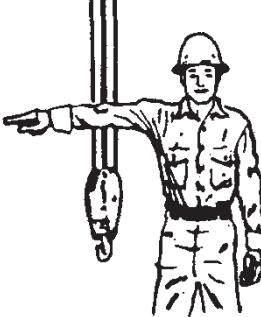
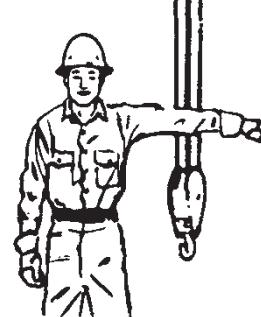
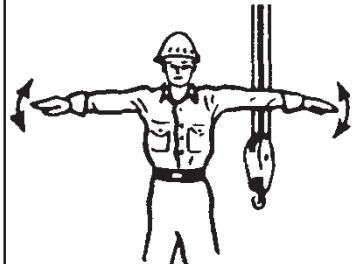
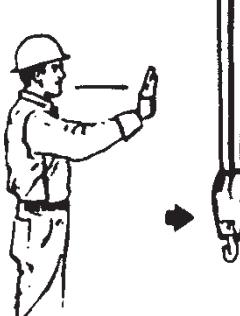
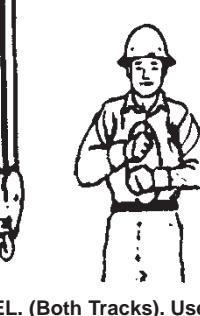
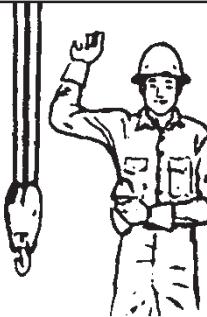


Figure 14

Standard Hand Signals for Controlling Crane Operations

 HOIST. With forearm vertical, forefinger pointing up, move hand in small horizontal circle.	 LOWER. With arm extended downward, forefinger pointing down, move hand in small horizontal circle.	 USE MAIN HOIST. Tap fist on head; then use regular signals.
 USE WHIPLINE. (Auxiliary Hoist). Tap elbow with one hand; then use regular signals.	 RAISE BOOM. Arm extended, fingers closed, thumb pointing upward.	 LOWER BOOM. Arm extended, fingers closed, thumb pointing downward.
 MOVE SLOWLY. Use one hand to give any motion signal and place other hand motionless in front of hand giving the motion signal. (Hoist slowly shown as example.)	 RAISE THE BOOM AND LOWER THE LOAD. With arm extended, thumb pointing up, flex fingers in and out as long as load movement is desired.	 LOWER THE BOOM AND RAISE THE LOAD. With arm extended, thumb pointing down, flex fingers in and out as long as load movement is desired.

 <p>SWING. Arm extended, point with finger in direction of swing of boom.</p>	 <p>STOP. Arm extended, palm down, move arm back and forth horizontally.</p>	 <p>EMERGENCY STOP. Both arms extended, palms down, move arms back and forth horizontally.</p>
 <p>TRAVEL. Arm extended forward, hand open and slightly raised, make pushing motion in direction of travel.</p>	 <p>DOG EVERYTHING. Clasp hands in front of body.</p>	 <p>TRAVEL. (Both Tracks). Use both fists in front of body, making a circular motion about each other, indicating direction of travel, forward or backward. (For land cranes only.)</p>
 <p>TRAVEL. (One Track) Lock the track on side indicated by raised fist. Travel opposite track in direction indicated by circular motion of other fist, rotated vertically in front of body. (For land cranes only.)</p>	 <p>EXTEND BOOM (Telescoping Booms). Both fists in front of body with thumbs pointing outward.</p>	 <p>RETRACT BOOM (Telescoping Booms). Both fists in front of body with thumbs pointing toward each other.</p>
 <p>EXTEND BOOM (Telescoping Boom). One Hand Signal. One fist in front of chest with thumb tapping chest.</p>		 <p>RETRACT BOOM (Telescoping Boom). One Hand Signal. One fist in front of chest, thumb pointing outward and heel of fist tapping chest.</p>

References

OSHA Requirements

Crane or Derrick Suspended Personnel Platforms, OSHA 3100 (Revised 2002), USDOL/OSHA
North Carolina Occupational Safety and Health Standards for General Industry (29 CFR 1910)
North Carolina Occupational Safety and Health Standards for the Construction Industry (29 CFR 1926)
U.S. Department of Energy (DOE), DOE Standard Hoisting and Rigging (Formerly Hoisting and Rigging Manual), DOE-STD-1090-2001, April 2001
Pocket Reference Guide for Power Line Clearance, Construction Safety Council, Hillside, Ill., 800-552-7744
Wire Rope Slings pocket reference guide, Institute of the Ironworking Industry, 202-783-3998

ANSI Standards

Safety Standards for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings

ANSI B30.1—Jacks
ANSI B30.2—Overhead and Gantry Cranes
ANSI B30.3—Hammerhead Tower Cranes
ANSI B30.4—Portal, Tower, and Pillar Cranes
ANSI B30.5—Mobile and Locomotive Cranes
ANSI B30.6—Derricks
ANSI B30.7—Base Mounted Drum Hoists
ANSI B30.8—Floating Cranes and Floating Derricks
ANSI B30.9—Slings
ANSI B30.10—Hooks
ANSI B30.11—Monorails and Underhung Cranes
ANSI B30.12—Handling Loads Suspended from Rotocraft
ANSI B30.13—Storage/Retrieval (S/R) Machines and Associated Equipment
ANSI B30.14—Side Boom Tractors
ANSI B30.15—Mobile Hydraulic Cranes (Note: B30.15-1973 has been withdrawn. The revision of B30.15 is included in the latest edition of B30.5.)
ANSI B30.16—Overhead Hoists
ANSI B30.17—Overhead and Gantry Cranes
ANSI B30.18—Stacker Cranes
ANSI B30.19—Cableways
ANSI B30.20—Below-the-Hook Lifting Devices
ANSI B30.21—Manually Lever Operated Hoists (Note: this standard is in the developmental stage.)
ANSI B30.22—Articulating Boom Cranes

Other ANSI Standards

ANSI B15.1—Safety Standards for Mechanical Power Transmission Apparatus
ANSI C2—National Electrical Safety Code
ANSI/IEEE C2 National Electrical Safety Code Interpretations, 1961–1977 Inclusive
ANSI/IEEE C2 National Electrical Safety Code Interpretations, 1978–1980 Inclusive, and Interpretations Prior to the 6th Edition
ANSI Z35.1—Specifications for Accident Prevention Signs

***Recommended Guidance* (Society of Automotive Engineers, SAE Handbook, v.4)**

SAE J115—Safety Signs
SAE J159—Crane Load Moment System
SAE J185—Access Systems for Off-Road Machines
SAE J220—Crane Boomstop

SAE J375—Radius-of-Load and Boom Angle Measuring System
SAE J376—Load Indicating Devices in Lifting Crane Service
SAE J765—Crane Load Stability Test Code
SAE J820—Crane Hoist Line Speed and Power Test Code
SAE J881—Lifting Crane Sheave and Drum Sizes
SAE J959—Lifting Crane, Wire-Rope Strength Factors
SAE J983—Crane and Cable Excavator Basic Operating Control Arrangements
SAE J987—Crane Structures Method of Test
SAE J999—Crane Boom Hoist Disengaging Device
SAE J1028—Mobile Crane Working Area Definitions
SAE J1040c—Performance Criteria for Rollover Protective Structures (ROPS) for Construction, Earthmoving, Forestry, and Mining Machines
SAE J1063—Cantilevered Boom Crane Structures Method of Test
SAE J1180—Telescoping Boom Length Indicating System
SAE J1238—Rating Lift Cranes on Fixed Platforms Operating
SAE J1257—Rating Chart for Cantilevered Boom Cranes
SAE J1289—Mobile Crane Stability Ratings
SAE J1332—Rope Drum Rotation Indicating Device

Bureau of the Construction Manufacturer's Association. Power Crane and Shovel Association. *Cable Controlled Power Cranes, Draglines, Hoes, Shovels, and Clamshells*.

Bureau of the Construction Manufacturer's Association. Power Crane and Shovel Association. *Hydraulic Excavators and Telescoping Boom Cranes*.

Bureau of the Construction Manufacturer's Association. Power Crane and Shovel Association. *Mobile Hydraulic Crane Standards*. PSCA Standard No.2.

Bureau of the Construction Manufacturer's Association. Power Crane and Shovel Association. *Mobile Power Crane and Excavator Standards*. PSCA Standard No. 1.

Dickie, D.E. 1975. *Crane Handbook*. Construction Safety Association of Ontario.

National Fire Protection Association. Cranes and Hoists. *National Electrical Code*. Chapter 6, Article 610.

U.S. Army Corps of Engineers. Department of the Army. *Safety and Health Requirements Manual*. EM 385-1-1.

The following industry guides are available from the N.C. Department of Labor's Division of Occupational Safety and Health:

- #1. *A Guide to Safety in Confined Spaces*
- #2. *A Guide to Procedures of the Safety and Health Review Board of North Carolina*
- #3. *A Guide to Machine Safeguarding*
- #4. *A Guide to OSHA in North Carolina*
- #5. *A Guide for Persons Employed in Cotton Dust Environments*
- #6. *A Guide to Lead Exposure in the Construction Industry*
- #7. *A Guide to Bloodborne Pathogens in the Workplace*
- #8. *A Guide to Voluntary Training and Training Requirements in OSHA Standards*
- #9. *A Guide to Ergonomics*
- #10. *A Guide to Farm Safety and Health*
- #11. *A Guide to Radio Frequency Hazards With Electric Detonators*
- #12. *A Guide to Forklift Operator Training*
- #13. *A Guide to the Safe Storage of Explosive Materials*
- #14. *A Guide to the OSHA Excavations Standard*
- #15. *A Guide to Developing and Maintaining an Effective Hearing Conservation Program*
- #17. *A Guide to Asbestos for Industry*
- #18. *A Guide to Electrical Safety*
- #19. *A Guide to Occupational Exposure to Wood and Wood Dust*
- #20. *A Guide to Crane Safety*
- #21. *A Guide to School Safety and Health*
- #23. *A Guide to Working With Electricity*
- #25. *A Guide to Personal Protective Equipment*
- #26. *A Guide to Manual Materials Handling and Back Safety*
- #27. *A Guide to the Control of Hazardous Energy (Lockout/Tagout)*
- #28. *A Guide to Eye Wash and Safety Shower Facilities*
- #29. *A Guide to Safety and Health in Feed and Grain Mills*
- #30. *A Guide to Working With Corrosive Substances*
- #31. *A Guide to Formaldehyde*
- #32. *A Guide to Fall Prevention in Industry*
- #33. *A Guide to Office Safety and Health*
- #34. *A Guide to Safety and Health in the Poultry Industry*
- #35. *A Guide to Preventing Heat Stress*
- #36. *A Guide to the Safe Use of Escalators and Elevators*
- #37. *A Guide to Boilers and Pressure Vessels*
- #38. *A Guide to Safe Scaffolding*
- #39. *A Guide to Safety in the Textile Industry*
- #40. *A Guide to Emergency Action Planning*
- #41. *A Guide to OSHA for Small Businesses in North Carolina*

Guidelines for Hoisting and Rigging Activity

The U.S. Department of Energy (DOE) ***Hoisting and Rigging Standard, DOE-STD-1090-2001***, is intended as a reference document to be used by supervisors, line managers, safety personnel, equipment operators, and any other personnel responsible for safety of hoisting and rigging. Although DOE-STD-1090-2001 was established for operations at DOE sites, other employer sites may also benefit from relevant information and applicable standards or guidelines it offers, therefore various sections have been condensed/consolidated and provided in this OSHNC industry guide (Crane Safety). The DOE's Hoisting and Rigging Standard, used here as source document, quotes verbatim or paraphrases (with minor editorial changes for consistency) the requirements of the U.S. Occupational Safety and Health Administration (OSHA) and the American National Standards Institute (ANSI).

The following list provides examples of recognized consensus standards as pertained to OSHA and ANSI/ASME standards addressed here:

29 CFR 1910, Occupational Safety and Health Standards for General Industry; Subpart N-Material Handling and Storage (i.e. 1910.179, Overhead and gantry cranes; 1910.180, Crawler locomotive and truck cranes; 1910.181, Derricks 1910.184, Slings);

29 CFR 1926, Occupational Safety and Health Regulations for Construction; Subpart N-Crane, Derricks, Hoists, Elevators, and Conveyors (i.e. 1926.550, Cranes and derricks; 1926.551, Helicopters; 1926.552, Material hoists, personnel hoist, and elevators; 1926.553, Base-mounted drum hoists; 1926.554, Overhead hoists; 1926.555, Conveyors; 1926.556, Aerial lifts);

ANSI/ASME B30.2, Overhead and Gantry Cranes; ASME B30.5, Crawler, Locomotive, and Truck Cranes; ASME B30.9, Slings; B30.10, Hooks; ASME B30.16, Overhead Hoists (Underhung); ASME B30.17, Overhead and Gantry Cranes (Top Running Bridge, Single Girder Underhung Hoist); B30.20, Below-the-Hook Lifting Devices; ASME B30.21, Manually Lever Operated Hoist; ASME B30.23, Personnel Lifting Systems.

DOE is owner and primary user of the source document (available on internet in public domain), however others may also benefit from compilation of information as provided in this industry guide. DOE-STD-1090-2001 offers a significant amount of information and guidelines applicable to many other employers or personnel involved in hoisting and rigging activity. DOE-STD-1090-2001 has 17 chapters, subdivided into 10 parts (sample table of content provided on next page). Material provided here has same number sequence as source document, however, all chapters or sections within the document are not addressed in this industry guide. The DOE standard occasionally goes beyond the minimum general industry standards established by OSHA and ANSI; and also delineates the more stringent requirements necessary to accomplish the extremely complex, diversified, critical, and oftentimes hazardous hoisting and rigging work found within the DOE complex. In doing so, it addresses the following items which are not covered in detail in the general industry standards:

1. Management responsibility and accountability
2. Operator/inspector training and qualification requirements
3. Definition of critical lifts and the additional requirements for making them
4. The need and responsibilities of a person-in-charge for critical lifts
5. The need and responsibilities of a designated leader for ordinary lifts
6. The definition and special requirements for preengineered production lifts
7. Special requirements for the testing, inspection, and maintenance of hoisting equipment in hostile environments
8. Nondestructive testing/nondestructive examination requirements for such items as hooks, welds, and spreader bars
9. Special requirements for inspection and load-testing of hoisting and rigging equipment/accessories
10. Hook latch requirements for cranes, slings, and rigging accessories
11. Design standards for such equipment as cranes, forklifts, and hooks
12. Operating practices for hoisting and rigging operations
13. Rigging information and load tables
14. Good and bad rigging practices.

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CHAPTER 1

TERMINOLOGY AND DEFINITIONS

The following are specialized terms commonly used when discussing hoisting and rigging operations. Many may not be used in this standard but are included for general information. The terms are arranged in alphabetical order. Illustrations are included for clarity.

ABRASION: Surface wear.

ACCELERATION STRESS: Additional stress imposed due to increasing load velocity.

ALTERNATE LAY: Lay of wire rope in which the strands are alternately regular and lang lay.

ANSI: American National Standards Institute.

APPOINTED: Assigned specific responsibilities by the employer or the employer's representative.

AREA, METALLIC: Sum of the cross-sectional areas of individual wires in a wire rope or strand.

ATTACHMENT: A device other than conventional forks or load backrest extension, mounted permanently or removably on the elevating mechanism of a truck for handling the load. Popular types are fork extension clamps, rotating devices, side shifters, load stabilizers, rams, and booms.

AUTHORIZED: Assigned by a duly constituted administrative or regulatory authority.

AUXILIARY HOIST: Supplemental hoisting unit of lighter capacity and usually higher speed than the main hoist.

BACK STAY: Guy used to support a boom or mast or that section of a main cable, as on a suspension bridge, or cableway, and the like, leading from the tower to the anchorage.

BAIL: A U-shaped member of a bucket, socket, or other fitting.

BASKET OR SOCKET: The conical portion of a socket into which a splayed rope end is inserted and secured with zinc.

BATTERY-ELECTRIC TRUCK: An electric truck in which the power source is a storage battery.

BECKET LOOP: A loop of small rope or a strand of rope fastened to the end of a large wire rope to facilitate installation.

BENDING STRESS: Stress on wires of a wire rope imposed by bending. This stress need not be added to direct load stresses. When sheaves and drums are of suitable size, bending stress does not affect the normal life of the wire rope.

BIRDCAGE: A colloquialism describing the appearance of a wire rope that is forced into compression. The outer strands form a "cage" and at times displace the core.

BIRDCAGING: The twisting of fiber or wire rope in an isolated area in the opposite direction of the rope lay, causing it to take on the appearance of a birdcage.

BOOM (CRANE): A member hinged to the rotating superstructure and used for supporting the hoisting tackle.

BOOM LINE: A wire rope for supporting or operating the boom on derricks, cranes, draglines, shovels, and the like.

BRAKE: A device used for slowing or stopping motion by friction or electromagnetic means.

BRAKE, DRAG: A brake that provides stopping force without external control.

BRAKE, HOLDING: A brake that sets automatically and that prevents motion when power is off.

BRAKE, PARKING: A device to prevent the movement of a stationary vehicle.

BRAKING, COUNTER TORQUE: A method of stopping motion in which the power to the motor is reversed to develop torque in the opposite direction.

BRAKING, DYNAMIC: A method of controlling crane motor speeds when in the overhauling condition to provide a retarding force.

BRAKING, MECHANICAL: A method of slowing motion by friction.

BRAKING, REGENERATIVE: A form of dynamic braking in which the electrical energy generated is fed back into the power system.

BREAKING STRENGTH: The measured load required to break a wire rope or chain.

BRIDGE: The part of a crane, consisting of girders, walkways, railings, trucks, and drive mechanisms, that carries the trolley or trolleys.

BRIDGE TRAVEL: Horizontal travel of the crane parallel with runway rails.

BRIDLE SLING: A sling composed of multiple legs (branches), the top ends of which terminate in a fitting that latches onto the lifting hook.

BULL RING: The main large ring of a sling to which sling legs are attached.

BUMPER (BUFFER): An energy-absorbing device for reducing impact when a moving overhead crane or trolley reaches the end of its permitted travel, or when two moving cranes or trolleys come into contact.

CAB: The operator's compartment.

CABLE: A term loosely applied to wire ropes, wire strands, manila ropes, and electrical conductors.

CABLE-LAID WIRE ROPE: A type of wire rope consisting of several independent wire ropes laid into a single wire rope.

CABLE CROWD ROPE: A wire rope used to force the bucket of a power shovel into the material being handled.

CANTILEVER TRUCK: A self-loading counterbalanced or noncounterbalanced truck equipped with cantilever load-engaging means, such as forks (see Figure 10-3).

CARRIAGE: A support structure for forks or attachments, generally roller-mounted, traveling vertically within the mast of a cantilever truck.

CENTER: A single wire or fiber in the center of a strand around which the wires are laid.

CENTER CONTROL: The position near the center of a truck cab from which the operator controls movement of the truck.

CHOKER ROPE: A short wire-rope sling used to form a slip noose around the object to be moved or lifted (see Figure 1-1).

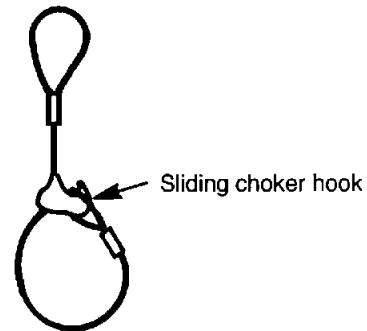


Figure 1-1. Choker rope.

CIRCUMFERENCE: Measured perimeter of a circle circumscribing the wires of a strand or the strands of a wire rope.

CLAMP, STRAND: A fitting used to form a loop at the end of a length of strand; consists of two grooved plates and bolts.

CLEARANCE: The distance by which one object clears another, or the clear space between them.

CLEVIS: A U-shaped fitting with pins.

CLIP: A fitting used to clamp two parts of wire rope.

CLOSED SOCKET: A wire-rope fitting consisting of an integral becket and bail.

CLOSING LINE: Wire rope that closes a clamshell or orange-peel bucket and then operates as a hoisting rope.

COIL: Circular bundle of wire rope not packed on a reel.

COLLECTOR: Contacting device mounted on a bridge or trolley and used to collect current from the conductor system.

COME-ALONG: A portable, hand-operated device consisting of a housing, a length of chain or wire rope, two hooks, and a ratcheting lever, that is used for miscellaneous pulling.

CONDUCTOR: Wire, angles, bars, tees, or special sections mounted to transmit current to the collectors.

CONICAL DRUM: Grooved hoisting drum of varying diameter.

CONSTRUCTION (WIRE ROPE): Refers to the design of wire rope, including number of strands, number of wires per strand, and arrangement of wires in each strand.

CONTINUOUS BEND: Reeving of wire rope over sheaves and drums so that it bends in one direction (as opposed to reverse bend).

CONTROLLER: An operator's device for regulating the power delivered to a motor or other equipment.

CONTROLLER, SPRING RETURN: A controller that, when released, will return automatically to a neutral position.

CORE: The center member of a wire rope around which the strands are laid. It may be fiber, a wire strand, or an independent wire rope.

CORING LINE: Wire rope used to operate the coring tool for taking core samples during the drilling of a well.

CORROSION: Chemical decomposition by exposure to moisture, acids, alkalies, or other destructive agents.

CORRUGATED: A term used to describe the grooves of a sheave or drum when worn so as to show the impression of a wire rope.

COUNTERBALANCED TRUCK: A truck equipped with load-engaging means wherein, during normal transporting, all the load is external to the polygon formed by the wheel contacts (see Figure 10-3).

COVER WIRES: The outer layer of wires.

CRANE: A machine used for lifting and lowering a load vertically and moving it horizontally and that has a hoisting mechanism as an integral part of it.

CRANES, TYPES OF:

Automatic Crane: A crane that, when activated, operates through a preset cycle or cycles.

Cab-Operated Crane: A crane controlled by an operator in a cab located on the bridge or trolley.

Cantilever Gantry Crane: A gantry or semigantry crane in which the bridge girders or trusses extend transversely beyond the crane runway on one or both sides.

Floor-Operated Crane: A crane whose operation is controlled by use of a pendant in the hands of an operator on the floor or on an independent platform.

Gantry Crane: A crane similar to an overhead crane, except that the bridge for carrying the trolley or trolleys is rigidly supported on two or more legs running on fixed rails or other runway.

Jib Crane: A fixed crane with a vertical rotating member supported at the bottom (also at the top in some types) from which an arm extends to carry the hoist trolley. Jib cranes are most commonly mounted on a vertical column, supplied as part of the jib crane, or on existing structural members (e.g., a wall-mounted jib crane).

Mobile Crane: For the purposes of this chapter, mobile cranes are defined as wheel-mounted cranes, truck cranes, and crawler cranes.

- o A **wheel-mounted** crane consists of a rotating structure with power plant, operating machinery, and boom, mounted on a base or platform equipped with axles and rubber-tired wheels for travel. The base is usually propelled by an engine in the superstructure, but it may be equipped with a separate engine controlled from the superstructure (see Figures 15-1, 15-3, 15-5, 15-6, 15-7, 15-9, and 15-10).

- o A **truck-mounted crane** consists of a rotating superstructure with power plant that operates machinery and boom, mounted on an automotive truck equipped with a power plant for travel. Commercial truck-mounted cranes are included in this category (see Figures 15-3, 15-7, 15-9, and 15-10).
- o A **crawler crane** consists of a rotating superstructure with power plant, operating machinery and boom, mounted on a base equipped with crawler treads for travel (see Figures 15-2 and 15-8).

Overhead Traveling Crane: A crane with a movable bridge carrying a movable or fixed hoisting mechanism and traveling on an overhead fixed-runway structure.

Power-Operated Crane: A crane whose mechanism is driven by electricity, air, hydraulics, or internal combustion.

Pulpit-Operated Crane: A crane operated from a fixed operator station that is not attached to the crane.

Remote-Operated Crane: A crane controlled by an operator not in a pulpit or a cab attached to the crane, by any method other than pendant or rope control (e.g., radio-controlled crane).

Semigantry Crane: A gantry crane with one end of the bridge rigidly supported on one or more legs that run on a fixed rail or runway, the other end of the bridge being supported by a truck running on an elevated rail or runway.

Shop Crane: A Portable Automotive Lifting Device (PALD), self contained hydraulic and pneumatic-hydraulic crane characterized by a pair of laterally spaced legs, an upright mast, a pivoting boom with a boom extension and hook, and a hydraulic unit. The hydraulic unit moves the boom up and down at a pivot point for the purpose of raising, removing, transporting in the lowered position, and replacing automotive engines, transmissions and other components. Shop cranes have a capacity of 4 tons (8000 pounds) or less.

Wall-Mounted Crane: A crane having a jib, with or without a trolley, supported from a side wall or line of columns of a building. It is a traveling-type crane and operates on a runway attached to the side wall or line of columns.

Wall-Mounted Jib Crane: See Cranes, Types Of, Jib Crane.

CRITICAL DIAMETER: Diameter of the smallest bend for a given wire rope that permits the wires and strands to adjust themselves by relative movement while remaining in their normal positions.

CYLINDRICAL DRUM: Hoisting drum of uniform diameter.

DECELERATION STRESS: Additional stress imposed on a wire rope due to decreasing the load velocity.

DEFLECTION:

- o Sag of a rope in a span, usually measured at midspan as the depth from a chord joining the tops of the two supports.
- o Any deviation from a straight line.

DESIGN FACTOR: Ratio of ultimate strength to the design working stress.

DESIGNATED: Selected or assigned by the employer or the employer's representative as being qualified to perform specific duties.

DESIGNATED LEADER: "An individual assigned responsibility for hoisting and rigging activities requiring more than one person".

DIAMETER: Distance measured across the center of a circle circumscribing the wires of a strand or the strands of a wire rope.

DIESEL-ELECTRIC TRUCK: An electric truck in which the power source is a generator driven by a diesel engine.

DOCKBOARD: A portable or fixed device for spanning the gap or compensating for the difference in level between loading platforms and carriers.

DOG-LEG: Permanent short bend or kink in a wire rope caused by improper use.

DRAGLINE: Wire rope used to pull an excavating or drag bucket.

DRIVE: Motor, coupling, brake and gear case, or gear cases used to propel bridge, trolley, or hoist.

DRIVE GIRDER: A girder on which is mounted the bridge drive, cross shaft, walk, railing, and operator's cab.

DRUM: A cylindrical-flanged barrel of uniform (cylindrical drum) or tapering (conical drum) diameter on which a wire rope is wound for operation or storage. It may be smooth or grooved.

ELASTIC LIMIT: Limit of stress beyond which a permanent deformation takes place within the material. This limit is approximately 55–65 percent of breaking strength of steel-wire ropes.

ELECTRIC TRUCK: A truck in which the principal energy is transmitted from power source to motor(s) in the form of electricity.

END CONTROL: An operator-control position that is located at the end opposite the load end of the truck.

EQUALIZER: A device used to compensate for unequal length or stretch of a hoist rope.

EQUALIZING SLINGS: Slings composed of wire rope and equalizing fittings.

EQUALIZING THIMBLES: A special type of fitting used as a component part of some wire-rope slings.

EYE OR EYE SPLICE: A loop with or without a thimble formed in the end of a wire rope.

FAIL-SAFE: A provision designed to automatically stop or safely control any motion in which a malfunction could occur.

FATIGUE: The tendency of a material to break under repeated stress.

FIBER CENTERS: Cords or rope made of vegetable fiber used in the center of a strand.

FIBER CORES: Cords or rope made of vegetable fiber used in the core of a wire rope.

FIRST POINT: The first setting on the operator's controller that starts crane motion (slowly) in each direction.

FITTING: Any accessory used as an attachment for wire rope.

FLAG: Mark or marker on a rope to designate position of load.

FLAT ROPE: Wire rope made of parallel alternating right-lay and left-lay ropes sewn together by relatively soft wires.

FLATTENED STRAND ROPE: A wire rope with either oval or triangular strands that present a flattened rope surface.

FLEET ANGLE: Angle between the position of a rope at the extreme end wrap on a drum and a line drawn perpendicular to the axis of the drum through the center of the nearest fixed sheave.

FORKS: Horizontal tine-like projections, normally suspended from the carriage, used to engage and support loads.

FORK HEIGHT: The vertical distance from the floor to the load-carrying surface adjacent to the heel of the forks with the mast vertical, and in the case of reach trucks, with the forks extended.

FORKLIFT TRUCK: A high-lift self-loading truck equipped with load carriage and forks for transporting and tiering loads (see Figure 10-3).

GALVANIZE: To coat with zinc to protect against corrosion.

GALVANIZED ROPE: Rope made of galvanized wire.

GALVANIZED STRAND: Strand made of galvanized wire.

GALVANIZED WIRE: Wire coated with zinc.

GAS-ELECTRIC TRUCK: An electric truck in which the power source is a generator driven by an LP-gas or gasoline engine.

GROMMET: A seven-strand wire-rope sling made from one continuous length of strand or an endless synthetic-web sling.

GROOVED DRUM: Drum with grooved outer surface to accommodate and guide a rope.

GROOVES: Depressions in the outer surface of a sheave or drum for positioning and supporting a rope.

GUY LINE: Strand or rope, usually galvanized, for holding a structure in position.

HANDLING FIXTURE: A cradle, structure, shipping fixture, or container designed specifically to facilitate supporting, lifting, or handling a component during fabrication, loading, shipping, storage, or installation.

HIGH-LIFT TRUCK: A self-loading truck equipped with an elevating mechanism designed to permit tiering. Popular types are high-lift platform trucks (see Figure 10-3).

HIGH-LIFT PLATFORM TRUCK: A self-loading truck equipped with an elevating mechanism intended primarily for transporting and tiering loaded skid platforms (see Figure 10-3).

HOIST: A device that applies a force for lifting or lowering.

HOIST, LEVER OPERATED: A lever-operated manual device used to lift, lower, or pull a load and to apply or release tension.

HOLDING LINE: Wire rope on a clamshell or orange-peel bucket that holds the bucket while the closing line is released to dump the load.

HOOK LOAD: The total live weight supported by the hook of a crane, derrick, or other hoisting equipment, including the load, slings, spreader bars, and other tackle not part of the load but supported by the hook and required for the handling of the load.

IDLER: Sheave or roller used to guide or support a rope.

INDEPENDENT WIRE-ROPE CORE: Wire rope used as the core of a larger rope.

INNER WIRES: All wires of a strand except surface or cover wires.

INTERNAL-COMBUSTION ENGINE

TRUCK: A truck in which the power source is a gas or diesel engine.

INTERNALLY LUBRICATED: Wire rope or strand having all wires coated with lubricant.

KINK: Permanent distortion of wires and strands resulting from sharp bends.

LAGGING: External wood covering on a reel of rope or a strand.

LANG-LAY ROPE: Wire rope in which the wires in the strands and the strands in the rope are laid in the same direction.

LAY LENGTH: The lengthwise distance on a wire rope in which a strand makes one complete turn around the rope's axis (see Figure 1-2).



Figure 1-2. Rope Lay

Left Lay:

- o **Strand:** Strand in which the cover wires are laid in a helix having a left-hand pitch, similar to a left-hand screw.
- o **Rope:** Rope in which the strands are laid in a helix having a left-hand pitch, similar to a left-hand screw.

Right Lay:

- o **Strand:** Strand in which the cover wires are laid in a helix having a right-hand pitch, similar to a right-hand screw.
- o **Rope:** Rope in which the strands are laid in a helix having a right-hand pitch, similar to a right-hand screw.

LIFT:

- o Maximum safe vertical distance through which a hook can travel.
- o The hoisting of a load.

LIFT, CRITICAL: A lift for which the application of requirements applicable to ordinary lifts would not adequately eliminate or control the likelihood or severity of the following:

- o personnel injury or significant adverse health impact (onsite or offsite).
- o significant release of radioactivity or other hazardous material or other undesirable conditions.
- o undetectable damage that would jeopardize future operations or the safety of a facility.
- o damage that would result in delay to schedule or other significant program impact such as loss of vital data.

LIFT, ORDINARY: Any lift not designated as a critical lift or a preengineered production lift.

LIFT, PREENGINEERED PRODUCTION:

Repetitive, production-type lifting operation, independent of the nature of the load to be lifted, in which the probability of dropping, upset, or collision is reduced to a level acceptable to the responsible manager by preliminary engineering evaluation, specialized lifting fixtures, detailed procedures, operation-specific training, and independent review and approval of the entire process.

LINE: A rope used for supporting and controlling a suspended load.

LOAD: The total weight superimposed on the load block or hook.

LOAD BLOCK: The assembly of hook or shackle, swivel, bearing, sheaves, pins, and frame suspended by the hoisting ropes.

LOAD-BACKREST EXTENSION: A device extending vertically from the fork carriage frame.

LOAD-BEARING PARTS: Any part of a material-handling device in which the induced stress is influenced by the hook load. A *primary* load-bearing part is a part the failure of which could result in dropping, upset, or uncontrolled motion of the load. Load-bearing parts which, if failed, would result in no more than stoppage of the equipment without causing dropping, upset, or loss of control of the load are not considered to be primary load-bearing parts.

LOAD CENTER (FORKLIFTS): The horizontal longitudinal distance from the intersection of the horizontal load-carrying surfaces and vertical load-engaging faces of the forks (or equivalent load-positioning structure) to the center of gravity of the load.

LOW-LIFT TRUCK: A self-loading truck equipped with an elevating mechanism designed to raise the load only sufficiently to permit horizontal movement (see Figure 10-3).

MAGNET: An electromagnetic device carried on a crane hook and used to pick up loads.

MAIN HOIST: The hoist mechanism provided for lifting the maximum-rated load.

MAN TROLLEY: A trolley having an operator's cab attached to it.

MARLINE SPIKE: Tapered steel pin used in splicing wire rope.

MESSENGER STRAND: Galvanized strand or bronze strand used to support telephone and electrical cables.

MODULUS OF ELASTICITY: Mathematical quantity giving the ratio, within the elastic limit, between a definite range of unit stress on a wire rope and the corresponding elongation.

MOUSING: A method of bridging the throat opening of a hook to prevent the release of load lines and slings, under service or slack conditions, by wrapping with soft wire, rope, heavy tape, or similar materials.

NARROW-AISLE TRUCK: A self-loading truck intended primarily for right-angle stacking in aisles narrower than those normally required by counterbalanced trucks of the same capacity (see Figure 10-3).

NONDESTRUCTIVE EXAMINATION

(NDE): The development and application of technical methods to examine materials or components, in ways that do not impair future usefulness and serviceability, in order to detect, locate, measure, and evaluate discontinuities, defects, and other imperfections; to assess integrity, properties, and composition; and to measure geometrical characteristics.

NONDESTRUCTIVE TESTING (NDT): See NONDESTRUCTIVE EXAMINATION.

NONROTATING WIRE ROPE: See Rotation-Resistant Wire Rope.

OPEN SOCKET: A wire-rope fitting consisting of a basket and two ears with a pin.

ORDER-PICKER TRUCK, HIGH-LIFT: A truck, controllable by an operator stationed on a platform, which is movable, has a load-engaging means, and is intended for (manual) stock selection. The truck may be capable of self-loading and/or tiering (see Figure 10-3).

OVERHEAD GUARD: A framework fitted to a truck over the head of a riding operator.

PALLET TRUCK: A self-loading, non-motorized or motorized low-lift truck equipped with wheeled forks of dimensions sized to go between the top and bottom boards of a double-faced pallet, the wheels fitting into spaces between the bottom boards, so as to raise the pallet off the floor for transporting (see Figure 10-3).

PEENING: Permanent distortion of outside wire in a rope caused by pounding.

PERSON-IN-CHARGE (PIC): The manager or other responsible person (other than the equipment operator) known to be qualified and appointed to be responsible for the safe handling of critical loads.

POWERED INDUSTRIAL TRUCK: A mobile, power-driven vehicle used to carry, push, pull, lift, stack, or tier material.

PRECISION LOAD POSITIONING

DEVICES: A rigging accessory designed specifically to precisely raise and lower a load through a limited range of lifting/lowering motion (stroke). Standards units typically have 12 in. (30 cm) stroke and can position a load within 0.001 in. (0.025 mm). These devices commonly include a built-in load scale and in such cases may also serve as a load-indicating device.

PREFORMED WIRE ROPE: Wire rope in which the strands are permanently shaped, before being fabricated into the rope, to the helical form they assume in the wire rope.

PREFORMED STRAND: Strand in which the wires are permanently shaped, before being fabricated into the strands, to the helical form they assume in the strand.

PRESTRESSING: Stressing a wire rope or strand before use under such a tension and for such a time that stretch that would otherwise occur once the load is picked up is largely nonexistent.

PROOF TEST: A nondestructive tension test performed to verify construction and workmanship of slings or rigging accessories.

PUBLIC CARRIER: A for-hire company engaged in the public transportation of goods.

QUALIFIED: A person who, by possession of a recognized degree, certificate, or professional standing, or who, by extensive knowledge, training, and experience, has successfully demonstrated an ability and competence to solve or resolve problems relating to the subject matter and work.

QUALIFIED ENGINEER/QUALIFIED ENGINEERING ORGANIZATION: An engineer or engineering organization whose competence in evaluation of the type of equipment in question has been demonstrated to the satisfaction of the responsible manager.

QUALIFIED INSPECTOR: One whose competence is recognized by the responsible manager and whose qualification to perform specific inspection activities has been determined, verified, and attested to in writing.

QUALIFIED OPERATOR: One who has had appropriate and approved training, including satisfactory completion of both written and operational tests to demonstrate knowledge, competence, and skill, in the safe operation of the equipment to be used.

QUALIFIED RIGGER: One whose competence in this skill has been demonstrated by experience satisfactory to the appointed person.

NOTE: The term “rigger” or “qualified rigger” in this standard refers to the function performed, and in no way relates to the worker’s classification in any union or bargaining unit.

RATED CAPACITY: The maximum hook load that a piece of hoisting equipment is designed to carry; also the maximum load that an industrial truck or a sling, hook, shackle, or other rigging tackle is designed to carry.

NOTE: At the option of the user, a rated capacity can be assigned that is less than the design-rated capacity.

REACH TRUCK: A self-loading truck, generally high-lift, having load-engaging means mounted so it can be extended forward under control to permit a load to be picked up and deposited in the extended position and transported in the retracted position (see Figure 10-3).

REEL: The flanged spool on which wire rope or strand is wound for storage or shipment.

REEVING: A system in which a rope travels around drums or sheaves.

REGULAR-LAY ROPE: Wire rope in which the wires in the strands and the strands in the rope are laid in opposite directions.

REVERSE BEND: Reeving of a wire rope over sheaves and drums so that it bends in opposite directions.

RIDER TRUCK: A truck that is designed to be controlled by a riding operator.

RIGGING: The hardware or equipment used to safely attach a load to a lifting device. The art or process of safely attaching a load to a hook by means of adequately rated and properly applied slings and related hardware.

ROLLERS: Relatively small-diameter cylinders or wide-faced sheaves used for supporting or guiding ropes.

ROTATION-RESISTANT WIRE ROPE: Wire rope consisting of a left-lay, lang-lay inner rope covered by right-lay, regular-lay outer strands.

RUNNING SHEAVE: A sheave that rotates as the load block is raised or lowered.

RUNWAY: Assembly of rails, girders, brackets, and framework on which a crane operates.

SAFE WORKING LOAD: Load that a rope may carry economically and safely.

SEALE: A strand construction having one size of cover wires with the same number of one size of wires in the inner layer and each layer having the same length and direction of lay. Most common construction is one center wire, nine inner wires, and nine cover wires.

SEIZE: To securely bind the end of a wire rope or strand with seizing wire or strand.

SEIZING STRAND: Small strand, usually of seven wires, made of soft-annealed-iron wire.

SEIZING WIRE: A soft-annealed-iron wire.

SELF-LOADER: A truck with tires that can fit between the top and bottom boards of a double-faced pallet.

SERVE: To cover the surface of a wire rope or strand with a wrapping of wire.

SHACKLE: A type of clevis normally used for lifting (see Figure 1-3).

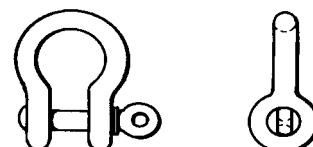


Figure 1-3. Shackle.

SHALL: A word indicating that an action is mandatory.

SHEAVE: A grooved wheel or pulley used with a rope to change direction and point of application of a pulling force.

SHEAVE, NONRUNNING (EQUALIZER): A sheave used to equalize tension in opposite parts of a rope, called nonrunning because of its slight movement.

SHEAVE, RUNNING: A sheave that rotates as the load block is lifted or lowered.

SHOULD: A word indicating a recommended action, the advisability of which depends on the facts in each situation.

SIDE LOADER: A self-loading truck, generally high-lift, having load-engaging means mounted in such a manner that it can be extended laterally under control to permit a load to be picked up and deposited in the extended position and transported in the retracted position (see Figure 10-3).

SIDE PULL: That portion of a hoist pull acting horizontally when the hoist lines are not operated vertically.

SLINGS: Wire ropes, chains, synthetic web, and metal mesh made into forms, with or without fittings, for handling loads.

SLINGS, BRAIDED: Very flexible slings composed of several individual wire ropes braided together.

SMOOTH-FACED DRUM: Drum with a plain, not grooved, face.

SPAN: The horizontal, center-to-center distance of runway rails.

SPIRAL GROOVE: Groove that follows the path of a helix around a drum, similar to the thread of a screw.

SPLICING: Interweaving of two ends of rope to make a continuous or endless length without appreciably increasing the diameter. Also refers to making a loop or eye in the end of a rope by tucking the ends of the strands.

Splice, Hand Tucked: A loop or eye formed in the end of a rope by tucking the end of the strands back into the main body of the rope in a prescribed manner.

Splice, Mechanical: A loop or eye formed in the end of a wire rope by pressing or swaging one or more metal sleeve over the wire rope junction.

STAINLESS-STEEL ROPE: Wire rope made of chrome-nickel steel wires having great resistance to corrosion.

STEEL-CLAD ROPE: Rope with individual strands spirally wrapped with flat steel wire.

STRAND: An arrangement of wires helically laid about an axis or another wire or fiber center to produce a symmetrical section.

SUSPECT/COUNTERFEIT ITEMS (S/CI): A suspect item is one in which visual inspection, testing, or other means indicate that it may not conform to established Government or industry-accepted specifications or national consensus standards. A counterfeit item is a suspect item that has been copied or substituted without legal right or authority to do so or one whose material, performance, or characteristics are knowingly misrepresented by the vendor, supplier, distributor, or manufacturer (see Figure 1-5).

NOTE: (refer to DOE G 440.1-6 “Implementation Guide For Use With Suspect/Counterfeit Requirements” of DOE O 440.1, Worker Protection Management).

SWAGED FITTINGS: Fittings in which wire rope is inserted and attached by a cold-forming method.

SWITCH, ELECTRIC: A device for making, breaking, or changing the connections in an electrical circuit.

SWITCH, EMERGENCY STOP: A manually or automatically operated electric switch to cut off electric power independently of the regular operating controls.

SWITCH, LIMIT: A switch that is operated by some part or motion of a power-driven machine or equipment to alter the electrical circuit associated with the machine or equipment.

SWITCH, MAIN: A switch controlling the entire power supply to a crane or other equipment, often called the disconnect switch.

TAG LINE: A rope used to prevent rotation of a load.

TAPERING AND WELDING: Reducing the diameter of the end of a wire rope and welding it to facilitate reeving.

THIMBLE: Grooved metal fitting to protect the eye of a wire rope (see Figure 1-4).

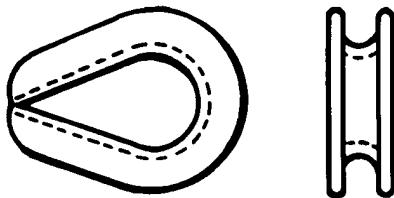


Figure 1-4. Thimble.

TIERING: The process of placing one load on or above another.

TINNED WIRE: Wire coated with tin.

TROLLEY: A unit consisting of frame, trucks, trolley drive, and hoisting mechanism moving on the bridge rails in a direction at right angles to the crane runway.

TROLLEY GIRTS: Structural members that are supported on the trolley trucks and that contain the upper sheave assemblies.

TROLLEY TRAVEL: Horizontal travel of a trolley at right angles to runway rails.

TROLLEY TRUCK: An assembly consisting of wheels, bearings, axles, and structural-supporting hoist mechanism and load girts.

TRUCK, POWERED INDUSTRIAL: A mobile, power-propelled truck used to carry, push, pull, lift, stack, or tier material (see Figure 10-3).

TURNBUCKLE: A device attached to wire rope for making limited adjustments in length. It consists of a barrel and right- and left-hand threaded bolts.

TWO-BLOCKING: The act of continued hoisting in which the load-block and head-block assemblies are brought into physical contact, thereby preventing further movement of the load block and creating shock loads to the rope and reeving system.

VERIFICATION: A procedure in which a design, calculation, drawing, procedure, instruction, report, or document is checked and signed by one or more parties. The one or more persons designated to sign verify, based on personal observation, certified records, or direct reports, that a specific action has been performed in accordance with specified requirements.

WEDGE SOCKET: Wire-rope fitting in which the rope end is secured by a wedge.

WHEEL BASE: Distance between centers of outermost wheels for bridge and trolley trucks.

WHEEL LOAD: The load on any wheel with the trolley and lifted load (rated load) positioned on the bridge to give maximum-loading conditions.

WIRE ROPE: Wire strands laid helically around an axis or a core.

WIRE (ROUND): Single continuous length of metal, cold drawn from a rod.

WIRE (SHAPED): A single continuous length of metal either cold drawn or cold rolled from a rod.

DOE HEADMARK LIST

ANY BOLT ON THIS LIST SHOULD BE TREATED AS DEFECTIVE WITHOUT FURTHER TESTING

ALL GRADE 5 AND GRADE 8 FASTENERS OF FOREIGN ORIGIN WHICH DO NOT BEAR ANY MANUFACTURE'S HEADMARKS:



GRADE 5



GRADE 8

GRADE 5 FASTENERS WITH THE FOLLOWING HEADMARKS:



MARK MANUFACTURER

J Jinn Her (TW)



MARK MANUFACTURER

KS Kosaka Kogyo (JP)

GRADE 8 FASTENERS WITH THE FOLLOWING HEADMARKS:



MARK MANUFACTURER

A Asahi Mfg (JP)



MARK MANUFACTURER

KS Kosaka Kogyo (JP)



E Dalai (JP)



M Minamida Sleybo (JP)



FM Fastener Co. of Japan (JP)



MS Minato Kogyo (JP)



H Hinamoto Metal (JP)



NF Nippon Fasteners (JP)



J Jinn Her (TW)



RT Takai Lid (JP)



KY Kyoel Mfg (JP)



UNY Unytite (JP)



Hollow Triangle Intasco (CA, TW, JP, YU) (Greater than 1/2 inch diameter)

GRADE 8.2 FASTENERS WITH THE FOLLOWING HEADMARKS:



MARK MANUFACTURER

KS Kosaka Kogyo (JP)

GRADE A325 FASTENERS (BENNETT DENVER TARGET ONLY) WITH THE FOLLOWING HEADMARKS:

Type 1



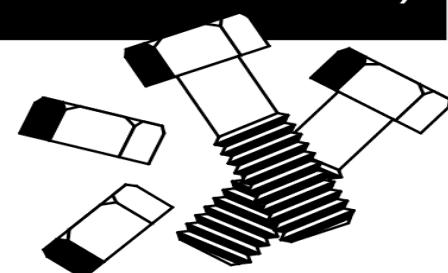
MARK MANUFACTURER

A325KS Kosaka Kogyo (JP)

Type 2



Type 3



AUGUST 1992

KEY: CA - CANADA JP - JAPAN TW - TAIWAN YU - YUGOSLAVIA

GF00 0209

Figure. 1-5.

CHAPTER 2

CRITICAL LIFTS

2.2 CRITICAL-LIFT REQUIREMENTS

- a. Ensure that the requirements are met for ordinary lifts specified in each section of this standard for each particular equipment category.
- b. The operating organization shall appoint a Person-In-Charge (PIC) for the entire operation. This person shall meet the definitions of appointed, designated, and qualified as described in Chapter 1, “Terminology and Definitions,” and shall be present at the lift site during the entire lifting operation.
- c. The PIC shall ensure that a pre-job plan or procedure is prepared that defines the operation and includes the following:
 - 1. Identification of the items to be moved, the weight, dimensions, and center of gravity of the load, and any hazardous or toxic materials that are present
 - 2. Identification of operating equipment to be used by type and rated capacity
 - 3. Rigging sketches that include (as applicable):
 - i. Identification and rated capacity of slings, lifting bars, rigging accessories, and below-the-hook lifting devices.
 - ii. Load-indicating devices.
 - iii. Load vectors.
 - iv. Lifting points.
 - v. Sling angles.
 - vi. Boom and swing angles.
 - 4. Operating procedures and special instructions to operators including rigging precautions and safety measures to be followed as applicable.
 - d. Experienced operators who have been trained and qualified to operate the specific equipment to be used shall be assigned to make the lift.
 - e. Only designated, qualified signalers shall give signals to the operator. *However, the operator shall obey a STOP signal at all times, no matter who gives the signal.*
 - f. The procedure and rigging sketches shall be reviewed and approved by the responsible manager (or designee) and the responsible oversight organization (such as safety, quality assurance, or quality control) before the lift is made.
 - g. A pre-lift meeting involving participating personnel shall be conducted prior to making a critical lift. The critical lift plan/procedure shall be reviewed and questions shall be resolved.
 - h. If required by the critical lift procedure, a practice lift shall be done before the critical lift. Conditions for a practice lift should closely simulate actual conditions involving: weight, rigging selection and configuration, load movement path, and other relevant factors. Practice lifts should be done by the same crew, using the same lifting equipment.

CHAPTER 4

LIFTING PERSONNEL

4.1 GENERAL

This chapter specifies the operation, design, testing, and inspection requirements for the use of personnel lift platforms or baskets suspended from mobile or overhead cranes. This chapter implements the requirements of 29 CFR 1926.550(g) "Cranes and Derricks" and ASME B30.23, "Personnel Lifting Systems."

4.1.1 Personnel Lifting Evaluation

- a. The use of a crane to hoist employees on a personnel lift platform is prohibited, except when the erection, use, and dismantling of conventional means of reaching the worksite, such as a personnel hoist, ladder, stairway, aerial lift, elevating work platform or scaffold, would be more hazardous or is not possible because of structural design or worksite conditions.
- b. The manager specifically responsible for the overall work function to be performed shall determine that the erection, use, and dismantling of conventional means of reaching the work site (i.e., scaffold, ladder, stairway, aerial lift, or elevating work platform) would be more hazardous or is not possible because of structural design or worksite conditions.
- c. For each personnel lifting procedure, the manager responsible for the task shall authorize the use of a crane-suspended work platform and attest to the need for the operation through a written justification attesting to that need. A statement describing the operation and its time frame shall be included. The statement, after being approved by the authorizer, shall be retained at the job site.
- d. The manager specifically responsible for the overall work function shall not allow or require any operator to lift personnel under the following circumstances:
 - 1. The operator does not feel physically or mentally fit to perform the operation.
 - 2. The operator has been working for more 10 hours prior to the start of the lift or the lift will not be completed before the operator has been working for 12 hours.

- 3. The operator did not have at least eight hours off, immediately prior to the work shift containing the person.

4.1.2 Designated Leader

- a. The Authorizing Manager shall appoint a Designated Leader for the entire personnel lifting operation.
- b. The Designated Leader shall ensure that a pre-job plan is prepared that defines the operation. The Designated Leader shall ensure:
 - 1. At each new job site prior to hoisting personnel, the personnel lift platform, rigging, and hook block shall be proof-tested by a qualified inspector to 125 percent of the personnel platform's rated capacity by holding it suspended for 5 minutes with the test load suitably distributed on the personnel platform.
 - 2. After proof-testing, any deficiencies revealed by inspection, or by the proof test, be corrected and another proof-test conducted.
 - 3. Any modification to the personnel lift platform or rigging requires retesting.
 - 4. Test reports be kept on file and be readily available to appointed personnel.
 - 5. A meeting, with the qualified operator, signaler, persons to be lifted, and the person responsible for overall worksite safety to plan is held prior to the trial lift to review the procedure.
 - 6. The procedures for entering and leaving the personnel platform and the points at which persons will enter and leave the device be reviewed. This meeting shall be held at each new work location, and shall be repeated for any employees newly assigned to the operation.
 - c. The designated leader and the crane operator shall determine that:
 - 1. The crane is uniformly level within 1 percent of level grade and firm footing exist under both crawler tracks or under each outrigger float. Cribbing mats under tracks or

blocks under outrigger floats are used as necessary to provide a firm and substantial footing.

2. Cranes equipped with outriggers have outriggers extended in accordance with the manufacturer's instructions.

3. Crane systems, controls, operator aids, and safety devices are activated and functioning properly.

4. No interferences exist.

5. The total weight of the loaded personnel lift platform (including personnel) and related rigging does not exceed 50 percent of the crane rating under the planned conditions of use.

6. The personnel lift platform is not loaded in excess of its rated load capacity.

7. The number of employees occupying the platform does not exceed the number required for the work being performed.

4.1.3 Trial Lift

a. Each shift, before personnel initially enter the personnel lift platform, the operator and signaler shall be conduct a trial lift. The trial lift shall include:

1. Loading the unoccupied personnel platform to at least the maximum anticipated load. Materials and tools to be used during the actual lift, if secured to prevent displacement, can be in the platform for the trial lift.

2. Making the trial lift from the location where personnel will enter the platform to each location where the platform will be hoisted and positioned. It is acceptable to perform a single trial lift on each shift for all locations to be reached from a single setup position.

b. The trial lift shall be repeated whenever:

1. The crane (mobile) is moved and set up in a new location or returned to a previously used location.

2. When the lift route is changed, unless the operator determines that the safety of the hoisted personnel is not affected.

3. If a different crane operator is assigned.

4.1.4 Lifting Operations

4.1.4.1 Pre-Lift Meeting

a. A meeting attended by the operator, the ground crew, signaler(s), person(s) to be lifted, and the designated leader shall be held each shift to plan and review procedures to be followed, including:

1. Points at which persons will enter and leave the platform.

2. Procedures for entering and leaving the platform.

3. Special precautions if personnel will perform work from the suspended platform.

b. This meeting shall be held at each new work location, and shall be repeated for any employees newly assigned to the operation.

4.1.4.2 Pre-Lift Inspection

a. After the trial lift, prior to lifting personnel:

1. A visual inspection of the crane, rigging, and personnel lift platform shall be conducted by a qualified inspector. Any defects found that create a safety hazard shall be corrected prior to hoisting personnel.

2. The platform shall be lifted a few inches and inspected to ensure that it is secure and properly balanced.

4.1.4.3 Lifting Personnel

a. Prior to hoisting personnel in a personnel lift platform ensure that:

1. No hazardous conditions exist with the platform and its associated rigging.

2. The hoist line is not wrapped around any part of the platform.

3. Hoist ropes are free of kinks.

4. Multiple-part lines are not twisted around each other.

5. The primary attachment is centered over the platform.
6. Ropes are properly seated on drums and sheaves.
7. The crane is within 1 percent of level.
8. The crane has an anti two-block device installed and operational.

b. Employees being hoisted or working in a personnel lift platform shall:

1. Remain in continuous sight of, and in direct communication with, the operator or signaler. In situations where direct visual contact with the operator is not possible and the use of a signaler would create a hazard for that person, direct communication alone (such as a two-way radio) may be used.
2. Keep all parts of their bodies inside the suspended personnel lift platform during raising, lowering, and positioning to avoid pinch points.
3. Wear body harnesses with lanyards attached to the lower load block or overhaul ball, or to a structural member within the platform that is capable of supporting a fall impact.
4. Not stand on or work from the top rail, midrail, or toe board of the suspended personnel platform.
5. When working above water, the requirements of 29 CFR 1926.106 (Occupational Safety and Health Regulations for Construction) shall also apply.
6. When welding is being performed from the personnel lift platform, the electrode holders shall be protected from contact with metal components of the personnel platform.

c. Operators of cranes hoisting personnel in a personnel lift platform shall:

1. Before commencing or continuing the lift, consult with the designated leader whenever there is any doubt as to the safety of the lift.
2. Remain at the controls when the personnel lift platform is occupied.
3. Operate the crane so that lowering will be power-controlled (no free-fall).
4. Ensure movement of the personnel lift platform is performed in a slow, controlled, cautious manner with no sudden movements of the crane or the platform. The lifting or lowering speed shall not exceed 100 ft/min (30 m/min).
5. After the personnel lift platform is positioned, set all brakes and locks on the lift crane before personnel perform any work.
6. If the personnel lift platform cannot be landed, ensure it is tied to the structure before personnel get off or on.
7. Ensure that no lifts are made on another of the crane's load lines while personnel are suspended on the personnel lift platform.
- d. Suspended personnel lift platforms shall be used only for personnel, their tools, and sufficient materials to do their work. They shall not be used for transporting bulk materials.
- e. Personnel lift platforms should not be used in winds greater than 20 mph (32.2 km/hr), electric storms, snow, ice, sleet, or other adverse weather conditions that could affect the safety of personnel.
- f. Use tag lines to control motion of occupied personnel lift platforms unless their use creates an unsafe condition.
- g. Cranes shall not travel while personnel are in the platform. Exceptions to this provision shall be approved by the manager specifically responsible for the overall work function and precautions to be taken documented in the personnel lift plan.

4.2 MOBILE CRANES

Mobile cranes are designed and intended for handling materials, not personnel. In addition to the general requirements in Section 4.1, "General," the following requirements shall be met when lifting personnel with a mobile crane:

- a. Personnel are permitted to ride only in one of the following:
 - 1. A personnel lift platform that is supported from the crane's hook which meets the requirements of Section 4.4, "Personnel Platform."
 - 2. A personnel basket attached directly to the boom which is approved by the crane manufacturer.
- b. Cranes and derricks with variable-angle booms shall be equipped with a boom-angle indicator that is readily visible to the operator.
- c. Cranes with telescoping booms shall be equipped with a device to indicate clearly to the operator, at all times, the boom's extended length, or an accurate determination of the load radius to be used during the lift shall be made prior to hoisting personnel.
- d. A positive-acting device shall be used that prevents contact between the load block or overhaul ball and the boom tip (anti-two-blocking device), or a system shall be used that deactivates the hoisting action before damage occurs in the event of a two-blocking situation (two-block damage-prevention feature).
- e. Cranes having booms in which lowering is controlled by a brake without aid from other devices which slow the lowering speeds is prohibited.
- f. Crane load lines shall be capable of supporting, without failure, at least seven times

the maximum intended load, except where rotation resistant rope is used, the lines shall be capable of supporting without failure, at least ten times the maximum intended load.

- g. Hydraulic cranes shall have check valves or other devices that will prevent uncontrolled movement in the event of system failure, engine failure, or hose rupture.
- h. Cranes shall have a means to prevent retraction of hydraulically or pneumatically activated outriggers or stabilizers in the event a hydraulic or pneumatic line fails.
- i. Pendant supported, jib type, boom extensions without positive stops are prohibited for personnel lifting.

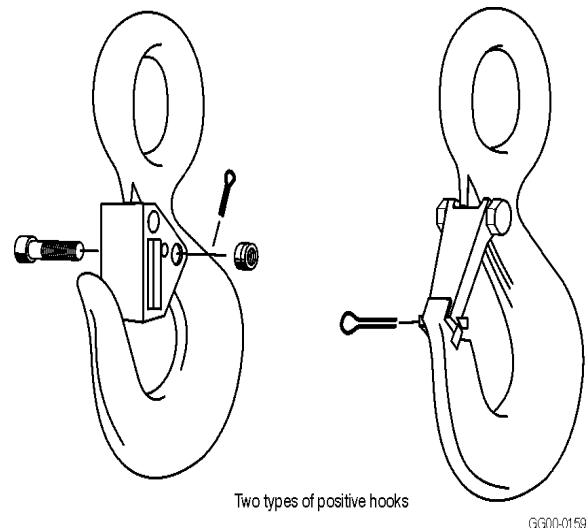


Figure 4-1. Positive Hooks

- j. Hooks on overhaul ball assemblies, lower load blocks, or other attachment assemblies shall be of the type that can be closed and locked, eliminating the hook throat opening. (See Figure 4-1). Alternatively, an alloy anchor type shackle with a bolt, nut and retaining pin may be used.

4.4 PERSONNEL LIFT PLATFORM

4.4.1 Platform Design and Construction

There is no attempt to comprehensively address platform design and construction in this chapter. Nevertheless, because many platform design and construction features can be observed and should be known by the platform user, (See Figure 4-2) the following key design and construction requirements are presented:

- a. The personnel lift platform and suspension system shall be designed by a qualified person competent in structural design and familiar with national consensus standards governing personnel platform design.
- b. All welding of the platform shall be performed by a qualified welder in accordance with ANSI/AWS D1.1. Where special steels or other materials are used, the manufacturer shall provide welding procedures. Welds shall be inspected by a qualified inspector
- c. The personnel lift platform shall have:
 1. A minimum design factor of five.
 2. A plate specifying its empty weight and its rated load capacity or maximum intended load.
 3. Perimeter protection consisting of a top rail approximately 45 in. (115 cm) high, a toe board at least 4 in. (10 cm) high, and a midrail approximately halfway between the top rail and the toe board.
 4. A grab rail inside the personnel lift platform to minimize hand exposure.
 5. Anchorage points within the platform for attaching personnel fall protection lanyards.
 6. The sides of the platform enclosed from the toe board to the midrail with solid construction or expanded metal having openings no greater than $\frac{1}{2}$ in. (1.27 cm).
 7. Platform access gates, including sliding or folding types, if installed, shall have a positive acting device to restrain the gate from accidental opening. Swinging type access gates shall open only to the interior of the personnel lift platform.

8. Rough edges exposed to contact by employees surfaced (ground smooth) to prevent injury.

9. High-visibility color or marking for easy identification.

d. In addition to wearing hard hats, personnel shall be protected by overhead protection on the personnel lift platform when there is an overhead hazard. Sufficient headroom shall be provided to allow employees to stand upright in the platform.

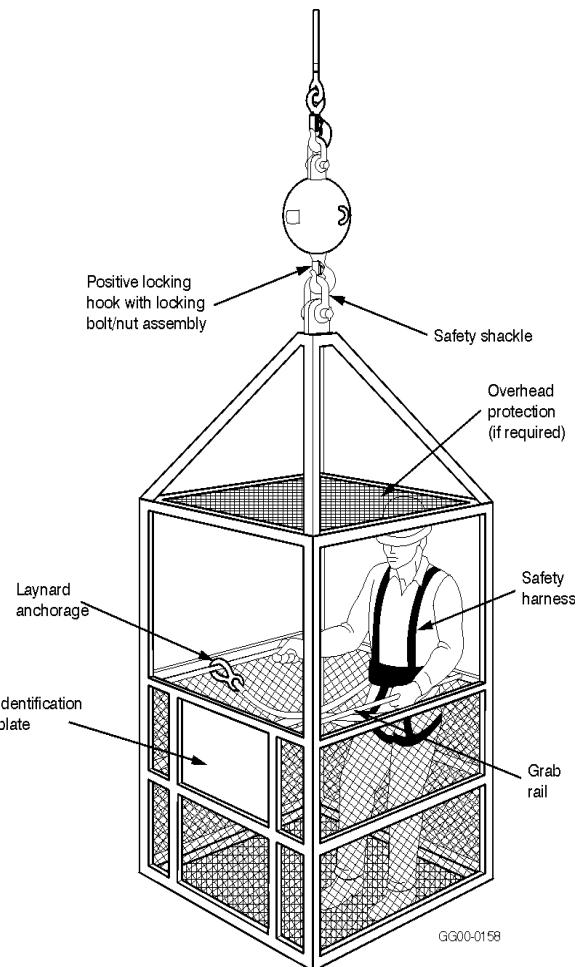


Figure 4-2. Personnel Lift Platform

4.5 INSPECTIONS

All equipment used in the lifting of personnel shall be inspected, tested, and maintained to protect against failure during lifting operation.

4.5.1 Frequent Inspection

4.5.1.1 General

a. The platform manufacturer shall furnish complete inspection criteria for the platform users. The criteria shall address all inspection frequency classifications and shall cover:

1. The platform
2. Rigging components
3. Fasteners
4. All safety features and attachments.

4.5.1.2 Personnel Lift Platform

a. Prior to initial use and at each new job the platform shall be inspected by a qualified inspector in accordance with the instructions provided by the manufacturer.

b. The platform, suspension system, attachment points, and any motion controls shall be inspected at least each day, before use, by a designated person. The inspection is to identify conditions that have been specifically indicated by the platform manufacturer, or a qualified person, as potentially creating a hazardous operating condition. Visually inspect items such as the following:

1. Platform and suspension system markings to ensure all information is legible.
2. Platform structure:
 - i. Load supporting members, welds and bolts.
 - ii. Perimeter protection; top rail, midrail, toe board, and barrier from toe board to midrail.
 - iii. Fall protection device anchorage points.

- iv. Gate locking mechanisms.
- v. Platform flooring.
- vi. Suspension attachment points.

3. Attachment mechanisms.
 - i. Master links, shackles, slings, bolt-ups, etc.
4. Special purpose items:
 - i. Overhead protection.
 - ii. Platform controls

c. For frequent inspections, dated records for the hoisting equipment and personnel lift platform shall be made and kept by the platform user for the duration of the personnel lift operation.

4.5.2 Periodic Inspection

4.5.2.1 Personnel Lift Platform

a. At least once every 12 months, or as required by the personnel lift platform manufacturer, a periodic inspection of the platform shall be performed by a qualified inspector in accordance with the instructions provided by the manufacturer.

b. Platforms which have been out of service for 12 or more consecutive months shall receive a periodic inspection prior to use.

c. Dated inspections records for the platform shall be made. The last periodic inspection records shall be kept with the platform and available for review.

4.5.2.2 Hoisting Equipment

a. Hoisting equipment shall be inspected in accordance with requirements of Chapter 7, "Overhead & Gantry Cranes," or Chapter 9, "Mobile Cranes."

4.7 LIFTING PERSONNEL NEAR ELECTRICAL POWER LINES

4.7.1 General

- a. When lifting personnel near electrical power lines, it is advisable to perform the lift so there is not possibility of the crane, load line, or personnel platform becoming a conductive path.
- b. Cranes shall not lift personnel under electrical power lines if any combination of boom, personnel platform, load line, or machine components will enter the prohibited zone (See figure 4-3).

c. Lifting personnel near electrical power lines is not allowed unless there is no less hazardous way to perform the job. The following conditions must be considered when lifting personnel near electrical power lines:

4.7.2 Condition A

a. Power Lines are de-energized and grounded. (The safest and preferred condition). The following steps shall be taken when lifting personnel in Condition A:

- 1. The electrical utility organization shall de-energize the power lines.
- 2. As a minimum, the power lines shall be visible grounded to avoid the possibility of electrical feedback.
- 3. Before lifting personnel, a qualified representative from the electrical utility organization shall be on site to verify that the power lines are de-energized and grounded.
- 4. In addition to Electrical Hazard Warning Signs required on all mobile cranes, Electrical Hazard Warning Signs shall be posted inside the personnel lift platform.
- 5. Proximity warning devices, insulated links or boom cages, if used, shall not be a substitute for any requirements of this section.

4.7.3 Condition B

a. Power lines are energized with the equipment outside the prohibited zone but working within a fully extended boom length of

the prohibited zone. Regardless of whether the crane boom will be fully extended, the fully extended boom length shall be considered (See figure 4-4). The following steps shall be taken when lifting personnel in Condition B:

- 1. A meeting, on the job site, between the Personnel Lift Authorizing Manager, the Designated Leader, and a qualified representative of the electrical utility organization shall take place. Procedures to safely complete the lift shall be established.
- 2. The clearance specified in Table 4-1 shall be considered.
- 3. Power line movements, horizontal and vertical, caused by wind shall be considered.
- 4. The required clearances to the power lines shall be continuously monitored by a signal person, also called a "wire watcher," whose sole responsibility is to maintain proper clearance. The "wire watcher" shall be in constant communication with the crane operator.
- 5. Tag lines to the personnel platform, when used, shall be of a nonconductive type, such as dry rope made of polypropylene or polyethylene fiber.
- 6. No person outside the platform or crane cab shall be permitted to touch the crane, load line or platform unless the "wire watcher" indicates it is safe.
- 7. Operation of the boom or the platform over power lines should be avoided. Poor perception of distance and multiple potential contact points make this very hazardous.
- 8. Consider attaching ribbons, balls, or other visibility enhancing devices, to the power line to aid in visually locating the prohibited zone.
- 9. In addition to Electrical Hazard Warning Signs required on all mobile cranes, Electrical Hazard Warning Signs shall be posted inside the personnel lift platform.

10. Proximity warning devices, insulated links or boom cages, if used, shall not be a substitute for any requirements of this section.

4.7.4 Condition C

a. Power lines are energized with the equipment inside the prohibited zone (See Table 4-1). **Lifting personnel in this condition is strictly prohibited.**

Table 4-1. Safe working distance from power lines.

a. When operating near high-voltage power lines:			
		Normal voltage (phase to phase)	Minimum required clearance
Over	50	to 50 kV	10 ft (3.1 m)
Over	200	to 200 kV	15 ft (4.6 m)
Over	350	to 350 kV	20 ft (6.1 m)
Over	500	to 500 kV	25 ft (7.6 m)
Over	750	to 750 kV	35 ft (10.7 m)
Over	750	to 1000 kV	45 ft (13.7 m)

b. While in transit with no load and boom or mast lowered:			
		Normal voltage (phase to phase)	Minimum required clearance
Over	0.75	to 0.75 kV	4 ft (1.2 m)
Over	50	to 50 kV	6 ft (1.3 m)
Over	345	to 345 kV	10 ft (3.5 m)
Over	750	to 700 kV	16 ft (4.9 m)
Over	750	to 1000 kV	20 ft (6.1 m)

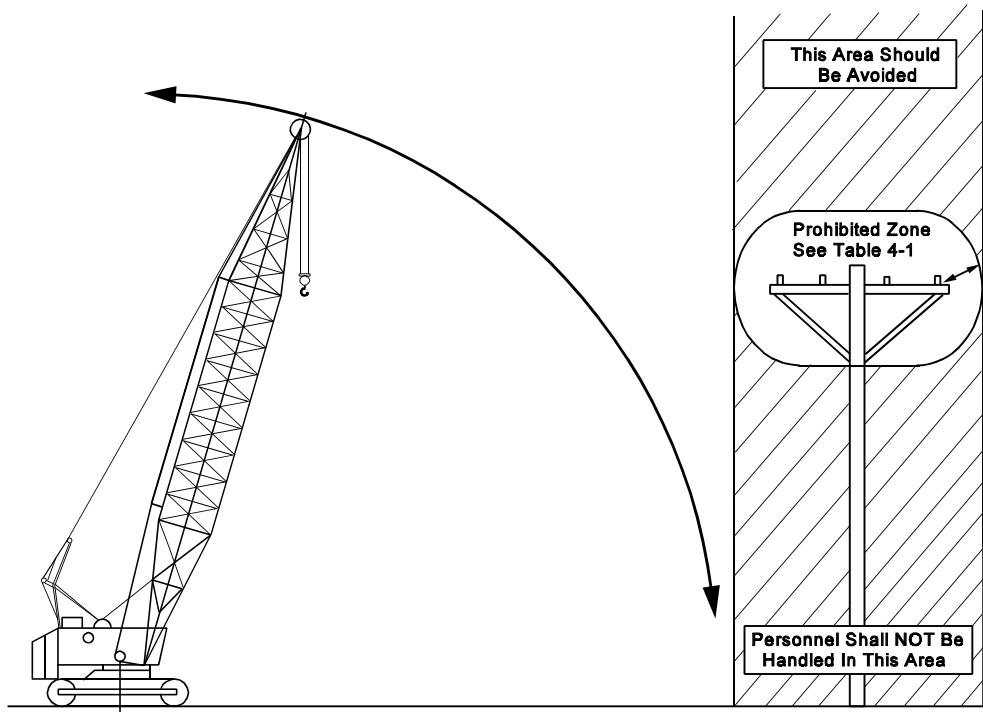


Figure 4-3 Danger Zone for Cranes and Lifting Personnel Near Electrical Transmission Line

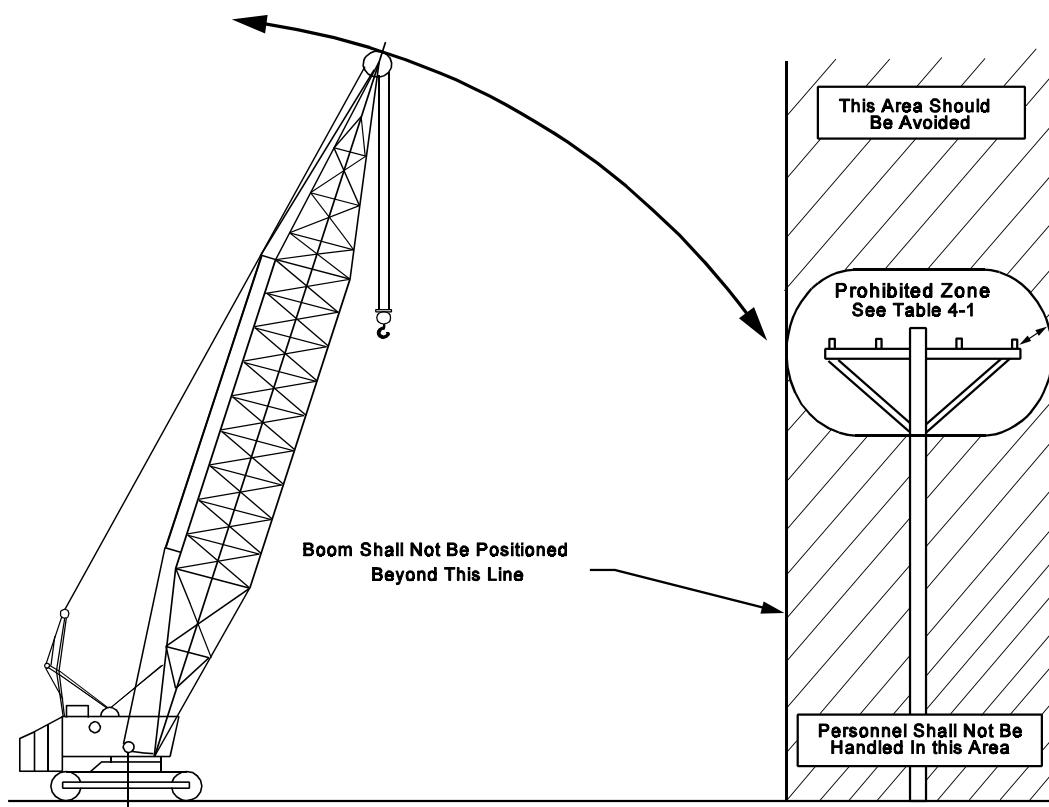


Figure 4-4. Danger Zone For Cranes Lifting Personnel Near Electrical Transmission Lines.

EXHIBIT I
(SAMPLE FORM)

BRIDGE, WALL, GANTRY CRANE LOAD TEST FORM

EQUIPMENT NO. _____ MAKE _____ RATED CAPACITY _____ DATE _____

LOAD TEST INSPECTION REPORT

The following checklist identifies the items to be inspected prior to the load test. Any unusual conditions observed during the inspection should be noted in the Remarks section.

NOTES: 1. Craftsmen shall initial and date all tests, work, and inspections completed below.
 2. Qualified inspector shall verify all steps prior to load test.

NO.	CRANE ITEM	DEFECT	OK	NA	NO.	CRANE ITEM	DEFECT	OK	NA
1	Load Hook & Blocks				18	Controllers			
2	Wire Rope and End Connections				19	Relays and Coils			
3	Handrails, Walkways, and Ladders				20	Conductors and Collectors			
4	Bridge and Trucks				21	Panel Wiring			
5	Bridge Wheels and Bearings				22	Resistors			
6	Trolley and Rails				23	Bypass Switches			
7	Trolley Wheels and Bearings				24	Limit Switches			
8	Crane Alignment				25	Contactor (Electrical)			
9	Runway Rail & Clamps				26	Motors			
10	Bumpers/Endstops				27	Gauges			
11	Brake System				28	Lighting System			
12	Drive Shafts, Gears, Couplings & Bearings				29	Heater and Switches			
13	Pawls, Ratchets, Spuds, & Windlocks				30	Operator's Cab			
14	Sheaves				31	Safety			
15	Warning Devices				32	Chain and Sprockets			
16	Capacity Signs				33	Structural			
17	Main Disconnect				34	Wire Rope Drum and Machinery Foundation			

REMARKS (Unusual conditions—noises, structural cracks, misalignment, etc.)

CHAPTER 6

PERSONNEL QUALIFICATION AND

TRAINING

6.1 GENERAL

- a. This chapter delineates the requirements for the qualification and training of operators, riggers, inspectors, maintenance personnel, trainers, persons-in-charge (PIC), designated leaders, and first-line supervisors.
- b. Personnel who are designated to operate equipment or perform work covered by this standard shall be qualified and trained to the level of proficiency consistent with assigned tasks.

6.2 QUALIFICATION

6.2.1 General

Only qualified personnel or trainees, under the direct supervision of qualified personnel, who meet the following requirements shall be allowed to rig, operate, inspect, or perform maintenance on cranes, hoists, or powered forklift trucks:

- a. Be at least 18 years old.
- b. Understand spoken and written English or a language generally in use at the work location.

6.2.2 Operators of Cab-Operated and Pulpit-Operated Cranes

a. Operators and operator trainees shall meet the following physical qualifications.

- 1. Have vision of at least 20/30 Snellen in one eye and 20/50 in the other, with or without corrective lenses. Operators whose jobs do not require binocular vision (operation of cranes with television cameras or periscope optics) shall have distant visual acuity of 20/30 in one eye and no specific visual requirement for the other eye.
- 2. Be able to distinguish colors, regardless of position, if color differentiation is required for operation.
- 3. Have adequate hearing, with or without a hearing aid, for a specific operation.
- 4. Have physical strength, coordination, and sufficient reaction speed to meet the demands of equipment operation.
- 5. Show no evidence of physical defects or of emotional instability that could be a hazard to themselves or others, or which, in the opinion of the examiner, could interfere with their safe performance; such evidence may be sufficient cause for disqualification. In these cases, medical judgments and tests may be required.
- 6. Show no evidence of being subject to seizures or to loss of physical control; such evidence shall be sufficient reason for disqualification. Medical examinations may be required to determine these conditions.

7. Have normal depth perception, field of vision, manual dexterity, coordination, and no tendencies to dizziness or similar potentially hazardous characteristics.

- 8. Have no detectable or known disease or physical restriction that would render them incapable of safely operating equipment or carrying out rigging duties. Where any deficiency of an upper or lower extremity exists, the acceptability of a candidate shall be the decision of the supervisor, after consulting with the designated physician.
- b. Operators shall be required by the employer to satisfactorily pass a written examination covering operational characteristics, controls, and emergency control skills.
- c. Operators shall be required by the employer to pass a practical operating skill evaluation. Qualification shall be limited to the type of equipment for which the operator is being evaluated. The actual or simulated operation shall enable trainees to demonstrate basic knowledge and skills at a level that ensures the safety of personnel and equipment.

6.2.3 Operators of Mobile Cranes

a. Operators and operator trainees shall meet the following physical qualifications.

- 1. Have vision of at least 20/30 Snellen in one eye and 20/50 in the other, with or without corrective lenses.
- 2. Be able to distinguish colors, regardless of position, if color differentiation is required for operation.
- 3. Have adequate hearing, with or without a hearing aid, for a specific operation.
- 4. Have physical strength, coordination, and sufficient reaction speed to meet the demands of equipment operation.
- 5. Show no evidence of physical defects or of emotional instability that could be a hazard to themselves or others, or which, in the opinion of the examiner, could interfere with their safe performance; such evidence may be sufficient

cause for disqualification. In these cases, medical judgments and tests may be required.

6. Show no evidence of being subject to seizures or to loss of physical control; such evidence shall be sufficient reason for disqualification. Medical examinations may be required to determine these conditions.

7. Have normal depth perception, field of vision, manual dexterity, coordination, and no tendencies to dizziness or similar potentially hazardous characteristics.

8. Have no detectable or known disease or physical restriction that would render them incapable of safely operating equipment or carrying out rigging duties. Where any deficiency of an upper or lower extremity exists, the acceptability of a candidate shall be the decision of the supervisor, after consulting with the designated physician.

9. Shall successfully pass with a negative result, a substance abuse test. The level of testing will be determined by the standard practice for the industry where the crane is employed and this test shall be confirmed by a recognized laboratory service.

10. Operator physical examinations shall be required every three years or more frequently if supervision deems it necessary.

b. Operators shall be required by the employer to satisfactorily pass a written examination covering operational characteristics, controls, and emergency control skills such as response to:

1. Fire.
2. Power line contact.
3. Loss of stability.
4. Control malfunction.

5. As well as characteristic and performance questions appropriated to the crane type for which qualifications is sought.

c. Operators shall demonstrate their ability to read, write, comprehend and exhibit arithmetic skills and load/capacity chart usage, in the language of the crane manufacturer's operation and maintenance instruction materials.

d. Operators shall satisfactorily complete a combination written and verbal test on load/chart usage that covers a selection of the configurations (the crane may be equipped to handle) for the type crane for which qualification is being sought.

e. The operator shall complete a practical operating skill evaluation test (actual or simulated), demonstrating proficiency and basic knowledge in handling the specific type crane for which the operator is being evaluated, including:

1. Pre-start and post-start inspection.
2. Maneuvering skills.
3. Shutdown.
4. Securing the crane.

f. Qualification shall be limited to the type of equipment for which the operator is being evaluated.

g. Trainee qualification requirements shall include but not limited to the following:

1. Satisfactory completing of a written examination covering safety, operational characteristics and limitations, and controls of the type crane for which they are being qualified.
2. Demonstrate their ability to read, write, comprehend, and exhibit arithmetic skills and load/capacity chart usage, in the language of the crane manufacturer's operations and maintenance instruction materials.
3. Satisfactory completion of a combination written and verbal test on load/capacity chart usage covering various crane configurations.

6.2.4 Operators of Truck Mounted Cranes - Capacity 1 Ton or Less

- a. Physical qualifications shall be based on specific job requirements.
- b. Operators shall be required by their employer to pass a practical operating skill evaluation. Qualification shall be limited to the type of equipment for which the operator is being evaluated.

6.2.5 Operators of Floor-Operated Cranes

- a. Physical qualifications shall be based on specific job requirements.
- b. Operators shall be required by their employer to pass a practical operating skill evaluation. Qualification shall be limited to the type of equipment for which the operator is being evaluated.
- c. The actual or simulated operation shall enable operators to demonstrate basic knowledge and skills at a level that ensures the safety of personnel and equipment.

6.2.6 Operators of Forklift Trucks

- a. Physical qualifications shall be based on specific job requirements.
- b. Operators shall be required by the employer to pass a practical operating skill evaluation. Qualification shall be limited to the type of forklift for which the operator is being evaluated.
- c. The actual or simulated operation shall enable operators to demonstrate basic knowledge and skills at a level that ensures the safety of personnel and equipment.

6.2.7 Riggers

Riggers shall be required to pass a practical rigging skill evaluation that requires the use of rigging equipment in safe configurations. The actual or simulated operation shall enable personnel to demonstrate basic knowledge and skills at a level that ensures the safety of personnel and equipment.

6.2.8 Person-In-Charge (PIC)

The PIC shall have the necessary knowledge and experience of the specific type of equipment and the hazards of critical lifts to direct the safe completion of the operation. The PIC shall understand the rules and procedures implemented at the site to ensure that the following are completed:

- a. Necessary administrative requirements.
- b. Personnel assignments and responsibilities.

- c. Selection of proper equipment/tools.
- d. Recognition and control of hazardous or unsafe conditions.
- e. Job efficiency and safety.
- f. Critical-lift documentation.

In addition, the PIC shall

- a. Direct operations in the case of an accident.
- b. Exercise authority to start and stop work activities.

6.2.9 Designated Leader

The designated leader shall have sufficient knowledge and experience to accomplish the following responsibilities:

- a. Ensure that personnel involved understand how the lift is to be made.
- b. Ensure that the weight of the load is determined and that proper equipment and accessories are selected.
- c. Survey the lift site for hazardous or unsafe conditions.
- d. Ensure that equipment is properly set up and positioned.
- e. Ensure that a signaler is assigned, if required, and is identified to the operator.
- f. Direct the lifting operation to ensure that the job is done safely and efficiently.
- g. Stop the job when any potentially unsafe condition is recognized.
- h. Direct operations if an accident or injury occurs.

6.2.10 Inspectors

- a. Qualified inspectors shall have the necessary knowledge and experience to properly inspect hoisting and rigging equipment.
- b. Employees who operate cranes to perform crane inspections shall be trained and qualified to operate the crane on which the inspection is being performed. See general and crane specific qualification requirements in Section 6.2. "Qualification."

c. Crane operation by crane inspectors shall be limited to those crane functions necessary to perform the inspection on the crane.

6.2.11 Instructors

Instructors responsible for developing or presenting hoisting and rigging training programs shall meet the qualification standards specified by the responsible training organization.

6.2.12 First-Line Supervisors

The first-line supervisor of hoisting and rigging operations should be knowledgeable of the specific types of hoisting and rigging operations under their supervision and their operational hazards. The supervisor shall be familiar with applicable rules and procedures implemented at the site to ensure that hoisting and rigging work under their control is done efficiently and safely, with safety as top priority. Supervisors should ensure that employees fully understand the importance of safety and that they recognize their own authority and responsibility to stop work when safety is questionable.

6.2.13 Maintenance Personnel

a. Employees who operate cranes to perform crane maintenance shall be trained and qualified to operate the cranes on which maintenance is being performed. See general and crane specific qualification requirements in Section 6.2. “Qualification.”

b. Crane operation by maintenance personnel shall be limited to those crane functions necessary to perform maintenance on the crane or to verify the performance of the crane after maintenance has been performed.

c. Employees who perform maintenance activities on equipment covered by this standard should have an understanding of the following criteria:

1. The tools to safely accomplish their work.
2. Access to operating instructions to perform adjustments.
3. Parts information furnished by the manufacturer or the responsible maintenance/engineering organization.
4. Manufacturers' recommendations as to points and frequency of lubrication and levels and types of lubricant to be used.
5. Maintenance and repair procedures recommended by the manufacturer or responsible maintenance/engineering organization.
6. Wiring diagrams.
7. Documentation requirements for maintenance and repair.

6.3 TRAINING

6.3.1 General

- a. Organizations that employ personnel who operate, rig, inspect, or perform maintenance on equipment covered in this standard shall provide training programs, including a means of evaluation, to ensure that the personnel are competent to perform the operations.
- b. Training programs for operators should address two levels of required performance.
 - 1. Persons who may operate pendant-controlled cranes, manual hoists, and forklifts as an incidental part of their normal work assignment.
 - 2. Persons whose principal assignment is the performance of hoisting and rigging work.
- c. The training organization shall use training methods best suited for the students and the subject material. This may include, but is not limited to, computer-aided training, classroom training, simulated field training, on-the-job training (OJT), and training by equipment manufacturer or commercial training companies.
- d. Score standards shall be set for each examination by the training organization. The minimum passing score will depend on the subject, testing technique, and test difficulty. Management shall determine the course of action for persons receiving negative evaluations.

6.3.2 Operators of Cab-Operated, Pulpit-Operated, and Floor-Operated Cranes

- a. Only qualified and authorized operators or operator trainees under the direct supervision of a qualified operator shall be permitted to operate cab-operated, pulpit-operated, and floor-operated cranes.
- b. The initial training of operators shall include:
 - 1. Applicant training on equipment for which qualification is sought, under the direction of a qualified operator or instructor who is designated by management to instruct in the operation of hoisting equipment.

2. Instructor review of the applicant's knowledge, including results of written and oral evaluation, and witnessing a demonstration of the operator's skills.

c. Operators should be able to demonstrate a knowledge of equipment operating characteristics, capabilities, limitations, effects of variables, safety features, and operating procedures. The following checklist contains basic factors with which an operator should be familiar. This checklist must be tailored to suit actual conditions.

1. Operating characteristics.
2. Environmental hazards—weather.
3. Electrical hazards.
4. Traveling with load.
5. Traveling without load.
6. Lifting personnel.
7. Inspections/tests.
8. Load weight estimation.
9. Emergency procedures.
10. Rigging.
11. Lessons learned.
12. Hand signals.
13. Load dynamics.
14. Applicable standards and regulations.
15. Critical lifts.
16. Safety features of equipment.
17. Terminology and definitions.
18. Ropes and reeving.
19. Two-blocking.
20. Records and documents.
21. Limit switches, warning signals.

- 22. Operating practices.
- 23. Fire protection.
- 24. Crane components.
- 25. Access and egress.
- 26. Warning devices.

6.3.3 Mobile Crane Operators

- a. Only qualified and authorized operators or operator trainees under the direct supervision of a qualified operator shall be permitted to operate mobile cranes.
- b. Operators shall meet the criteria specified in paragraphs 6.3.2.b and c, and they should also be able to demonstrate an understanding of the following:

1. Stability.
2. Load charts.
3. Crane setup.
4. Refueling.
5. Lifting operations involving multiple cranes.
6. Assembly and disassembly.
7. Outriggers.
8. Operator aids.

6.3.4 Operators of Truck Mounted Cranes - Capacity 1 Ton or Less

- a. Only qualified and authorized operators or operator trainees under the direct supervision of a qualified operator shall be permitted to operate truck mounted cranes - capacity 1 ton or less.
- b. The initial training of operators shall include applicable training on equipment for which qualification is sought, under the direction of a qualified operator or instructor.
- c. Instructor review of the applicant's knowledge, shall include results of written and/or oral evaluation, and witnessing a demonstration of the operator's skills.

- d. Operators should be able to demonstrate a knowledge of equipment operating characteristics, capabilities, limitations, effects of variables, safety features, and operating procedures.

6.3.5 Forklift Truck Operators

- a. Only qualified and authorized operators shall be permitted to operate powered forklift trucks. Operator trainees may operate powered forklift trucks under the direct supervision of a qualified operator or trainer and only where such operation does not endanger the trainee or other employees.
- b. The initial training of operators shall include:
 1. A combination of formal instruction (e.g., lecture, discussion, interactive computer learning, videotape, written material).
 2. Practical training (demonstrations performed by the trainer and practical exercises performed by the trainee).
 3. Evaluation of the operator's performance in the workplace including results of written and oral evaluation, and witnessing a demonstration of the operator's skills.
- c. The following checklist contains basic factors with which a forklift truck operator should be familiar. This checklist must be tailored to suit actual conditions.
 1. Operating instruction, warnings, and precautions for the type of forklift truck the operator will be authorized to operate.
 2. Differences between the forklift truck and the automobile.
 3. Forklift truck controls and instrumentation:
 - i. Where they are located.
 - ii. What they do.
 - iii. How they work.
 4. Engine or motor operation.
 5. Steering and maneuvering.

CHAPTER 7

OVERHEAD AND GANTRY CRANES

7.1 GENERAL

Overhead and gantry cranes include top-running single- or multiple-girder bridge with top-running trolley hoists (Figure 7-1), top-running single-girder bridge with underhung trolley hoists (Figure 7-2), and monorails/underhung cranes (Figure 7-3).

7.1.1 Operator Training/ Qualification

Operators of overhead cranes shall be trained and qualified as required in Chapter 6, "Personnel Qualification and Training."

7.1.2 Rated-Load Marking

The rated capacity shall be marked on each side of the crane. If the crane has more than one hoisting unit, each hoist shall have its rated capacity marked on it or on its load block. Markings on the bridge, trolley, and load block shall be legible from the ground or floor.

7.1.3 Modification

Cranes may be modified or rerated provided that the modifications or supporting structures are analyzed thoroughly by a qualified engineer or by a manufacturer of cranes. Modifications and reratings must be approved by the cognizant safety organization. A rerated crane, or one whose load-supporting components have been modified, shall be tested in accordance with Section 7.3, "Testing." The new rated capacity shall be displayed in accordance with Section 7.1.2, "Rated-Load Marking."

7.1.4 Egress

On cab-operated cranes, there shall be at least two means of egress from the crane, remote from each other, and arranged to permit departure under emergency conditions.

7.1.5 Hoist Brakes

a. Each independent hoisting unit shall be equipped with at least one holding brake applied directly to the motor shaft or some part of the gear train.

- b. Each independent hoisting unit (except worm-gear hoists, the angle of whose worm prevents the load from accelerating as it is being lowered) shall be equipped with a controlled-braking means in addition to the holding brake to control speed of lowering.
- c. Holding brakes on hoists shall be applied automatically when power is removed.

7.1.6 Power Shutoff

- a. The power supply for the runway conductors shall be controlled by a switch or circuit-breaker located on a fixed structure, accessible from the floor, and capable of being locked in the OPEN position.
- b. On cab-operated cranes, an enclosed switch or circuit-breaker (with provisions for locking in the OPEN position) shall be provided in the leads from the runway conductors. A means of opening this device shall be located within reach of the operator when the operator is in the operating position. When the operator opens this switch or circuit-breaker, the holding brakes should set.
- c. On floor, remote, or pulpit-operated cranes, an enclosed disconnect device shall be provided in the leads from the runway conductors. This device shall be mounted on the bridge or footwalk near the runway collectors. There shall be provisions for locking the device in the OPEN position unless the crane is the only load on a lockable switch or circuit-breaker that is accessible from the floor. One of the following types of floor, remote, and pulpit-operated disconnects shall be provided.

1. A nonconductive rope attached to the main disconnect device on a floor-operated crane. If this is selected, the rope shall be suspended adjacent to the operating ropes if manual controllers are used, or near the pendant push-button station if magnetic controls are used.

2. An under-voltage trip for a main circuit-breaker, operated by an emergency stop button in the pendant push-button station or the pulpit.

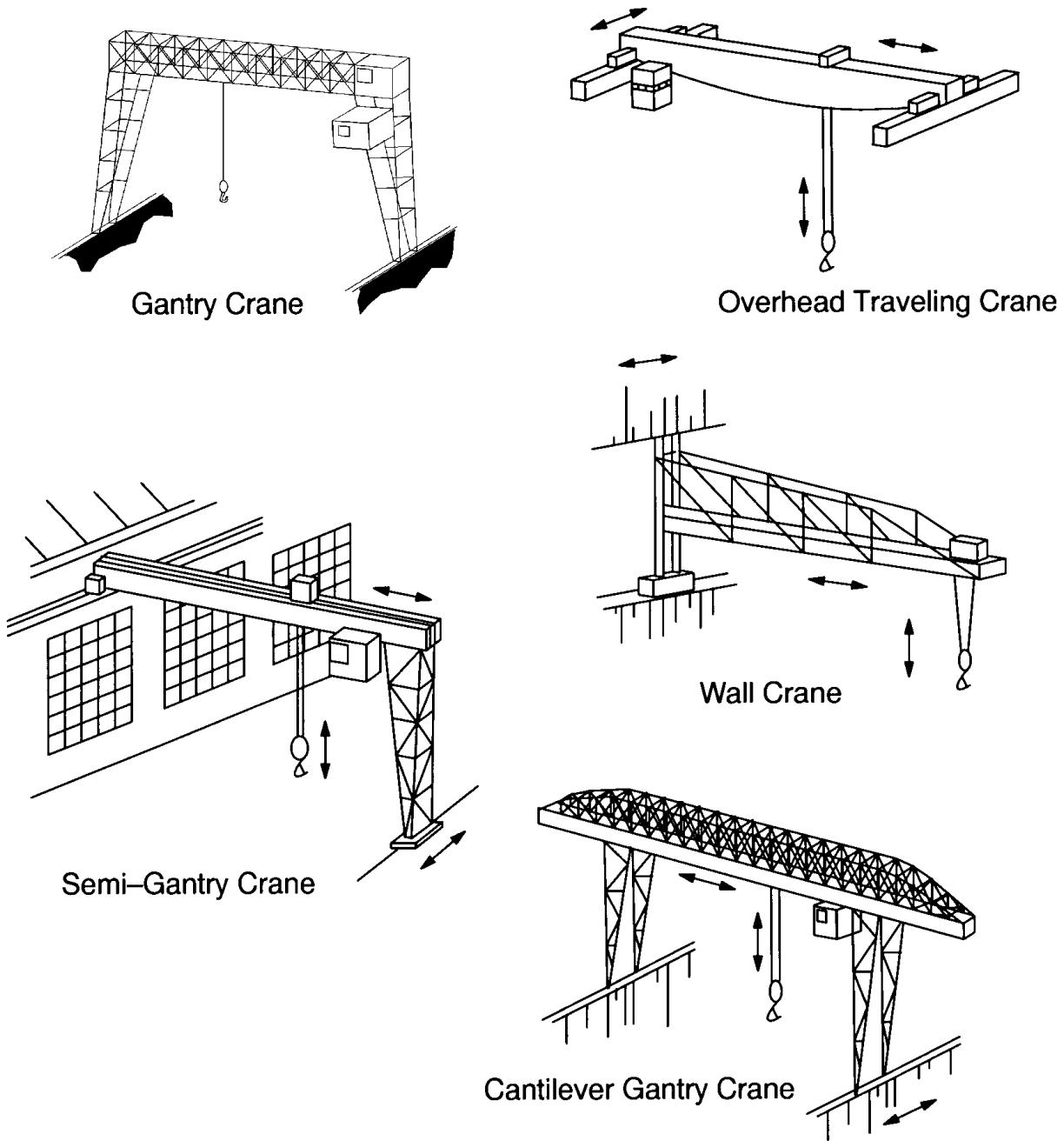


Figure 7-1. Top-running single- or multiple-girder bridge with top-running trolley hoist.

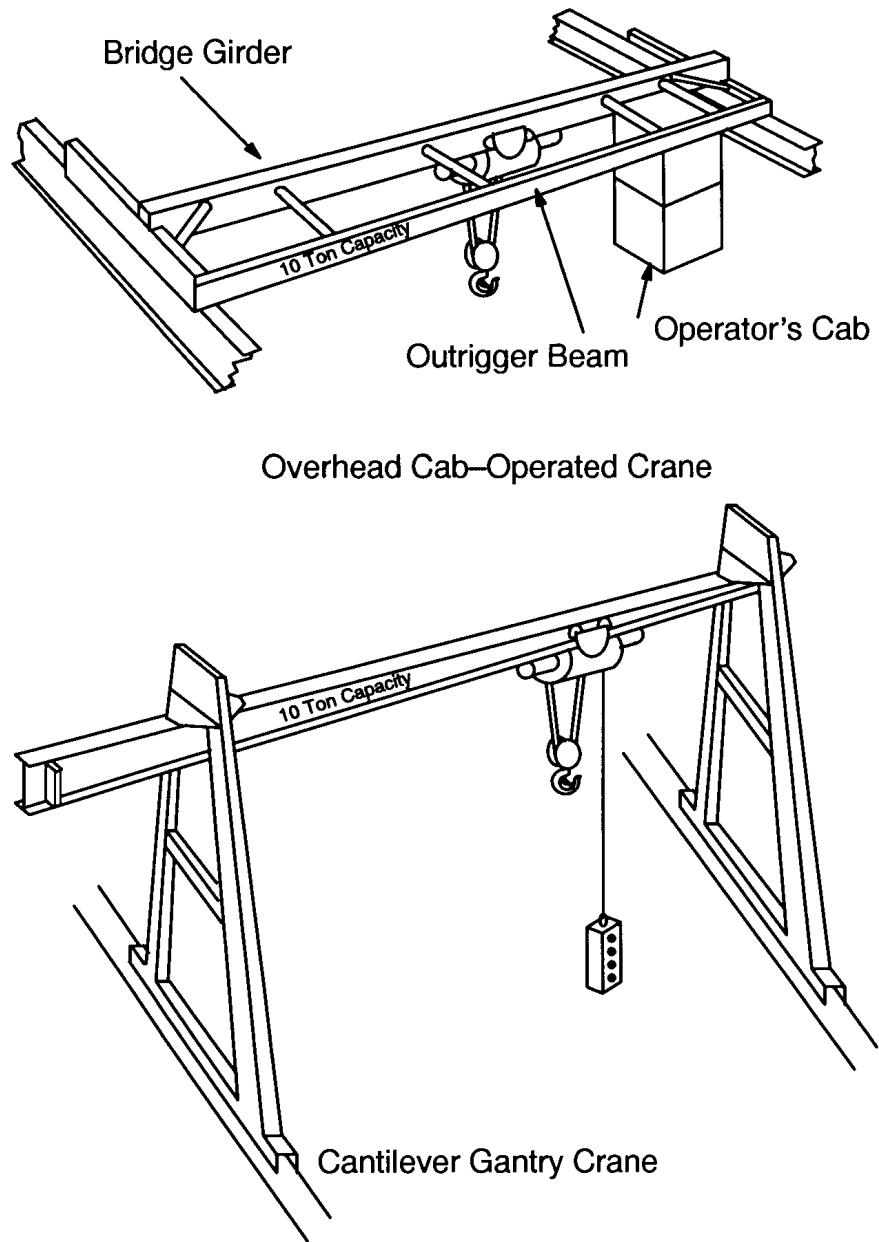
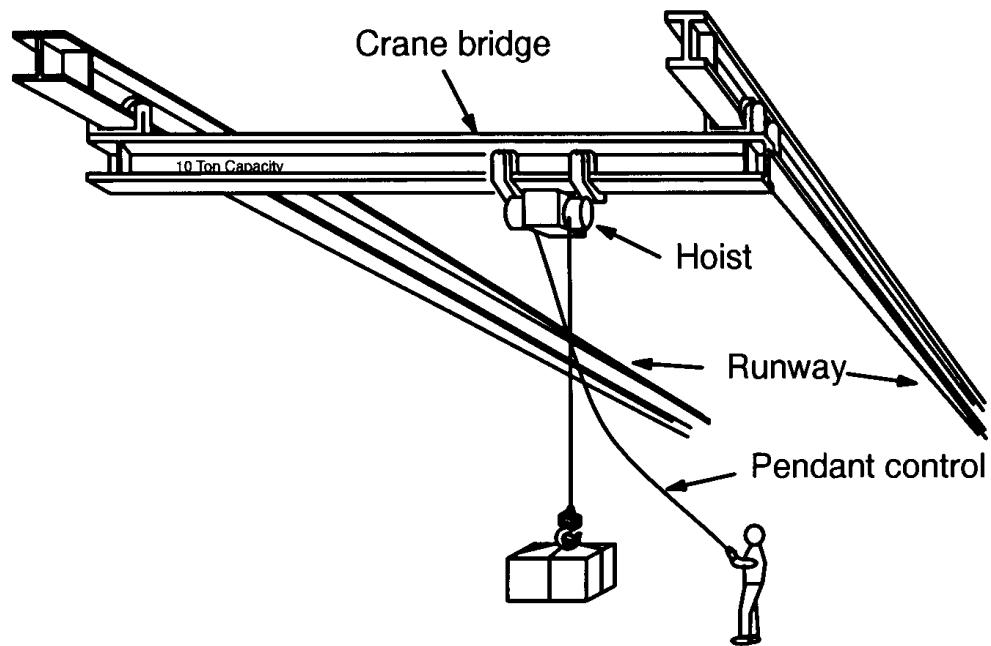
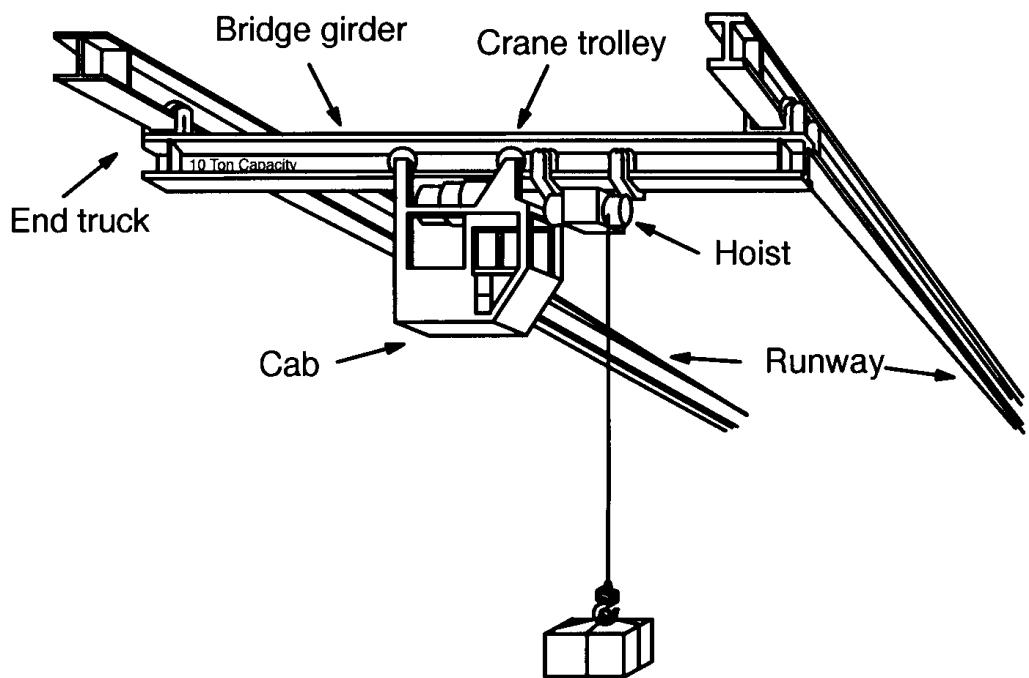


Figure 7-2. Top-running single-girder bridge with underhung trolley hoist.



Floor-operated crane



Cab-operated crane

Figure 7-3. Monorails and underhung cranes.

3. A main-line contactor operated by a switch or push button on the pendant push-button station, the remote-control station, or the pulpit.

7.1.7 Hoist-Limit Switch

- a. The hoisting motion of all cranes shall have an overtravel-limit switch/device in the hoisting direction to stop the hoisting motion.
- b. Lower-travel limit switches/devices should be provided for all hoists where the load block enters pits or hatchways in the floor.

7.1.8 Load Limits

The crane shall not be loaded beyond its rated capacity except for test purposes, as described in Section 7.3.

7.1.9 Maintenance History

The maintenance history of the crane shall be retained throughout its service life.

7.2 INSPECTIONS

7.2.1 General

There shall be no apparent damage, excessive wear, or deformation of any load-bearing part of the equipment. Brakes shall work satisfactorily and load brakes shall be designed to hold any load up to at least 125 percent of the rated capacity of the equipment without slipping or overheating. All safety devices, load indicators, controls, and other operating parts of the equipment shall be checked during each inspection and shall be in good working order. Parts found to be defective during any inspection or nondestructive examination shall be replaced or repaired as directed by the responsible line manager or that person's designated representative.

7.2.2 Crane Service

Crane service is defined as follows:

- a. Normal service—operating at less than 85 percent of rated load and not more than 10 lift cycles/hr except for isolated instances.
- b. Heavy service—operating at 85 to 100 percent of rated load or in excess of 10 lift cycles/hr as a regular specified procedure.
- c. Severe service—operating at normal or heavy service under abnormal operating conditions (i.e., extreme temperatures, corrosive atmospheres).

7.2.3 Initial Inspection

Prior to their initial use, all new, reinstalled, modified, or repaired cranes shall be inspected by a qualified inspector to ensure compliance with applicable provisions of this chapter. Inspections of repaired and modified cranes may be limited to the provisions affected by the alteration, repair, or modification as determined by a qualified person. Dated and signed inspection reports shall be kept on file and shall be readily available.

7.2.4 Daily Preoperational Check

- a. Operators or other designated personnel shall visually inspect items such as the following each day or prior to first use if the

hoist has not been in regular service (records are not required):

- 1. Controls and operating mechanisms for proper operation.
- 2. Hoist upper-limit switch/device for proper operation at the beginning of each shift or prior to use if hoist has not been in regular service.
- 3. Lines, valves, and other parts of air systems for leakage.
- 4. Hooks for cracks, deformation and damage from chemicals (see Chapter 13, "Load Hooks," for additional hook requirements).
- 5. Hoist rope for significant wear, kinking, crushing, birdcaging, and corrosion. The inspection shall be made by running out as much of the rope or chain as is necessary to visually examine those portions that flex over sheaves, sprockets, and the like, and other areas subject to wear or abrasion.
- 6. Hoist chain for nicks, gouges, distortion, wear, and corrosion.
- 7. Hook latch, if used, for proper operation.
- b. Operators or other designated personnel shall examine deficiencies and determine whether they constitute a hazard and whether a more detailed inspection is required.

7.2.5 Monthly Rope, Chain, and Hook Inspection

- a. The operator or other designated person shall visually inspect the following items for damage, wear, or other deficiency that might reduce capacity or adversely effect the safety of the crane:
 - 1. hoist rope or chain
 - 2. hooks
- b. Lower the hook block to its lowest position and examine for any condition that could result in an appreciable loss of strength.

- c.. Hoist rope for significant wear, kinking, crushing, birdcaging, and corrosion.
- d. Hoist chain for nicks, gouges, distortion, wear, and corrosion.
- e. Hooks for cracks, deformation, damage from chemicals, latch engagement (if provided), and evidence of heat damage.
- f. Signed and dated inspection records shall be kept on file and shall be readily available.
- g. Before the crane is returned to service, correct deficiencies that could reduce its capacity or adversely effect its safety.

7.2.6 Frequent Inspection

- a. Operators or other designated personnel shall visually inspect the crane at the following intervals (records are not required):
 - 1. Normal service—monthly.
 - 2. Heavy service—weekly to monthly.
 - 3. Severe service—daily to weekly.
- b. In addition to the requirements of Section 7.2.4, “Daily Preoperational Check,” these inspections shall include the following:
 - 1. Hoist braking system for proper operation.
 - 2. Hoist rope or chain reeving for compliance with hoist manufacturer's recommendations.
 - 3. Observations during operation.
- c. Operators or other designated personnel shall examine deficiencies and determine whether a more detailed inspection is required.

7.2.7 Periodic Inspection

- a. A qualified inspector shall perform a complete inspection at the following intervals:
 - 1. Normal service—yearly.
 - 2. Heavy service—semiannually.
 - 3. Severe service—quarterly.

- b. The qualified inspector shall examine deficiencies and determine whether they constitute a safety hazard and whether the crane should be removed from service until it is repaired.
- c. Dated and signed inspection records shall be kept on file and shall be readily available.
- d. A sample load test form is included as Exhibit I, which appears at the end of this chapter. This form is intended to be a sample only and is not intended to be mandatory.

7.2.7.1 Cranes

In addition to the requirements of Section 7.2.6, “Frequent Inspections,” periodic inspections shall include the following:

- a. Components for deformation, cracks, or corrosion.
- b. Bolts, rivets, nuts, and pins for being loose or absent.
- c. Check for suspect/counterfeit parts (see Terminology and Definitions, Chapter 1).
- d. Sheaves and drums for cracks or wear.
- e. Parts such as pins, bearings, shafts, gears, rollers, locking and clamping devices, bumpers, and stops for wear, cracks, or distortion.
- f. Brake-system parts, linings, pawls, and latches for excessive wear.
- g. Load, wind, and other indicators over their full range for any significant inaccuracies.
- h. Gasoline, diesel, electric, or other power plants for improper performance or noncompliance with other applicable standards.
- i. Chain-drive sprockets for excessive wear and chains for excessive stretch.
- j. Electrical apparatus for signs of any deterioration of controllers, master switches, contacts, limit switches, and push-button stations (not limited to these items).
- k. Hooks for damage from chemicals, deformation, cracks, or having more than 15 percent in excess of normal throat opening,

or more than 10 degree twist from the plane of the unbent hook (see Chapter 13 for additional hook requirements).

- l. Hook retaining nuts or collars and pins, welds, or riveting used to secure the retaining members for soundness.
- m. Nondestructive examination of hooks and of welds, bearings, or other suspect load-bearing parts when required by the inspector.
- n. Testing of motion limit devices, which interrupt power or cause a warning to be activated, for proper performance (each motion shall be inched or operated at low speed into the limit device with no load on the crane).
- o. Function labels for legibility.

7.2.7.2 Wire Rope

a. A qualified inspector shall inspect all ropes at least annually. This inspection shall include examination of the entire length of the rope, without detaching it from the hoist drum. More frequent intervals shall be determined by a qualified person and shall be based on such factors as expected rope life as determined by experience on the particular installation or similar installations, severity of environment, percentage of capacity lifts, frequency rates of operation, and exposure to shock loads. The qualified inspector shall carefully note any deterioration such as described below resulting in appreciable loss of original strength and determine whether further use of the rope constitutes an acceptable risk.

1. Reduction of rope size below nominal diameter, whether due to loss of core support, internal or external corrosion, or wear of outside wires (see Table 7-1).
2. The number and distribution or concentration of broken outside wires.
3. Worn outside wires.
4. Sections of rope that are normally hidden during inspection or maintenance procedures, such as parts passing over sheaves (these are points most subject to deterioration).
5. Corroded or broken wires at end connections.
6. Corroded, cracked, bent, worn, or improperly applied end connections.

7. Kinking, crushing, cutting, or unstranding.

b. All rope on cranes that have been idle for 1 month or more due to shutdown or storage shall be inspected before the crane is returned to service. A dated and signed report of the rope inspection, including results, shall be filed.

c. No precise rules can be given for determining the exact time to replace rope because many variables are involved. Safety in this respect depends largely on the use of good judgment by an appointed person in evaluating remaining strength in a used rope, after allowance for deterioration disclosed by inspection. Safety of rope operation depends on this remaining strength.

d. Conditions such as the following shall be sufficient reason for questioning rope safety and considering replacement:

1. In running ropes, 12 randomly distributed broken wires in one rope lay, or 4 broken wires in one strand in one rope lay.
2. Wear of one-third of the original diameter of outside individual wires.
3. Kinking, crushing, birdcaging, or any other damage resulting in distortion of the rope structure.
4. Evidence of heat damage from any cause.
5. Reductions from nominal diameter greater than those listed in Table 7-1.
- e. Replacement rope and connections shall have a strength at least as great as the original rope and connections furnished by the crane manufacturer. Any deviation from the original size, grade, or construction shall be specified by a rope manufacturer, the crane manufacturer, or a qualified person.
- f. Never use discarded rope for slings.

7.2.7.3 Chain (Welded Link)

- a. Operate the crane under load in raising and lowering directions, and observe the operation of the chain and sprockets. The chain should feed smoothly into and away from the sprockets.
- b. If the chain binds, jumps, or is noisy, first see that it is clean and properly lubricated. If

the trouble persists, inspect the chain and mating parts for wear, distortion, or other damage.

Table 7-1. Maximum allowable rope reductions.

Rope diameter	Maximum allowable reduction from Nominal diameter
Up to 5/16 in. (8 mm)	1/64 in. (0.4 mm)
Over 5/16 in. to 1/2 in. (13 mm)	1/32 in. (0.8 mm)
Over 1/2 in. to 3/4 in. (19 mm)	3/64 in. (1.2 mm)
Over 3/4 in. to 1 1/8 in. (29 mm)	1/16 in. (1.6 mm)
Over 1 1/8 in. to 1 1/2 in. (38 mm)	3/32 in. (2.4 mm)

c. The chain should be cleaned before inspection. Examine visually for gouges, nicks, weld spatter, corrosion, and distorted links. Slacken the chain and move adjacent links to one side to inspect for wear at the contact points. If wear is observed or stretching is suspected, the chain should be measured according to the hoist manufacturer's instructions. If instructions are not available, proceed as follows:

1. Select an unworn, unstretched length of the chain (e.g., at the slack end).

2. Suspend the chain vertically under tension and, using a caliper-type gauge, measure the outside length of any convenient number of links approximately 12 in. (305 mm) to 14 in. (356 mm) overall.

3. Measure the same number of links in the used sections and calculate the percentage of increase in length.

d. Conditions such as the following shall be sufficient reason for questioning safety and for considering replacement:

1. If the used chain exceeds a crane manufacturer's recommended length or, in the absence of such a recommendation, the used chain is 1.5 percent longer than the unused

chain for powered hoists or is 2.5 percent longer than the unused chain for hand-operated chain, replace the chain.

2. The existence of gouges, nicks, corrosion, weld spatter, or distorted links.

e. Repairing the load chain by welding or any other means shall not be attempted by anyone other than the chain manufacturer.

f. Replacement chain shall be the same size, grade, and construction as the original chain furnished by the crane manufacturer unless otherwise recommended by the manufacturer due to working conditions.

g. Load-chain links that pass over the load sprocket on edge (alternate to those that lie flat in the pockets) should be installed with the welds away from the center of the sprocket. This precaution is not required on idler sprockets, which change the direction but not the tension in the chain.

h. The chain shall be installed without any twist between the hoist and an anchored end on either the loaded side or the slack side.

i. When a chain is replaced, disassemble and inspect the mating parts (sprockets, guides, stripper) for wear, and replace if necessary.

j. Discarded load chain shall not be used for slings.

7.2.7.4 Chain (Roller)

a. Test the crane under load in raising and lowering directions, observing the operation of the chain and sprockets. If the chain binds, jumps, or is noisy, clean and properly lubricate it. If the trouble persists, inspect the chain and mating parts for wear, distortion, or damage.

b. If wear is observed or stretching is suspected, the chain shall be measured according to the crane manufacturer's instructions. If instructions are not available, proceed as follows:

1. Suspend the hoist in normal position and apply a light load of approximately 50 lb (23 kg).

2. Select a 12-in. (305-mm) section of chain that normally travels over the load sprocket.

3. Determine elongation by measuring with a caliper from the edge of one chain pin to the corresponding edge of another pin. If elongation exceeds 1/4 in. (6.3 mm) in 12 in. (305 mm) compared to new or unstretched chain values, the chain shall be replaced.

4. Inspect for twist. Replace if the twist in any 5-ft (1.52-m) section exceeds 15 degrees.

5. Check for straightness in a plane perpendicular to the plane of the rollers. Replace if the chain has a bow exceeding 1/4 in. (6.3 mm) in any 5-ft (1.52-m) section.

6. Additional inspection shall be made by removing the chain from the crane and cleaning it thoroughly. Deficiencies such as those listed below shall be carefully examined and a determination shall be made as to whether they constitute a safety hazard:

- i. Pins turned from original position.
- ii. Rollers that do not run freely with light finger pressure.
- iii. Joints that cannot be flexed by easy hand pressure.
- iv. Side plates that are spread open.
- v. Corrosion, pitting, or discoloration.
- vi. Gouges, nicks, or weld spatter.

c. Roller chain shall be replaced if any of the conditions exist as stated in paragraphs 7.2.7.4.b., 1 through 5 above.

d. Deficiencies as stated in paragraph 7.2.7.4.b.6 above are reason for questioning chain safety and considering its replacement.

e. Repairing of roller chain by welding or heating shall not be attempted.

f. Replacement chain shall be the same size, grade, and construction as the original chain furnished by the crane manufacturer unless otherwise recommended by the manufacturer due to working conditions.

g. Roller chain, discarded or new, shall not be used for slings.

7.2.8 Cranes Not in Regular Service

a. Cranes that have been idle for 1 month or more but less than 6 months shall be inspected before being placed in service according to the requirements listed above in Section 7.2.6, "Frequent Inspection."

b. Cranes that have been idle for 6 months or longer shall be inspected before being placed in service according to the requirements listed above in Section 7.2.7, "Periodic Inspection."

7.3 TESTING

7.3.1 Operational Tests

a. Prior to initial use, all new, reinstalled, repaired, or modified cranes shall be tested by a designated person to ensure compliance with this chapter, including the following functions:

1. Lifting and lowering.
2. Trolley travel.
3. Bridge travel.
4. Locking, limiting, and indicating devices, if provided.
5. Limit switches/devices.

b. The trip setting of hoist-limit devices shall be determined by tests with an empty hook traveling at increasing speeds up to the maximum speed. The actuating mechanism of the upper-limit device shall be located so that it will trip the device under all conditions and in sufficient time to prevent contact of the hook or load block with any part of the trolley or crane.

7.3.2 Rated Load Test

a. Prior to initial use, all new or reinstalled cranes and cranes in which the load sustaining parts have been altered, modified, repaired, or replaced, or whose rated capacities have been affected shall be tested by or under the direction of a qualified inspector

b. A written report confirming the rated load testing of the crane shall be furnished by the inspector.

c. Test loads shall not be less than 100 percent or more than 125 percent of the rated capacity, unless otherwise recommended by the manufacturer or a qualified person.

d. Testing shall consist of the following operations as minimum requirements:

1. Hoist the test load a sufficient distance to ensure that the load is supported by the crane and held by the hoist brakes. Personnel shall be kept clear of the test load while it is suspended.

2. Transport the test load by means of the trolley for the full length of the bridge.

3. Transport the test load by means of the bridge for the full length of the runway, in one direction with the trolley as close to the extreme right-hand end of the crane as practical, and in the other direction with the trolley as close to the extreme left-hand end of the crane as practical.

4. Lower the test load, stopping by the brakes.

e. The replacement of load chain and rope is specifically excluded from this requirement; however, an operational test of the crane shall be made in accordance with para. 7.3.1.a.1 prior to putting the crane back in service.

f. If wire rope clips or wedge socket end connection are installed during wire rope installation:

1. The crane should be cycled several times with a load equal to or greater than the maximum operational load, normally 100 percent of the rated capacity.

2. If wire rope clips are used, then check and retighten nuts to the wire rope clip or wire rope manufacturer's recommended torque value.

3. If a wedge socket is used, then verify that the rope is properly seated.

g. Operational testing of altered, repaired, or modified cranes whose load sustaining parts or rated capacities have not been affected may be limited to the functions affected by the alteration, repair, or modification as determined by a qualified person.

h. The transporting of test loads as required by paragraph 7.3.2.a above, shall be done insofar as interfering equipment/structures permit and in accordance with recommendations from the manufacturer or a responsible engineering organization. However, test loads should not be carried over critical systems or components.

i. Test weights shall be accurate to within -5 percent, +0 percent of stipulated values.

7.4 MAINTENANCE

7.4.1 Operating Equipment

- a. A preventive maintenance program shall be established and based on the recommendation of the crane manufacturer. If manufacturer's recommendations are no longer available, a qualified person shall establish the program's requirements. Dated records should be kept where readily available to appointed personnel.
- b. Replacement parts shall be at least equal to the original manufacturer's specifications.
- c. All moving parts of the crane for which lubrication is specified shall be regularly lubricated. Check lubricating systems for delivery of lubricant. Follow manufacturer's recommendations as to points and frequency of lubrication, maintenance of lubricant levels, and types of lubricant to be used.
- d. Maintenance personnel shall take the following precautions before performing maintenance on a crane:
 - 1. Move the crane to a location where it will cause the least interference with other cranes and operations.
 - 2. Place any attached loads on the ground or floor.
 - 3. Place all controllers in the OFF position.
 - 4. Perform a lockout/tagout procedure.
 - 5. Use warning signs and barriers on the floor beneath the crane where overhead maintenance work creates a hazard.
 - 6. If the runway remains energized, place stops or signalers full-time at a visual vantage point to observe the approach of active cranes and prohibit contact by the active cranes with the idle crane, with persons performing maintenance, or with the maintenance equipment.

- 7. Install a guard or barrier between adjacent runways for the length of the established work area to prevent contact between persons performing maintenance and any crane on the adjacent runway.

7.4.2 Wire-Rope Maintenance

Personnel using wire rope shall ensure proper care by doing the following:

- a. Store rope to prevent damage or deterioration.
- b. Unreel or uncoil rope as recommended by the rope manufacturer and with care to avoid kinking or inducing a twist.
- c. Before cutting rope, use some method to prevent unlaying the strands. Heat affected zones of flame cut wire rope shall not be allowed to bear load.
- d. During installation, avoid dragging the rope in dirt or around objects that will scrape, nick, crush, or induce sharp bends in it.
- e. Maintain rope in a well-lubricated condition to reduce internal friction and prevent corrosion. Ensure that lubricant applied as part of a maintenance program is compatible with the original lubricant and is also a type that does not hinder visual inspection. Those sections of rope located over sheaves or otherwise hidden during inspection and maintenance procedures require special attention when the rope is being lubricated.

7.5 OPERATION

- a. The following shall apply to all personnel involved in overhead and gantry crane operation.
- b. At the initial stage of the planning process, an appointed person shall classify each lift into one of the DOE-specified lift categories (ordinary, critical, or preengineered production).

7.5.1 Conduct of Operator

- a. Do not engage in any practice that will divert your attention while operating the crane.
- b. Do not operate cranes without complying with the requirements of Chapter 6. Your immediate supervisor shall participate in this determination.
- c. Operators shall be held directly responsible for the safe operation of their equipment. Whenever there is any question as to the safety of the activity, an operator has the authority to stop and refuse to handle loads until the matter has been resolved by supervisory personnel.
- d. Sound a warning signal (if furnished) during travel, particularly when approaching personnel.
- e. If you find the crane's main or emergency switch open when starting on duty, do not close it until it has been determined that no one is on or close to the crane. If there is a warning sign on the switch, do not remove it unless you placed it there. Do not close the switch until the warning sign has been removed by the person who placed it there.
- f. Before closing the main switch, ensure that all controllers are in the OFF position.
- g. If a power failure occurs during operation, immediately switch all controllers to the OFF position.
- h. Become familiar with your equipment and its proper care. If adjustments or repairs are necessary, or any defects are known, report them promptly to the responsible supervisor. Also, notify the next operator of the defects at shift change.
- i. Contacts with runway stops or other cranes shall be made with extreme caution. If you are ordered to engage with or push other cranes, do this with particular care for the safety of persons on or below the cranes, and only after making

- certain that any persons on the other cranes are aware of what action is to be taken.
- j. Secure outdoor cranes before leaving them.
- k. When the wind-indicating alarm is given, anchor the bridge on outside cranes.
- l. Lock and tag the main positive electrical control switch in the OPEN position before any crane maintenance is performed.
- m. Operate all controls before beginning a new shift. If any controls do not operate properly, adjust or repair them before operations begin.
- n. Do not hoist two or more separately rigged loads in one lift, even though the combined load is within the crane's rated capacity.
- o. Ensure that a 10BC or larger fire extinguisher is installed in the cab of cab-operated cranes. The extinguisher shall be maintained in a serviceable condition.
- p. Do not lift, lower, or travel the crane while anyone is on the load or hook.

7.5.2 Hoist-Limit Switch/Device

- a. At the beginning of each work shift, or the first time the crane is used during a shift, test the upper-limit switch/device of each hoist under no load. Exercise extreme care to avoid two-blocking; "inch" the block into the limit switch or run it in at slow speed. If the switch/device does not operate properly, immediately notify the supervisor.
- b. If a lift is in progress during a shift change, this testing requirement is considered to have been satisfied for the completion of that lift. However, test the limit switch again before the next lift.
- c. Do not use the final hoist-limit switch/device that controls the upper limit of travel of the load block as an operating control.

7.5.3 Standard Hand Signals

The standard hand signals for DOE use shall be as specified in the latest edition of the ASME B30 standards for the particular type of crane or hoist being used (see Figure 7-4).

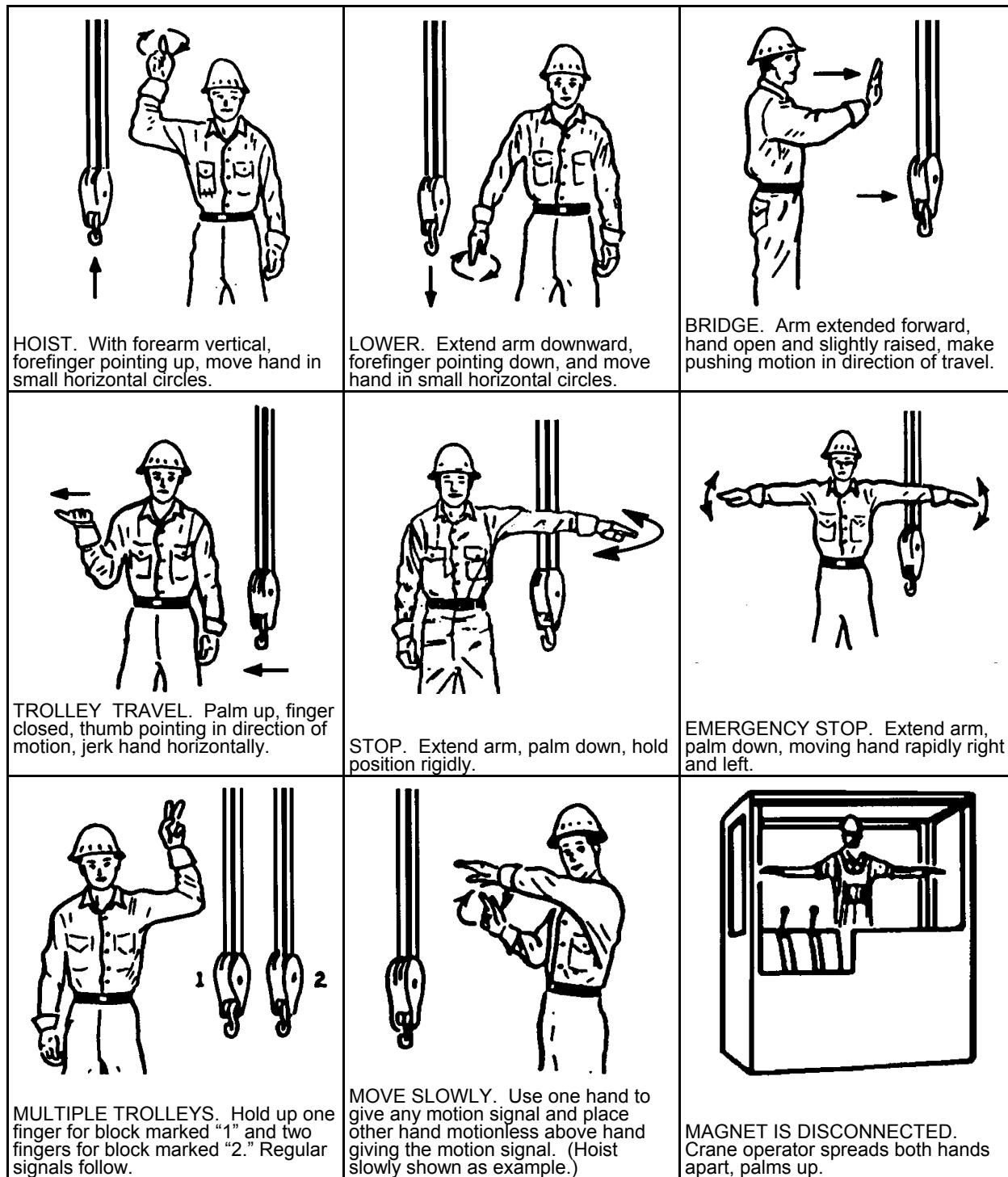


Figure 7-4. Standard hand signals for controlling overhead crane operation.

7.5.4 Identification of Signalers

- a. All personnel acting as signalers during crane operations shall be clearly identified to the crane operator by using the following (one or more, as required by the responsible manager): orange hardhat, orange gloves, and orange vest. This requirement may be waived by the responsible manager when the lift is very closely controlled or personnel are required to wear special clothing for protection from a hazardous environment.
- b. In those cases where the crane operator cannot see the signaler, a second person (relay signaler) shall be stationed where he or she can see both the signaler and the crane operator and signals can be relayed to the operator. The relay signaler shall also be clearly identified by the items described in the previous paragraph.
- c. Where voice (direct or two-way radio) communication is used, the signaler shall communicate directly with the operator, not through a third person.
- d. The operator shall obey signals only from the designated signaler. *Obey a STOP signal no matter who gives it.*

7.5.5 Size of Load

- a. The weight of the load shall be determined prior to making the lift.
- b. The crane and rigging equipment shall not be loaded beyond its rated capacity, except for authorized testing described in Section 7.3.

7.5.6 Attaching the Load

- a. Ensure that the hoist rope is free from kinks or twists. Do not wrap the hoist rope around the load.
- b. Ensure the load is attached to the load-block hook by means of slings or other approved devices.
- c. Take care to make certain that the sling clears all obstacles.

7.5.7 Moving the Load

- a. The person appointed to direct the lift shall see that the load is well secured and properly balanced in the sling or lifting device before it is lifted more than a few inches.
- b. Before starting to hoist, note the following conditions:
 - 1. Hoist rope shall not be kinked.
 - 2. Multiple-part lines shall not be twisted around each other.
 - 3. The hook shall be positioned above the center of gravity of the load in such a manner as to minimize swinging when the load is lifted.
 - 4. If there is a slack-rope condition, it should be determined that the rope is properly seated on the drum and in the sheaves.
 - 5. All personnel including the qualified rigger shall be clear of the load.
- c. During hoisting, take care to ensure that:
 - 1. The load is lifted slowly until it clears the ground or other support to minimize swinging.
 - 2. There is no sudden acceleration or deceleration of the moving load.
 - 3. The load does not contact any obstructions. A “dry run” shall be conducted in areas where clearance is limited.
 - 4. Cranes shall not be used for side pulls except when specifically authorized by an appointed person who has determined that the stability of the crane is not endangered and that load-bearing parts of the crane will not be overstressed.
 - 5. Avoid carrying loads above people.
 - 6. Each time a load approaching the rated capacity is handled, test the hoist brakes by raising the load a few inches and applying the brakes. Any slippage or downward motion is unacceptable.

- g. Do not lower the hook below the point where less than two full wraps of rope remain on the hoisting drum.
- h. When the load or hook approaches personnel, sound the warning signal.
- i. Tag lines should be used as required to guide, snub, or otherwise control the load.
- j. Place any attached load on the ground or floor, place controls in the OFF position, and turn off the power source before leaving the crane unattended, unless required to do otherwise by an approved emergency procedure.
- k. Work on suspended loads is prohibited under normal conditions. If the responsible manager decides that it is necessary to work on a suspended load, guidelines for safe operation shall be established through consultation with the appropriate safety organization. Suspended loads that must be worked on shall be secured against unwanted movement.

7.5.8 Ordinary Lifts

- a. The requirements of all preceding paragraphs in Section 7.5, "Operation," also shall apply to ordinary lifts.
- b. An appointed person shall classify each lift into one of the DOE categories (ordinary, critical, or preengineered production) before the lift is planned.
- c. Hoisting and rigging operations for ordinary lifts require a designated leader who shall be present at the lift site during the entire lifting operation. If the lift is being made by only one person, that person assumes all responsibilities of the designated leader.
- d. Leadership designation may be by written instructions, specific verbal instructions for the particular job, or clearly defined responsibilities within the crew's organizational structure.

- e. The designated leader's responsibility shall include the following:
 - 1. Ensure that personnel involved understand how the lift is to be made.
 - 2. Ensure that the weight of the load is determined, that proper equipment and accessories are selected, and that rated capacity is not exceeded.
 - 3. Survey the lift site for hazardous/unsafe conditions.
 - 4. Ensure that equipment is properly set up and positioned.
 - 5. Ensure that a signaller is assigned, if required, and is identified to the operator.
 - 6. Direct the lifting operation to ensure that the job is done safely and efficiently.
 - 7. Stop the job when any potentially unsafe condition is recognized.
 - 8. Direct operations if an accident or injury occurs.

- f. The operator, or a designated person, shall ensure that the crane is still within the inspection interval.
- g. The operator, or a designated person, shall visually examine the crane in accordance with Section 7.2.4.

7.5.9 Critical Lifts

See Chapter 2, "Critical Lifts," for critical-lift requirements.

Exhibit I is intended to be a sample form only.
The equipment manufacturer's inspection/testing
criteria supercede any other criteria.

In cases where the equipment manufacturer does not include
inspection/testing criteria, other forms developed to facilitate
required inspection/testing are acceptable.

EXHIBIT I
(SAMPLE FORM)BRIDGE, WALL, GANTRY CRANE LOAD TEST FORM

EQUIPMENT NO. _____ MAKE _____ RATED CAPACITY _____ DATE _____

LOAD TEST INSPECTION REPORT

The following checklist identifies the items to be inspected prior to the load test. Any unusual conditions observed during the inspection should be noted in the Remarks section.

NOTES:

1. Craftsmen shall initial and date all tests, work, and inspections completed below.
2. Qualified inspector shall verify all steps prior to load test.

NO.	CRANE ITEM	DEFECT	OK	NA	NO.	CRANE ITEM	DEFECT	OK	NA
1	Load Hook & Blocks				18	Controllers			
2	Wire Rope and End Connections				19	Relays and Coils			
3	Handrails, Walkways, and Ladders				20	Conductors and Collectors			
4	Bridge and Trucks				21	Panel Wiring			
5	Bridge Wheels and Bearings				22	Resistors			
6	Trolley and Rails				23	Bypass Switches			
7	Trolley Wheels and Bearings				24	Limit Switches			
8	Crane Alignment				25	Contactor (Electrical)			
9	Runway Rail & Clamps				26	Motors			
10	Bumpers/Endstops				27	Gauges			
11	Brake System				28	Lighting System			
12	Drive Shafts, Gears, Couplings & Bearings				29	Heater and Switches			
13	Pawls, Ratchets, Spuds, & Windlocks				30	Operator's Cab			
14	Sheaves				31	Safety			
15	Warning Devices				32	Chain and Sprockets			
16	Capacity Signs				33	Structural			
17	Main Disconnect				34	Wire Rope Drum and Machinery Foundation			

REMARKS (Unusual conditions—noises, structural cracks, misalignment, etc.)

BRIDGE CRANE AND FOLLOW UP CHECKS

NOTES:

1. Craftsmen shall initial all steps completed below.
2. Qualified inspector shall verify all steps below.
3. Load test shall be performed on all new, repaired, or modified cranes prior to initial use.
4. Load test crane at 125% of rated capacity. In no case shall the load test exceed 125% of rated capacity. Test weights shall be accurate to -5%, + 0% of stipulated values.

INITIAL

- _____ 1. Set crane up for load test and qualified inspector verify inspection is complete prior to load test.
- _____ 2. The trip setting of hoist-limit devices shall be determined by tests, with an empty hook traveling at increasing speeds up to the maximum speed. The actuating mechanism of the limit device shall be located so that it will trip the device under all conditions and in sufficient time to prevent contact of the hook or load block with any part of the trolley or crane.
- _____ 3. Rig test weight to hoist hook using appropriate slings.
- _____ 4. Hoist the test load a sufficient distance to ensure that the load is supported by the crane and held by the hoist brakes.
- _____ 5. Transport the test load by means of the trolley for the full length of the bridge. Ensure during operation that the trolley runs true on the bridge. Check trolley motor, brake, and gear case for overheating.
- _____ 6. Transport the test load by means of the bridge for the full length of the runway, first in one direction with the trolley as close to the extreme right-hand end of the crane as practical and next in the other direction with the trolley as close to the extreme left-hand end of the crane as practical. Ensure that the bridge runs true on the runway rails and that no undue girder deflection occurs. Check for bridge motor, brake, and gear-case overheating.
- _____ 7. Move the test load back into the original position and lower the test load, stopping by the brakes. Hold the load for 10 min or the time required to check all primary load-bearing parts while under load for slippage, damage, or permanent deformation.
- _____ 8. Slowly lower the test load to the floor.
- _____ 9. At the completion of the load test, visually inspect the following load-bearing parts for signs of wear, deformation, and deterioration:

DEFECTIVE/OK/NA

- _____ a. Bridge track
- _____ b. Bridge wheels
- _____ c. Trolley track
- _____ d. Trolley wheels
- _____ e. Gears
- _____ f. Magnetic brakes
- _____ g. Blocks.

Visually inspect rope in accordance with Chapter 11, "Wire Rope and Slings."

- _____ a. Rope diameter: (Previous) _____ (Present) _____
- _____ b. Wear
- _____ c. Kinks
- _____ d. Broken wires
- _____ e. Other signs of deterioration.

Visually inspect the rope drum for:

- _____ a. Wear
- _____ b. Deformation
- _____ c. Deterioration.

INITIAL

- _____ 10. Qualified inspector shall perform nondestructive tests on hook by visual examination, liquid penetrant examination, or magnetic-particle examination. Acceptance: No cracks, linear indications, laps, or seams.

Hooks with more than 15% normal (new hook) throat opening shall be replaced. Hooks with more than 10 degree twist from the normal (new hook) plane of the hook shall be replaced. Hooks having more than 10% wear in the throat section or 5% elongation of the shank shall be replaced. Lubricate hook bearing and latch pin as applicable.

Establish three marks, A, B, and C, with a center punch. For ease in measuring, set distances on an even number of inches.

BEFORE LOAD TEST

Length AB _____ in.

Length BC _____ in.

AFTER LOAD TEST

Length AB _____ in.

Length BC _____ in.

Check for:

1. Wear and deformation
2. Cracks and twisting
3. Signs of opening between Point A and Point B

Load Test Inspection Date _____

Qualified Inspector _____

Operated By _____

Actual Load Test _____ lb

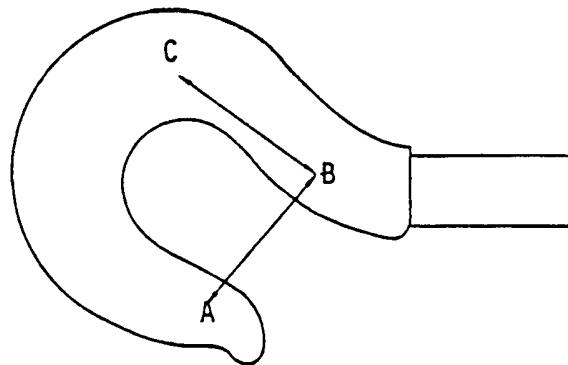


EXHIBIT II
(SAMPLE FORM)

Page 1 of 2

OVERHEAD CRANE PRE-OPERATIONAL CHECKLIST
(Records Are Not Required)

CRANE NO.	CAPACITY	TYPE	LOCATION	SHIFT 1 2 3
OPERATORS NAME:		INSTRUCTIONS: Check all items. Inspect and indicate as: Satisfactory - S, Unsatisfactory - U, or Not Applicable - NA		
1. WALK AROUND INSPECTION		S /U/ NA	2. MACHINERY INSPECTION	S/U/ NA
a	Foundations		a	Holding Brake *
b	Access		b	Load Control Brake
c	Secured Items		c	Covers Secured
d	Walkways/Handrails		d	Upper Sheaves *
e	Bridge, Drive Motor		e	Wire Rope *
f	Bridge Brake *		f	Hooks: Cracks, Wear, Deformation, * Throat Opening, Latch Operation
g	Hydraulics		g	Fluid Leaks
h	Couplers/Connection Rods		h	Batteries
i	End Trucks *		i	Electric Motors
j	Rail Sweeps		j	Electric Panels
k	Windlocks/Chock/Stops		k	Runway/Bridge Conductors
l	Housekeeping		l	Runway/Bridge Collectors
			m	Electrical Guards
			n	Festoon System
			o	Warning Tags/Signs
			p	Exposed Electrical Hazards
			q	Trolley Stops *

OVERHEAD CRANE PRE-OPERATIONAL CHECKLIST
(Records Are Not Required)

3. OPERATOR CAB INSPECTION		S/U/ NA	4. OPERATION INSPECTION		S/U/ NA
a	Housekeeping		a	Power Supply Relay	*
b	Warning Tags	*	b	Manual Reset	
c	Cab Door(s)		c	Stop Button/Control	*
d	Fire Extinguisher		d	Pendant Buttons	*
e	Controls Identification		e	Upper Limit/Main	*
f	Electrical Enclosures		f	Upper Limit/Auxiliary	*
g	Pendant Strain Relief		g	Lower Limit/Main	
h	Visibility/Windows		h	Lower Limit/Auxiliary	
i	Safety Devices		i	Bridge Controls	*
j	Warning/Indicator Light		j	Bridge Brake	*
k	Alarms		k	Trolley Control	*
			l	Main Hook	*
			m	Auxiliary Hook	*
			n	Work Area	
			o	Runway Stops	*
			p	Travel Limit Relays	*
INSTRUCTIONS: Inspect all applicable items each shift of operation. Suspend all operations immediately when observing an unsatisfactory condition for asterisked (*) items. In addition, suspend operation when any unsafe condition is observed and immediately notify supervisor. Other conditions not affecting safety shall be noted under "Remarks" and reported to supervisor.					
REMARKS:					

EXHIBIT III
(SAMPLE FORM)

Page 1 of 2

PERIODIC CRANE INSPECTION REPORT

MECHANICAL ITEMS					
MAKE:	CAPACITY:		LOCATION:		
STATUS CODE: SR - Should be Replaced NR - Needs Repair R - Repaired SN - See Notes N/A - Not Applicable					
ITEM	OK	CODE	ITEM	OK	CODE
Bridge			- Cam Followers/Guide*		
- Alignment			- Runway End-Stops		
- Girders (camber)			- Railway Sweeps / Safety Lugs		
- Rails			- Energy Absorbing Bumpers		
- Walks, Ladders, Railings			Mono Rail		
- Trucks to Girder Connection			- Girders		
- Trucks			- Girder Supports		
- Wheels, Driver *			- Sway Braces		
- Wheels, Idler *			Misc.		
- Wheels, Bearings *			- Clearances Overhead (3")		
- Axles & Coupling *			- Clearances Lateral (2")		
- Squaring Shaft			Rated Load Markings:		
- Squaring Shaft Bearings			- Each Side of Crane Bridge		
- Squaring Shaft Couplings			- Each Hoist/Load Block		
- Motor Coupling *			Trolley Drive		
- Gear Reducer			- Wheels, Driver *		
- Gear Reducer Oil Seals			- Wheels, Idler *		
- Axle Pinion			- Wheels Bearings *		
- Axle Gear			- Axles & Couplings		
- Runway Alignment			- Motor Couplings *		

EXHIBIT III (continued)
(SAMPLE FORM)

Page 2 of 2

ITEM	OK	CODE	ITEM	OK	CODE
- Gear Reducer			- Drum Grooving		
- Gear Reducer Oil Seals			- Drum Shafts		
- Axle Pinion			- Motor Pinion		
- Axle Gear			- Motor Gear		
- Cam Followers/Guides *			- Intermediate Pinion		
- Energy Absorbing Bumpers			- Intermediate Gear		
- End Stops			- Drum Pinion		
Hoist (M - Main) (A - Auxiliary)			- Drum Gear		
- Hook			- Hoist Case Bearing		
- Hook Bearing			- Mechanical Load Brake*		
- Sheaves *			- Friction Disc*		
- Sheave Bearings *			- Pawl *		
- Equalizer Sheave *			- Pawl Shifter		
- Rope/Chain			- Ratchet or Band		
- Rope Anchors			- Motor Coupling *		
			- Hoist Case Coupling *		
Needs Immediate Action:					
Notes:					
Circle One: PASS FAIL					
INSPECTOR (print): _____ SIGNATURE: _____ DATE: _____					

Items with * to be inspected prior to use as part of the Pre-Operational check and lubricated as needed. All other items to be inspected and lubricated annually.

EXHIBIT IV
(SAMPLE FORM)

Page 1 of 2

OVERHEAD CRANE PERIODIC INSPECTION REPORT

ELECTRICAL ITEMS						
MAKE:	CAPACITY:		LOCATION:			
STATUS CODE: SR - Should be Replaced NR - Needs Repair R - Repaired SN - See Notes N/A - Not Applicable						
ITEM	OK	CODE		ITEM	OK	CODE
Brakes				- Trolley Motor rings		
- M.H. Brake Shoes & Disc				- M.H. Motor Bearings		
- M.H. Brake Linings *				- M.H. Motor Brushes *		
- M.H. Brake Linkage				- M.H. Motor Rings		
- M.H. Brake Coil				Misc		
- A.H. Brake Shoes & Discs						
- A.H. Brake Lining *						
- A.H. Brake Linkage						
- A.H. Brake Coil						
- Trolley Brake Shoes & Disc						
- Trolley Brake Lining *				Controls		
- Trolley Brake Linkage				- For Magnetic Control		
- Trolley Brake Coils				- Master Switches		
- Hydraulic Brake Bleeder *				- Push-button Station		
Motors				- M.H. Contactors		
- Bridge Motor Bearings				- A.H. Contactors		
- Bridge Motor Brushes *				- Trolley Contactors		
- Bridge Motor Rings				- Bridge Contactors		
- Trolley Motor Bearings				- M.H. Overhead Relays		
- Trolley Motor Brushes *				- A.H. Overhead Relays		

EXHIBIT IV (continued)
(SAMPLE FORM)

Page 2 of 2

ITEM	OK	CODE	ITEM	OK	CODE
Controls (continued)			Resistors		
- Trolley Overhead Relays			- M.H. Resistors		
- Bridge Overhead Relays			- A.H. Resistors		
- M.H. Limit Switch Contacts			- Trolley Resistors		
- A.H. Limit Switch Contacts			- Bridge Resistors		
For Manual Drum Control			Mainline		
- M.H. Finger Tips*			- Mainline Switch		
- M.H. Segments *			- Fuses (Sizes)		
- A.H. Finger Tips *			- Power Wiring		
- A.H. Segments *			- Control Wiring		
- Trolley Finger Tips *			- Trolley Collectors *		
- Trolley Segments *			- Runway Collectors *		
- Bridge Finger Tips *			- Bridge Conductors		
- Bridge Segments *			- Runway Conductors		
Needs Immediate Action:					
Notes:					
Circle One: <input type="radio"/> PASS <input type="radio"/> FAIL					
INSPECTOR (Print): _____ SIGNATURE: _____ DATE: _____					

Items with * to be inspected prior to use as part of the Pre-operational check and lubricated as needed.
All other items to be inspected and adjusted annually.

CHAPTER 9

MOBILE CRANES

9.2 INSPECTIONS

9.2.1 General

Equipment shall operate with a smooth, regular motion without any hesitation, abnormal vibration, binding, gross shimmy, or irregularity. There shall be no apparent damage, excessive wear, or deformation of any load-bearing part of the equipment. All safety devices, load indicators, boom angle and radius indicators, controls, and other operating parts of the equipment shall be checked during each inspection and shall be in good working order.

9.2.2 Initial Inspection

Prior to initial use, all new or modified cranes shall be inspected as required in Section 9.2.6, "Periodic Inspection," by a qualified inspector to ensure compliance with the applicable provisions of this chapter. Dated and signed inspection reports shall be kept on file and shall be readily available.

9.2.3 Daily Preoperational Check

a. Operators or other designated personnel shall visually inspect items such as the following each day or prior to use if the crane has not been in regular service (records are not required):

1. All control mechanisms for maladjustment interfering with proper operation.
2. Crane hooks and latches for deformation, cracks, and wear.
3. Hydraulic systems for proper oil level.
4. Lines, tanks, valves, pumps, and other parts of air or hydraulic systems for leakage.
5. Hoist ropes for kinking, crushing, birdcaging, and corrosion.
6. Anti-two-block, two-block warning, and two-block damage prevention systems for proper operation.
7. Booms for damage or deformation of structural components.

b. Operators or other designated personnel shall examine deficiencies and determine

whether they constitute a safety hazard.

9.2.4 Monthly Inspection

a. The operator or other designated person shall visually inspect the following items for damage, wear, or other deficiency that might reduce capacity or adversely effect the safety of the crane:

1. Critical items such as brakes and crane hooks.
2. Hoist ropes.
- b. Lower the hook block to its lowest position and examine for any condition that could result in an appreciable loss of strength.
- c. Hooks for cracks, deformation, damage from chemicals, latch engagement (if provided), and evidence of heat damage.
- d. A hoist rope with any of the conditions noted in the replacement criteria in Section 9.2.6 shall be removed from service and replaced.
- e. Signed and dated inspection records shall be kept on file and shall be readily available.
- f. Before the crane is returned to service, correct deficiencies that could reduce its capacity or adversely effect its safety.

9.2.5 Frequent Inspection

a. Operators or other designated personnel shall visually inspect the crane at daily to monthly intervals (records are not required).

b. These inspections shall, in addition to the requirements of Section 9.2.3, "Preoperational Check," include the following:

1. All control mechanisms for maladjustment, excessive wear, and contamination by lubricants or other foreign matter that could interfere with proper operation.
2. All safety devices for malfunction.
3. Rope reeving for noncompliance with crane manufacturer's recommendations.
4. Electrical apparatus for malfunctioning, signs of excessive deterioration, and accumulation of dirt or moisture.

- 5. Tires for recommended inflation pressure.
- 6. Boom sections for damaged, deformed, or missing structural members or parts.
- c. Operators or other designated personnel shall examine deficiencies and determine whether a more detailed inspection is required.

9.2.6 Periodic Inspection

- a. Complete inspections of the crane shall be performed by a qualified inspector at 1- to 12-month intervals, depending on the crane's activity, severity of service, and environment.
- b. The qualified inspector shall examine deficiencies and determine whether they constitute a hazard.
- c. Dated and signed inspection records shall be kept on file and shall be readily available.
- d. A sample load test form is included as Exhibit I, which appears at the end of this chapter. This form is intended to be a sample only and is not intended to be mandatory.
- e. These inspections shall, in addition to the requirements of Sections 9.2.4, "Monthly Inspection," and 9.2.5, "Frequent Inspection," include the following.

9.2.6.1 Cranes

Inspect for:

- a. Deformed, cracked, or corroded members in the crane structure and entire boom.
- b. Bolts, rivets, nuts, and pins for being loose or absent
- c. Check for suspect/counterfeit parts (see Terminology and Definitions, Chapter 1).
- d. Cracked or worn sheaves and drums.
- e. Hooks damaged from chemicals, deformation, or cracks, or having more than 15 percent in excess of normal throat opening or more than 10 degree twist from the plane of the unbent hook (dye-penetrant, magnetic-particle, or other suitable crack-detecting inspections should be performed at least once a year; see Chapter 13, "Load Hooks," for additional hook requirements).
- f. Worn, cracked, or distorted parts such as pins, bearings, shafts, gears, rollers, and locking devices.

- g. Excessive wear on brake and clutch system parts, linings, pawls, and ratchets.
- h. Load, boom angle, and other operating aids over their full ranges for any significant inaccuracies (if calibration is required, it shall be done by a qualified person).
- i. Gasoline, diesel, electrical, or other power plants for improper performance or noncompliance with safety requirements.
- j. Radiators and oil coolers, for leakage, improper performance, or blockage of air passages.
- k. Excessive wear of chain drive sprockets and excessive chain stretch.
- l. Steering, braking, and locking devices, for malfunctioning.
- m. Excessively worn or damaged tires.
- n. Rust on piston rods and control valves when crane has been idle.

9.2.6.2 Hydraulic and Pneumatic Hose, Fittings, and Tubing

Inspect for:

- a. Evidence of leakage at the surface of the flexible hose or its junction with the metal couplings.
- b. Blistering or abnormal deformation of the outer covering of the hydraulic or pneumatic hose.
- c. Leakage at threaded or clamped joints that cannot be eliminated by normal tightening or recommended procedures.
- d. Evidence of excessive abrasion or scrubbing on the outer surface of a hose, rigid tube, or fitting (means shall be taken to eliminate the interface of elements in contact or to otherwise protect the components).

9.2.6.3 Hydraulic and Pneumatic Pumps and Motors

Inspect for:

- a. Loose bolts or fasteners.
- b. Leaks at joints between sections.
- c. Shaft seal leaks.
- d. Unusual noises or vibration.

- e. Loss of operating speed.
- f. Excessive heating of the fluid.
- g. Loss of pressure.

9.2.6.4 Hydraulic and Pneumatic Valves

Inspect for:

- a. Cracks in valve housing.
- b. Improper return of spool to neutral position.
- c. Leaks at spools or joints.
- d. Sticking spools.
- e. Failure of relief valves to attain correct pressure setting (relief valve pressures shall be checked as specified by the manufacturer).

9.2.6.5 Hydraulic and Pneumatic Cylinders

Inspect for:

- a. Drifting caused by fluid leaking across the piston.
- b. Rod seal leakage.
- c. Leaks at welded joints.
- d. Scored, nicked, or dented cylinder rods.
- e. Dented case (barrel).
- f. Loose or deformed rod eyes or connecting joints.

9.2.6.6 Hydraulic Filters

Evidence of rubber particles on the filter element may indicate deterioration of the hose, "O" ring, or other rubber components. Metal chips or pieces on the filter may denote failure in pumps, motors, or cylinders. Further checking will be necessary to determine the origin of the problem before corrective action can be taken.

9.2.6.7 Wire Rope

- a. A qualified inspector shall inspect wire ropes at least annually. More frequent intervals shall be determined by a qualified person and shall be based on such factors as expected rope life as determined by severity of environment, percentage of capacity lifts, frequency rates of

operation, and exposure to shock loads. The qualified inspector shall carefully note any deterioration, such as described below, that results in appreciable loss of original strength and determine whether further use of the rope constitutes an acceptable risk. This inspection shall include examination of the entire rope length without detaching it from the drum.

1. Reduction of rope size below nominal diameter, whether due to loss of core support, internal or external corrosion, or wear of outside wires (see Table 9-2).

Table 9-2. Maximum allowable rope reductions.

Rope diameter	Maximum allowable reduction from nominal diameter
Up to 5/16 in. (8 mm)	1/64 in. (0.4 mm)
Over 5/16 in. to 1/2 in. (13 mm)	1/32 in. (0.8 mm)
Over 1/2 in. to 3/4 in. (19 mm)	3/64 in. (1.2 mm)
Over 3/4 in. to 1 1/8 in. (29 mm)	1/16 in. (1.6 mm)
Over 1 1/8 in. to 1 1/2 in. (38 mm)	3/32 in. (2.4 mm)

2. The number and distribution or concentration of broken outside wires.
3. Worn outside wires.
4. Corroded or broken wires at end connections.
5. Corroded, cracked, bent, worn, or improperly applied end connections.
6. Kinking, crushing, cutting, or unstranding.

b. The qualified inspector shall take care when inspecting running rope where rapid deterioration could occur, such as in the following:

1. Sections in contact with saddles, equalizer sheaves, or other sheaves where rope travel is limited.
2. Sections of the rope at or near terminal ends where corroded or broken wires may protrude.

c. The qualified inspector shall take care when inspecting certain ropes such as the following:

1. Rotation-resistant ropes, because of their higher susceptibility to damage. The internal deterioration of rotation-resistant ropes may not be readily observable.
2. Boom hoist ropes, because of the difficulties of inspection and the important nature of these ropes.

d. No precise rules can be given for determining the exact time to replace wire rope because many factors are involved. Safety in this respect depends largely on the use of good judgment by an appointed person in evaluating remaining strength in a used rope, after allowance for deterioration disclosed by inspection. Safety of rope operation depends on this remaining strength.

e. Conditions such as the following shall be sufficient reason for questioning wire-rope safety and for considering replacement:

1. In running ropes, 6 randomly distributed broken wires in one rope lay, or 3 broken wires in one strand in one rope lay.
2. 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.
3. In rotation resistant ropes, two randomly distributed broken wires in six rope diameters or four randomly distributed broken wires in thirty rope diameters.
4. One outer wire broken at the point of contact with the core of the rope that has worked its way out of the rope structure and protrudes or loops out from the rope structure; additional inspection of this part of the rope is required.
5. Wear of one-third the original diameter of outside individual wires.
6. Kinking, crushing, birdcaging, or any other damage resulting in distortion of the rope structure.
7. Evidence of heat damage from any cause.

8. Reduction from nominal diameter greater than the amounts listed in Table 9-2.

f. All rope that has been idle for a month or more due to shutdown or storage of a crane on which it is installed shall be inspected before it is placed in service. This inspection shall be for all types of deterioration and shall be performed by an appointed person whose approval shall be required before further use of the rope. A written and dated report of the rope condition shall be filed.

g. In order to establish data as a basis for judging the proper time for replacement, a continuing inspection record shall be maintained.

h. Replacement rope shall be the same size, grade, and construction as recommended by the crane manufacturer, unless otherwise recommended by a rope or crane manufacturer due to actual working-condition requirements.

i. Never use discarded wire rope for slings.

9.2.7 Load Hooks/Load Blocks

Load hooks/load blocks that have been changed out shall be inspected by a qualified inspector before returning the crane to service. Inspection records shall be retained throughout the service life of the hook or load block and shall be readily available.

9.2.8 Cranes Not in Regular Use

a. A crane that has been idle for 1 month or more but less than 6 months shall be given an inspection according to the requirements of Section 9.2.5 before being placed in service.

b. A crane that has been idle for more than 6 months shall be given a complete inspection according to the requirements of Section 9.2.6 before being placed in service.

c. Standby cranes shall be inspected at least semiannually, according to the requirements of Section 9.2.6. Cranes exposed to adverse environments should be inspected more frequently.

9.3 TESTING

9.3.1 Operational Tests

The following shall be tested during an initial test:

- a. Load lifting and lowering mechanisms.
- b. Boom lifting and lowering mechanisms.
- c. Boom extension and retraction mechanism.
- d. Swinging mechanism.
- e. Travel mechanism.
- f. Safety devices.

9.3.2 Rated Load Test

- a. Prior to initial use, all cranes in which load-sustaining parts have been modified, replaced, or repaired shall be load-tested by a qualified inspector or under the direction of that inspector. A designated or authorized

person shall determine if repairs made to a crane are extensive and require a rated load test, or if repairs are routine maintenance and require only operational testing. The replacement of rope is excluded from this requirement. However, a functional test of the crane under a normal operating load should be made prior to putting it back in service.

- b. Test weights shall not exceed 110 percent of the rated capacity and shall be accurate to within -5 percent, +0 percent of stipulated values.

NOTE: Load tests shall not be conducted in locations where the lift meets the definition of a critical lift (see Chapter 1, "Terminology and Definitions").

- c. A written report shall be furnished by the inspector showing test procedures and confirming the adequacy of repairs or alterations. Test reports shall be kept on file and shall be readily available to appointed personnel.

EXHIBIT I
(SAMPLE FORM)

Page 1 of 4

MOBILE CRANE LOAD TEST

LICENSE OR EQUIPMENT NO. _____ MAKE _____ DATE _____

HOUR METER-ODOMETER TOTAL _____ RATED CAPACITY _____

LOAD TEST INSPECTION REPORT

The following checklist identifies the items to be inspected prior to the load test. Any unusual conditions observed during the inspection should be noted in the Remarks section. Equipment shall be inspected by maintenance personnel prior to load test.

NOTES: 1. Qualified inspector shall verify the inspection is completed.
2. Craftsmen shall initial and date all tests, work, and inspections completed below.

NO.	CRANE ITEM	DEFECT	OK	NA	NO.	CRANE ITEM	DEFECT	OK	NA
1	Wire Rope				13	Hoist Clutch Lining			
2	Cracked or Worn Sheaves & Drums				14	Hoist Drum Brake Bands			
3	Limit Switch (Anti-Two-Blocking)				15	Open Gears			
4	Boom				16	Boom Jibs (Where Applicable)			
5	Master Clutch				NO.	CARRIER ITEM	DEFECT	OK	NA
6	Steering Clutches				1	Steering Gears and Connections			
7	Hydraulic Pump				2	Brakes (Service and Hand)			
8	Hydraulic Controls				3	Tires and Wheels			
9	Hydraulic Hoses				4	General Lubrication			
10	Mechanical Controls				OPERATING TEST				
11	Drive Chains				OVERALL CONDITION				
12	Swing Clutches								

REMARKS (Unusual conditions—noises, structural cracks, misalignment, etc.)

SAFETY ITEMS: (Fire extinguisher, signs, guards, etc.)

CHAPTER 10

FORKLIFT TRUCKS

10-1 GENERAL

This chapter specifies operation, inspection, testing, and maintenance requirements for industrial trucks powered by electric motors or internal-combustion engines. See Figures 10-3 for examples of powered industrial trucks.

Guidelines may also be taken from this chapter regarding pallet trucks and other small miscellaneous non-powered lift trucks (see Figure 10-4), but training, operating, maintenance, inspection, and testing requirements for non-powered equipment shall be based on the manufacturer's instructions and recommendations.

10.1.1 Operator Training/ Qualification

Operators of forklift trucks shall be trained and qualified as described in Chapter 6, "Personnel Qualification and Training."

10.1.2 Rated Capacity

Rated capacity is the maximum weight the truck can transport and stack at a specified load center and for a specified load elevation. Trucks shall not be used or tested above their rated capacities.

10.1.3 Nameplate(s) and Marking

Every truck shall have appended to it a durable, corrosion-resistant nameplate(s), legibly inscribed with the following information:

- a. Truck model and truck serial number.
- b. Weight of truck.
- c. Rated capacity.
- d. Designation of compliance with the mandatory requirements of ASME B56.1, "Safety Standard for Low and High Lift Trucks," applicable to the manufacturer.
- e. Type designation to show conformance with the requirements, such as those prescribed

by Underwriters Laboratories, Inc., and Factory Mutual Research Corporation.

f. Batteries for use in electric trucks shall have the battery weight legibly stamped on the battery tray near the lifting means as follows: Service Weight _____ lb(kg).

In addition to the above requirements, additional information is required (and allowed) on nameplates on high-lift trucks, electric trucks, and trucks intended for hazardous locations (see ASME B56.1, Section 7.5, "Nameplates and Markings").

10.1.3.1 Fork Arm Data

For forklift trucks purchased after December 1984, each fork arm shall be clearly stamped with its rated capacity in an area readily visible and not subject to wear. For example, the designation 1500 @ 24 means 1,500-lb (680-kg) capacity at 24-in. (600-mm) load center.

10.1.4 Attachments

Attachments almost always affect rated capacity of the truck. When a forklift truck is equipped with an attachment, the rated capacity of the truck/attachment combination shall be established by the truck manufacturer. Capacity, operation, and maintenance instruction plates, tags, or decals shall be changed accordingly.

- a. The rated capacity of an attachment/truck combination shall not be exceeded.
- b. On every removable attachment (excluding fork extensions), a corrosion-resistant nameplate with the following information is required:
 1. Model number
 2. Serial number on hydraulically actuated attachments
 3. Maximum hydraulic pressure (on hydraulically actuated attachments)
 4. Weight
 5. Capacity

6. The following instructions (or equivalent); "Capacity of truck and attachment combination may be less than capacity shown on attachment. Consult truck nameplate."

NOTE: The above information should be provided by the attachment manufacturer.

10.1.5 Modifications

Modifications or additions that affect capacity or safe operation shall not be performed without prior written approval from the forklift truck manufacturer. Capacity, operation, and maintenance instruction plates, tags, or decals shall be changed accordingly.

10.1.6 Warning Devices

- a. Every truck shall be equipped with an operator-controlled horn, whistle, gong, or other sound-producing device(s).
- b. The using organization shall determine if operating conditions require the truck to be equipped with additional sound-producing or visual devices (such as lights or blinkers), and shall be responsible for providing and maintaining such devices. Backup or motion alarms that sound continuously may be warranted in special cases but generally are less effective than operator-controlled devices.

10.1.7 Overhead Guards

An overhead guard is intended to offer protection to the operator from falling objects, but it cannot protect against every possible impact. Therefore, it should not be considered a substitute for good judgement and care in load handling.

- a. High lift rider trucks, including order picker trucks, shall be equipped with an overhead guard manufactured in accordance with ASME B56.1, unless the following conditions are met:

1. Vertical movement of the lifting mechanism is restricted to 72 in. (1800 mm) or less from the ground.

2. The truck will be operated only in an area where:

- i. The bottom of the top tiered load is not higher than 72 in. (1800 mm) and the top is not more than 120 in. (3000 mm) from the ground where tiered.
- ii. Only stable (preferably interlocked, unitized or containerized) loads are handled.
- iii. There is protection against falling objects from adjacent high stack areas.

b. Rough terrain forklift trucks shall be fitted with an overhead guard manufactured in accordance with ASME B56.6.

10.1.8 Fire Hazard Areas

Powered forklift trucks for operation in fire hazard areas shall be of the type recommended in ANSI/NFPA 505 ("Powered Industrial Trucks, Type Designation and Areas of Use").

10.1.9 Work Atmosphere

- a. The operation of forklift trucks may effects the concentrations of carbon monoxide and oxygen in the work location. Concentrations of these materials in the work location must meet the requirements of 29 CFR 1910.1000, Table Z-1 Limits For Air Contaminants, Occupational Safety and Health Standards for General Industry.
- b. Where general lighting is less than 2 lumens per square foot, auxiliary directional lighting shall be provided on the truck.

Figure 10-3. Types of Trucks. (Sheet 1 of 6)

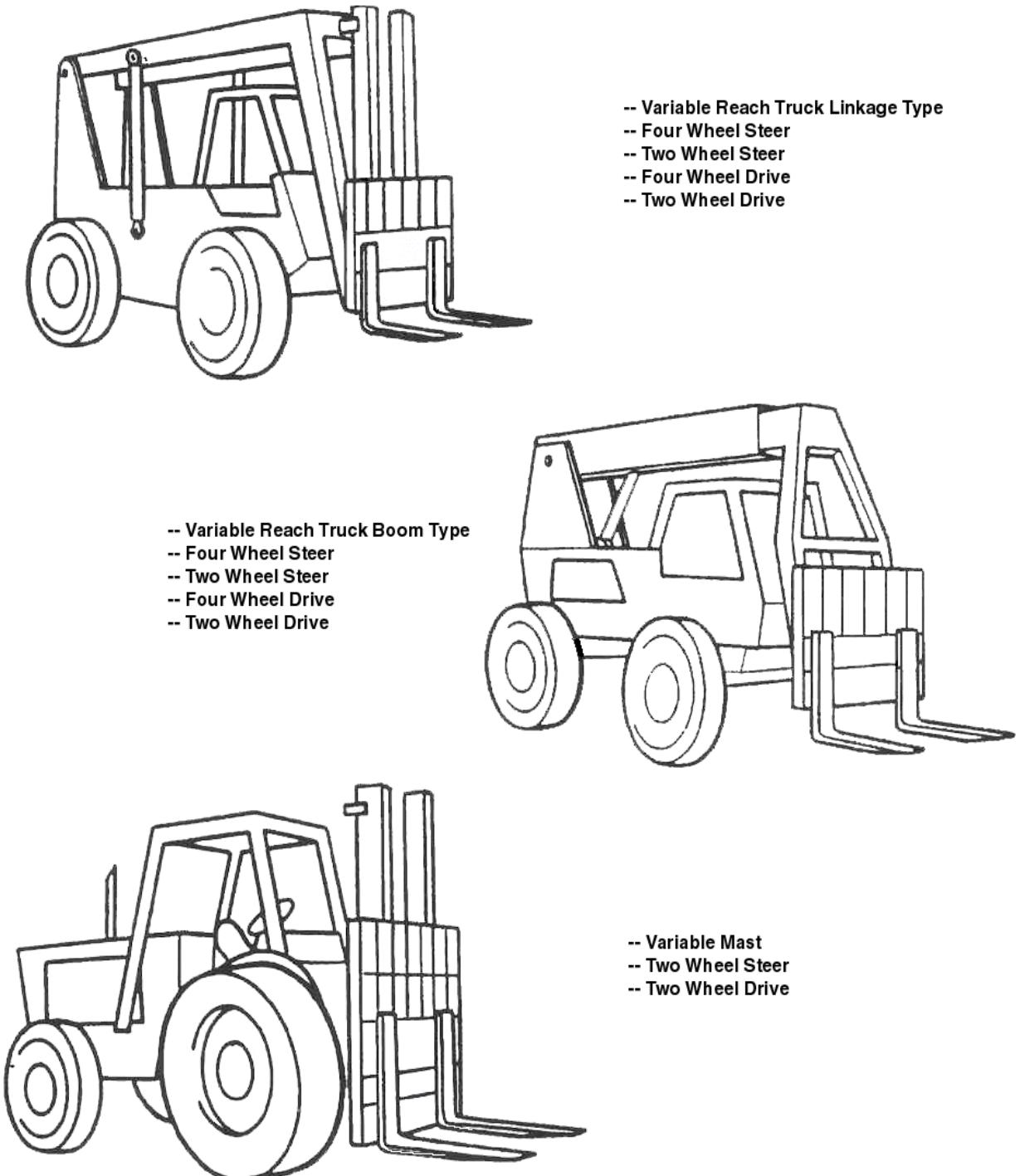


Figure 10-3. Types of Trucks. (sheet 2 of 6)

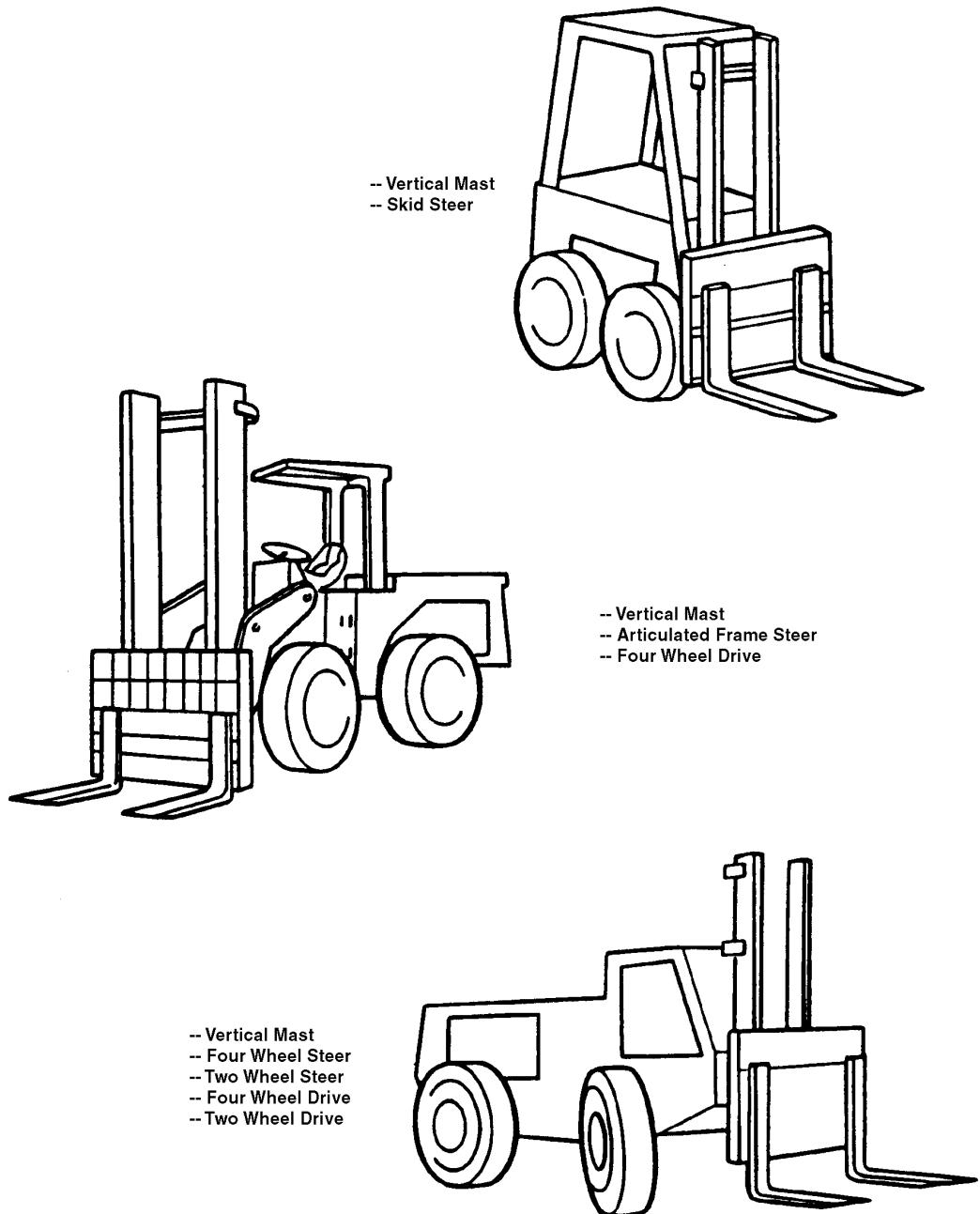


Figure 10-3. Types of Trucks. (sheet 3 of 6)

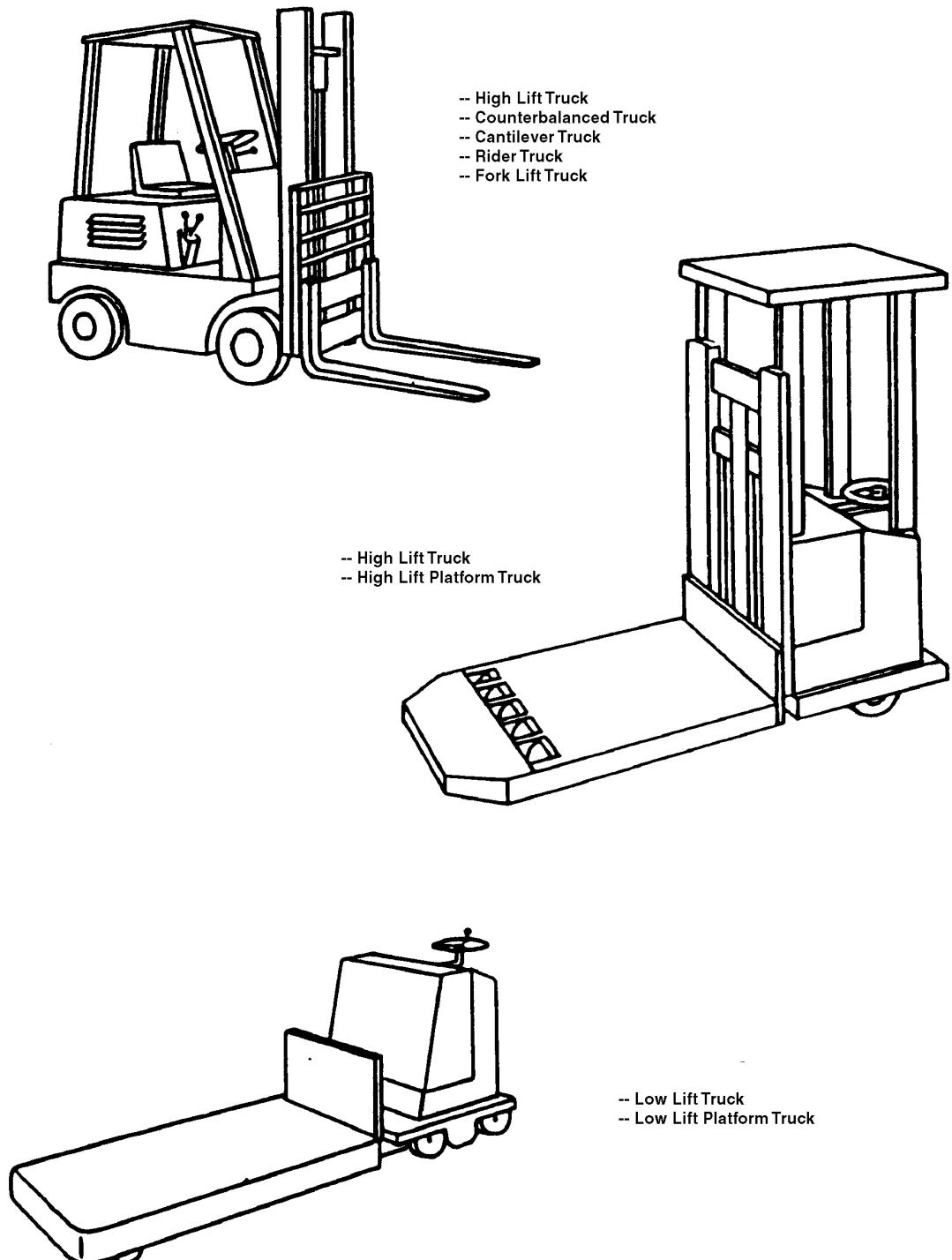
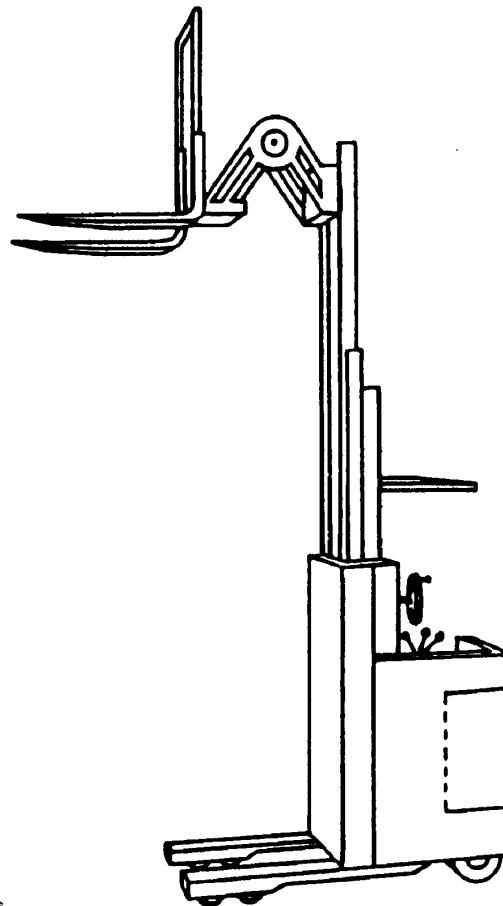


Figure 10-3. Types of Trucks. (sheet 4 of 6)



-- Reach Rider Trucks

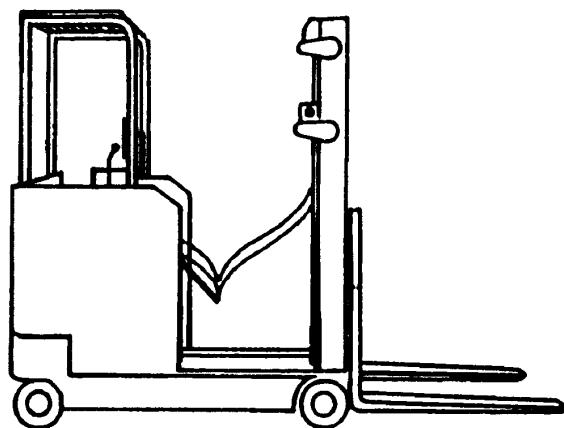


Figure 10-3. Types of Trucks. (sheet 5 of 6)

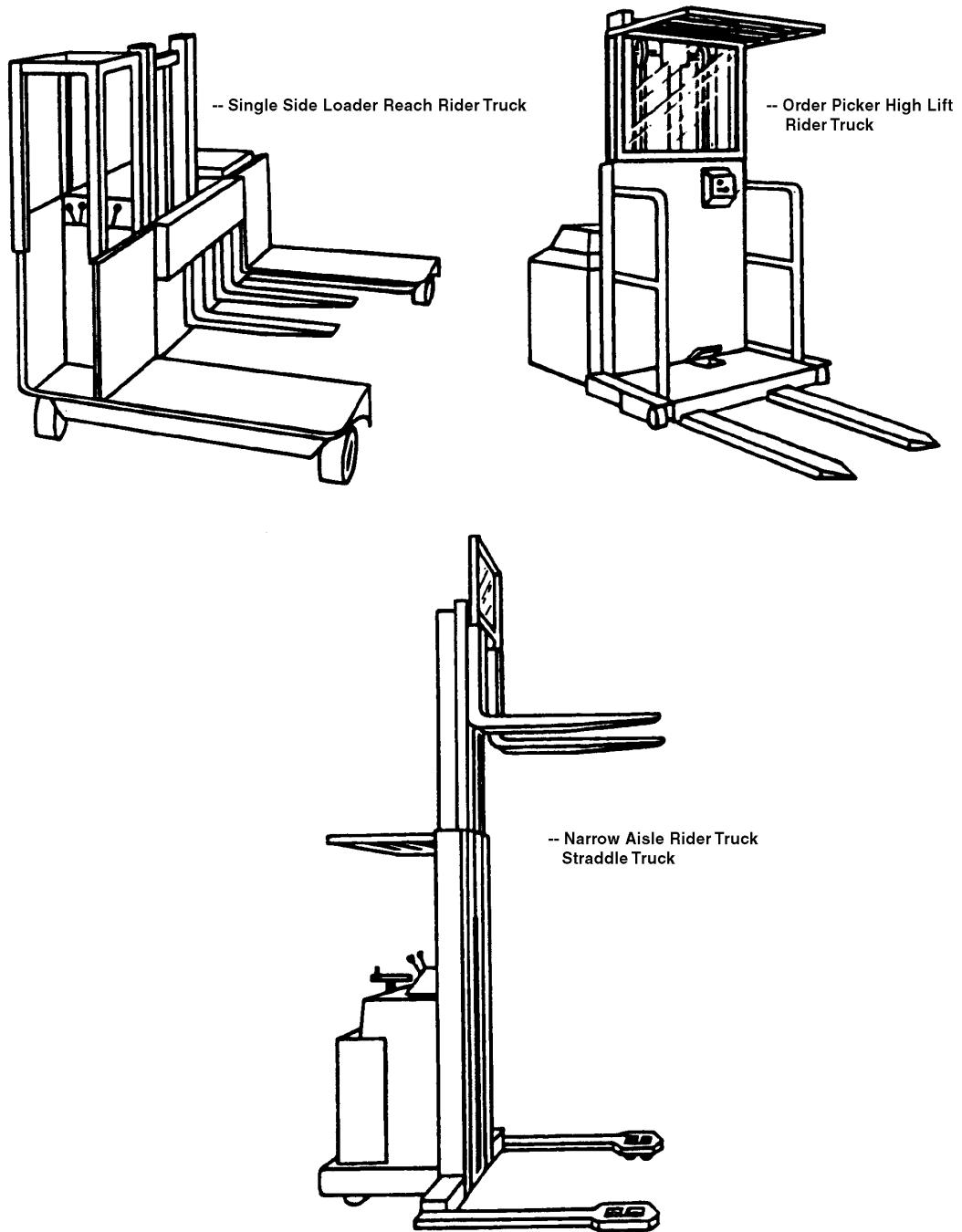
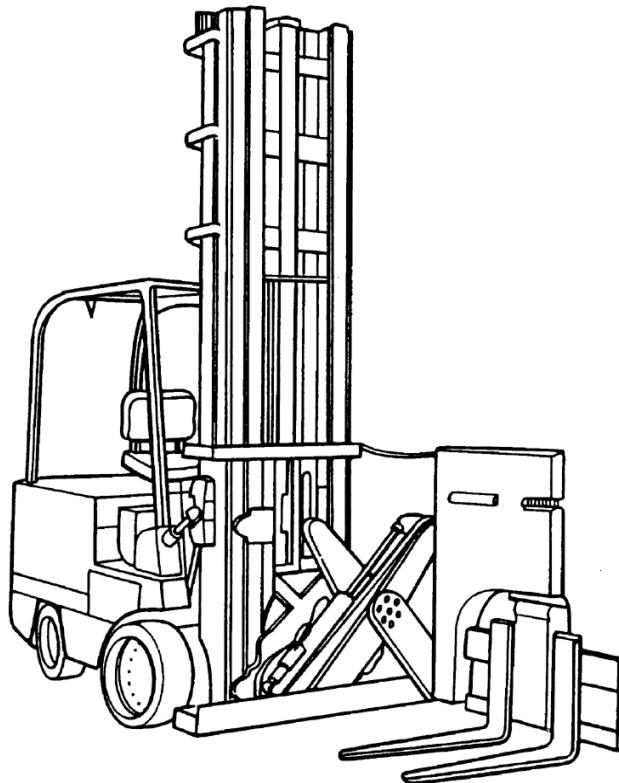
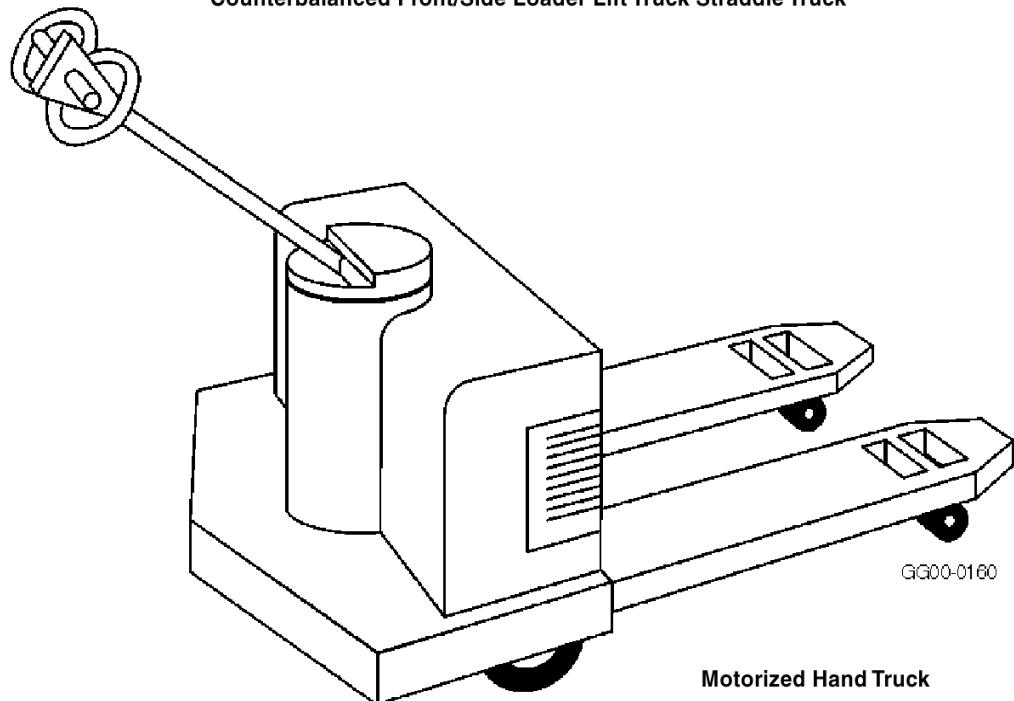


Figure 10-3. Types of Trucks. (sheet 6 of 6)



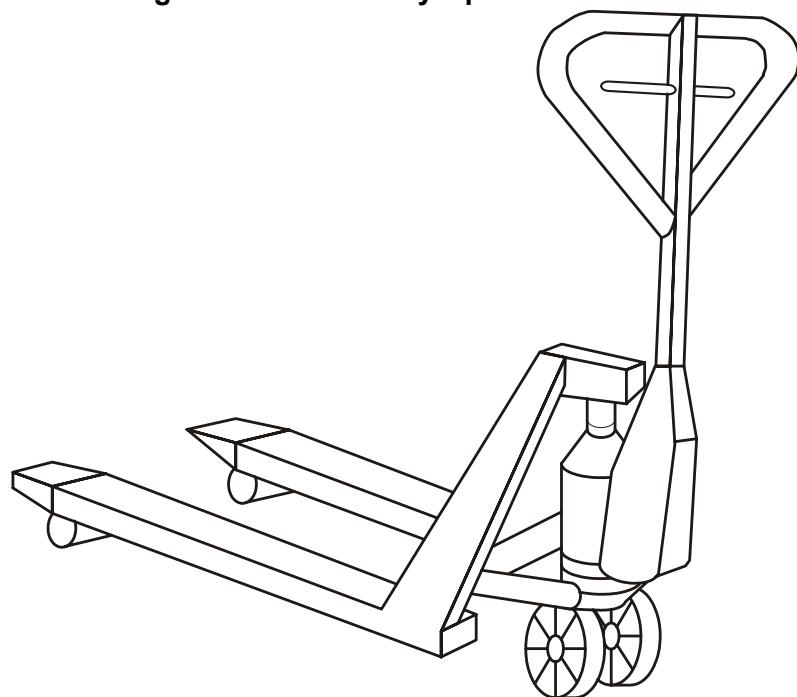
Counterbalanced Front/Side Loader Lift Truck Straddle Truck



Motorized Hand Truck

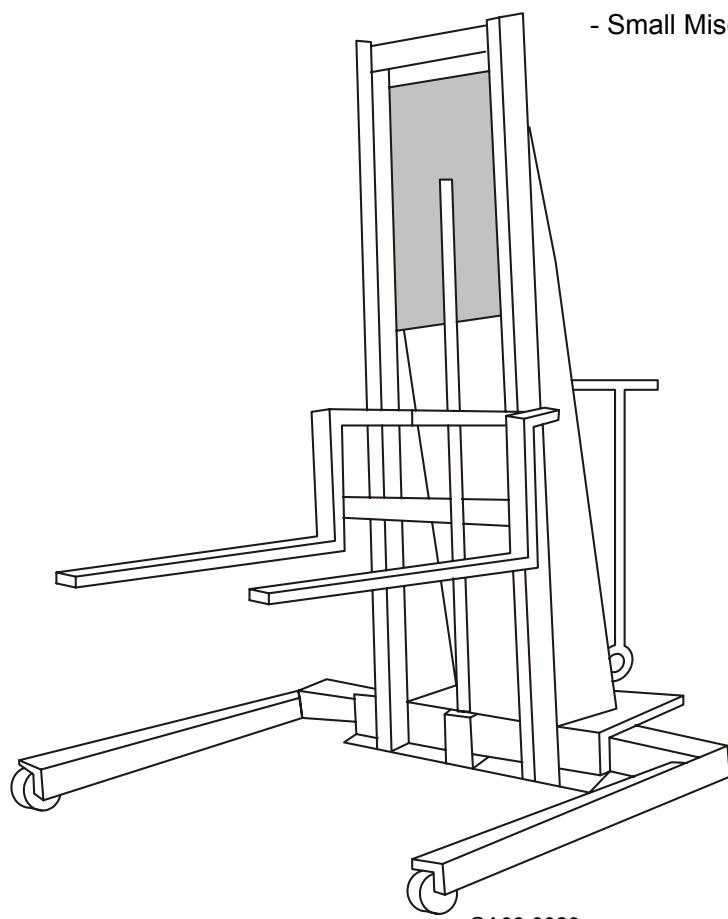
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Figure 10-4. Manually Operated Pallet Trucks



GA99 0028

- Small Miscellaneous Truck



GA99 0029

10.2 TYPE DESIGNATIONS AND AREAS OF USE

10.2.1 Type Designation

It is essential to use proper equipment in hazardous (explosive) areas. Trucks approved for use in hazardous areas shall have the manufacturer's label or some other identifying mark indicating approval for the intended use by a recognized national testing laboratory [e.g., Underwriters Laboratories (UL) or Factory Mutual (FM)].

- a. Durable markers indicating the designation of the type of truck for use in hazardous areas shall be applied to each side of the vehicle in a visible but protected area. These markers shall be distinctive in shape, as indicated in Figure 10-1.
- b. Hazardous-Area Signs. The entrance to hazardous areas shall be posted with a sign to identify the type of forklift truck permitted, see Figure 10-2, or the truck shall be clearly marked as to the area(s) it is not to enter.

10.2.1.1 Non-Hazardous Areas

The following units are not suitable for use in hazardous areas since they include only minimum safeguards against inherent fire hazards:

- a. *Type D Forklifts* — diesel-powered units having minimum acceptable safeguards against inherent fire hazards
- b. *Type E Forklifts* — electrically powered units having minimum acceptable safeguards against inherent fire and electrical shock hazards
- c. *Type G Forklifts* — gasoline-powered units having minimum acceptable safeguards against inherent fire hazards
- d. *Type LP Forklifts* — liquefied-petroleum-gas-powered units having minimum acceptable safeguards against inherent fire hazards

10.2.1.2 Hazardous Areas

The following units are suitable for use in hazardous areas since they are equipped with additional safeguards (i.e., special exhaust, fuel, or electrical systems) or other modifications against inherent fire hazards:

- a. *Type DS Forklifts* — diesel-powered units that are provided with all the requirements for the type D units and that have additional safeguards to the exhaust, fuel, and electrical systems
- b. *Type DY Forklifts* — diesel-powered units that have all the safeguards of the type DS units except that they do not have any electrical equipment, including ignition; they are equipped with temperature-limitation features
- c. *Type ES Forklifts* — electrically powered units that are provided with all the requirements for the type E units and that have additional safeguards to the electrical system to prevent emission of hazardous sparks and to limit surface temperatures
- d. *Type EE Forklifts* — electrically powered units that are provided with all the requirements for the type E and ES units, and that also have electric motors and all other electrical equipment completely enclosed
- e. *Type EX Forklifts* — electrically powered units that differ from type E, ES, or EE units in that the electrical fittings and equipment are designed, constructed, and assembled so that the units may be used in atmospheres containing specifically named flammable vapors, dusts, and, under certain conditions, fibers; type EX units are specifically tested and classified for use in Class I, Group D, or for Class II, Group G locations as defined in NFPA 70, *National Electrical Code*

f. *Type GS Forklifts* — gasoline-powered units that, in addition to all the requirements for the type G units, are provided with additional safeguards to the exhaust, fuel, and electrical systems

g. *Type LPS Forklifts* — liquefied-petroleum-gas-powered units that, in addition to the requirements for the type LP units, are provided with additional safeguards to the exhaust, fuel, and electrical systems.

10.2.2 Specific Areas of Use

The atmosphere or location where the powered forklift is to be used shall be classified.

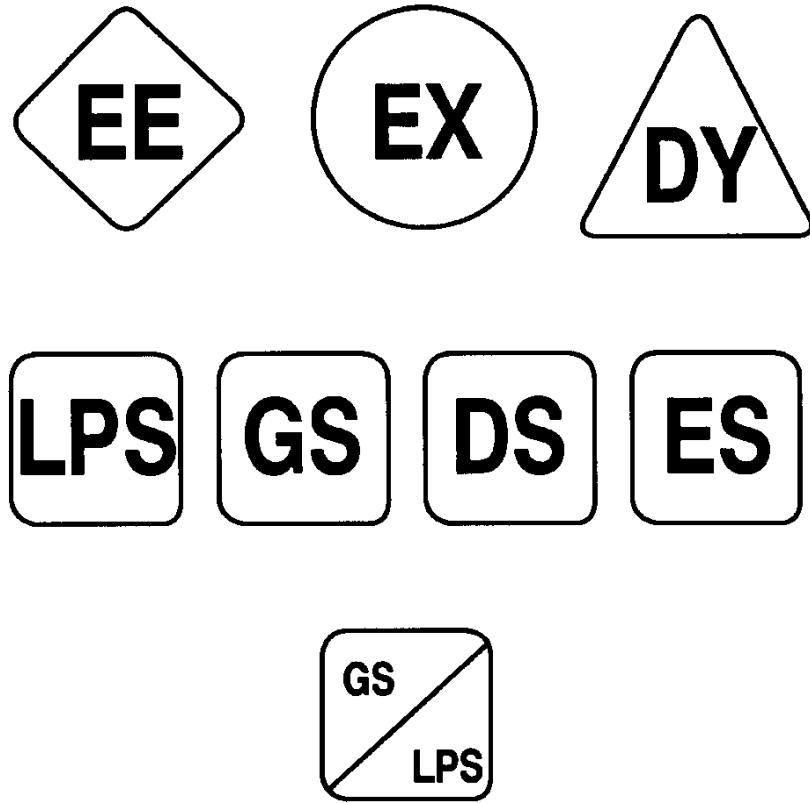
Location classifications are described as follows:

a. *Class I* — locations in which flammable gases or vapors are present or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

b. *Class II* — locations that are hazardous because of the presence of combustible dust.

c. *Class III* — locations where easily ignitable fibers or filings are present but are not likely to be suspended in quantities sufficient to produce ignitable mixtures.

d. *Unclassified* — locations not possessing atmospheres defined as Class I, II, or III locations.



NOTE: The markers for EE, EX, and DY are 5 in. (12.7 cm) high. The rest are 4 in. (10 cm) square. The signs shall have black borders and lettering on a yellow background.

Figure 10-1. Markers to identify type of industrial truck.

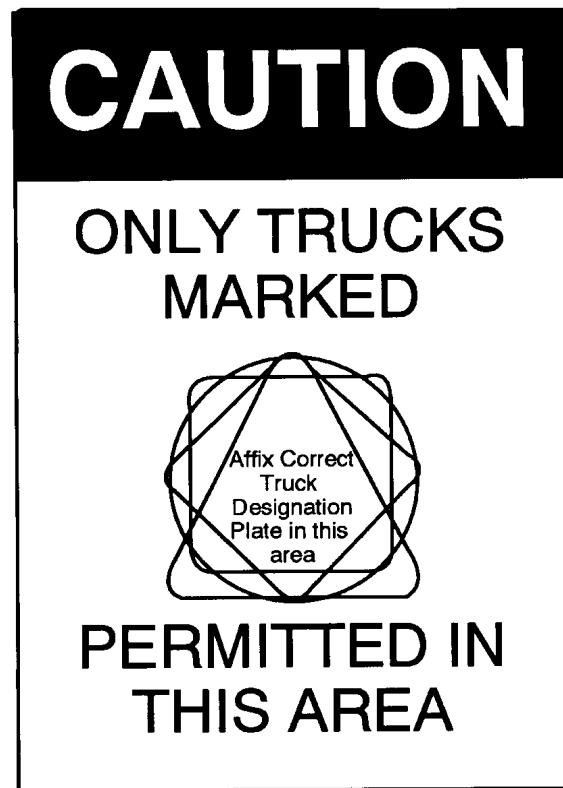


Figure 10-2. Building signs for posting at entrance to hazardous areas.

NOTE: The minimum width of the sign is 11 in. (28 cm); the minimum height is 16 in. (40 cm). The sign shall have the word "caution" in yellow letters on a black background. The body of the sign shall have black letters on a yellow background. A marker identical to the one used on the side of the truck as shown in Figure 10-1, shall be installed on the sign.

CHAPTER 11

WIRE ROPE AND SLINGS

11.2 WIRE ROPE

11.2.1 Wire-Rope Lays

- a. In a right-lay rope, the strands twist to the right around the core like a conventional screw thread; in a left-lay rope, the strands twist to the left.
- b. A rope has a lang lay when the strands and the individual wires have the same lay direction. When the strands and the wires have an opposite lay direction, the rope has a regular lay.
- c. A standard wire rope, unless otherwise stated, is understood to be right regular lay. With few exceptions, all wire rope is made right lay. Left-lay rope is a special-purpose rope.
- d. Figure 11-2 shows ropes with right and left lays combined with regular and lang lays.
- e. Lay length is the lengthwise distance measured along a wire rope in which a strand makes one complete revolution about the rope's axis.

11.2.2 Wire-Rope Cores

- a. Wire rope consists of multistrand metal wires wrapped around a suitable core material. Wire-rope cores are carefully designed and must be precisely manufactured to close tolerances to ensure a perfect fit in the rope. The most common types of cores include the following (see Figure 11-3):
 - 1. **Fiber Core (FC) or Sisal Core**—Sisalanna is the most common fiber that is used in the manufacture of wire-rope cores. In smaller ropes, cotton and jute are sometimes used for the core.
 - 2. **Independent Wire-Rope Core (IWRC)**—The primary function of the core is to provide adequate support for the strands. As the name implies, an IWRC is a separate small-diameter wire rope that is used as the core for a larger wire rope. When severe crushing or flattening of the rope is encountered, an IWRC is usually specified.

- 3. **Strand Core**—This type of core has a single strand used as the core. This type is generally confined to the smaller ropes as a substitute for IWRC. The strand core may or may not have the same cross section as the surrounding strands.

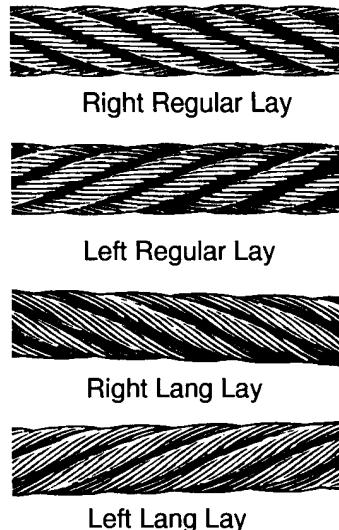


Figure 11-2. Wire-rope lays.

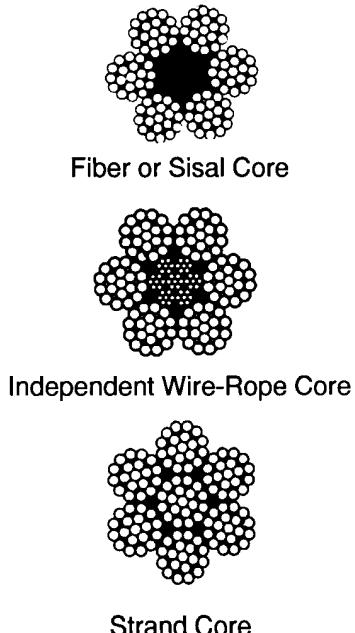


Figure 11-3. Wire-rope cores.

11.2.3 Wire Rope for General Purposes

11.2.3.1 6 × 19 Classification

a. Most applications can use a rope from this classification; it is the most versatile of all ropes made. Figure 11-4 shows four varieties of 6 × 19 wire ropes with FCs and IWRCs. Table 11-2 provides breaking strengths for 6 × 19 wire ropes with FC and IWRC cores.

b. The principal types of ropes in this classification include:

1. **6 × 19F**—The most popular and versatile of all wire ropes and the most flexible is the 6 × 19F classification. This rope is considered the perfect compromise between maximum abrasion resistance and maximum flexibility.

2. **6 × 16F**—Slightly more abrasion resistant than the 6 × 19F, the 6 × 16F makes an excellent rope for small draglines and similar uses. The resistance to wear is gained by a slight sacrifice in flexibility.

3. **6 × 19 Seale**—The 6 × 19 Seale is a rugged wire rope for applications involving heavy wear. Car pullers often use this rope, and it is widely used for slushers and drag scrapers.

4. **6 × 19 Warrington**—The alternating large and small outer wires make this rope an all-around performer. The 6 × 19 Warrington is used for general-purpose hoisting, churn drills, and miscellaneous slings.

11.2.3.2 6 × 37 Classification

a. When sheaves and drums are fairly small and abrasive conditions are not severe, the ropes in this classification will show better performance than the coarser 6 × 19 construction. Under conditions of repeated bending, they will outlast a 6 × 19 rope; when abrasion is severe, the small outer wires quickly show the effect. Figure 11-5 shows three varieties of 6 × 37 wire rope with FC and IWRC cores. Table 11-3 provides breaking strengths for 6 × 37 wire ropes with FC and IWRC cores.

b. The principal types of ropes in this classification include:

1. **6 × 37 2-operation**—A 6 × 37 2-operation strand has 18 outer wires. This construction is used on industrial equipment, for flexible slings, and in miscellaneous hoisting.

2. **6 × 29F**—A 6 × 29F is used for applications requiring a flexible rope slightly more resistant to wear than the 6 × 37 2-operation rope.

3. **6 × 41**—A 6 × 41 rope is used widely for ropes over 1-in. diameter in the 6 × 37 classification.

11.2.4 Wire-Rope Inspections

A qualified inspector shall inspect wire ropes at least annually. Inspection requirements vary depending on what type of equipment the wire ropes are used on. Refer to other sections in this standard, based on the equipment being used, for specific inspection requirements.

11.2.5 Wire-Rope Maintenance

Personnel using wire rope shall ensure proper care by doing the following:

- a. Store rope to prevent damage or deterioration.
- b. Unreel or uncoil rope as recommended by the rope manufacturer or a qualified person and with care to avoid kinking or inducing a twist.
- c. Before cutting a rope, use some method to prevent unlaying of the strands. Heat-affected zones of flame cut wire rope shall not be allowed to bear load.
- d. During installation, avoid dragging the rope in the dirt or around objects that will scrape, nick, crush, or induce sharp bends.
- e. Unless prohibited by other considerations, maintain rope in a well-lubricated condition. The object of rope lubrication is to reduce internal friction and to prevent corrosion. Ensure that lubricant applied as a part of a maintenance program is compatible with the original lubricant and is also a type that does not hinder visual inspection. Those sections of rope in contact with sheaves or otherwise hidden during inspection and maintenance procedures require special attention when lubricating rope.

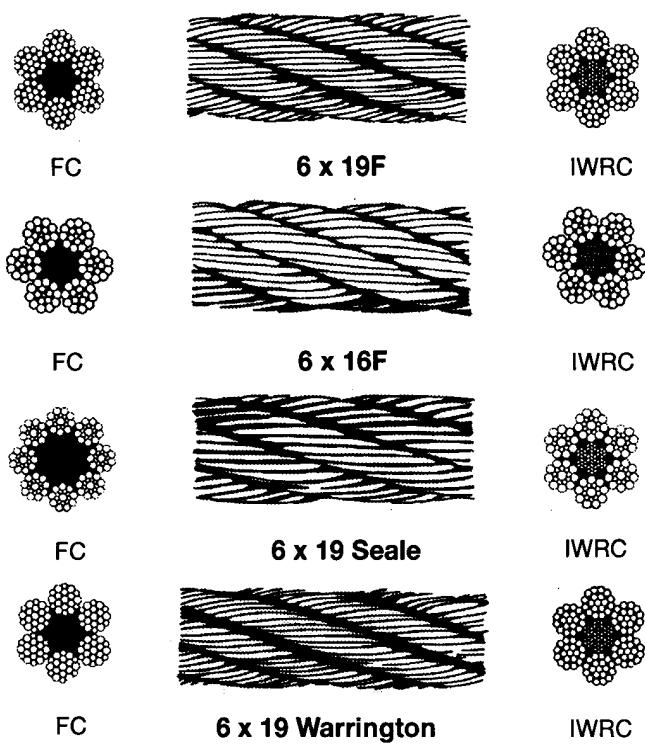
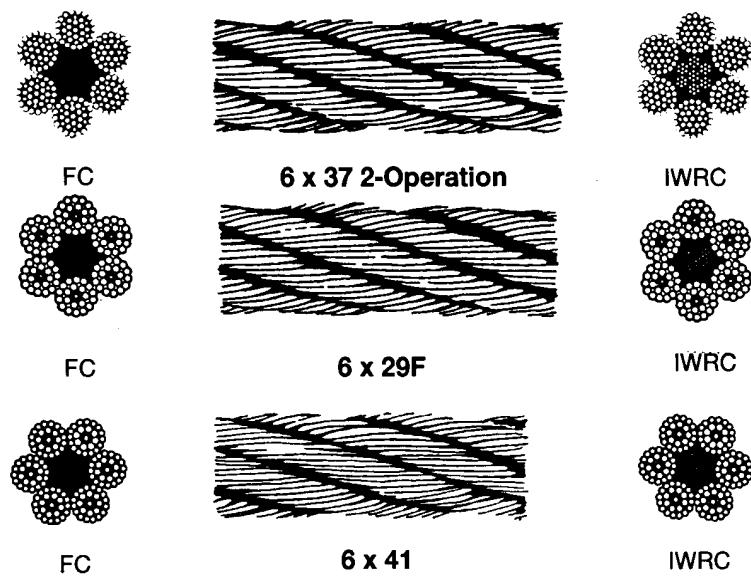


Figure 11-4. 6 x 19 classification of wire rope.

Table 11-2. Breaking strength of wire rope (6 x 19 classification).

6 x 19 (FC)				6 x 19 (IWRC)			
Rope diameter (in.)	Weight (lb per ft)	Breaking strength in tons of 2,000 lb		Rope diameter (in.)	Weight (lb per ft)	Breaking strength in tons of 2,000 lb	
		Plow steel	Improved plow steel			Plow steel	Improved plow steel
3/16	0.06	1.3	1.5	3/16	0.07	1.4	1.6
1/4	0.10	2.4	2.7	1/4	0.11	2.6	2.9
5/16	0.16	3.8	4.1	5/16	0.18	4.1	4.4
3/8	0.23	5.4	6.0	3/8	0.25	5.8	6.5
7/16	0.31	7.0	8.0	7/16	0.34	7.5	8.6
1/2	0.40	10.0	11.0	1/2	0.44	10.8	11.8
9/16	0.51	11.7	13.3	9/16	0.56	12.6	14.3
5/8	0.63	15.0	16.5	5/8	0.69	16.1	17.7
3/4	0.90	21.5	23.8	3/4	0.99	23.1	25.6
7/8	1.23	28.3	32.0	7/8	1.35	30.4	34.4
1	1.60	38.0	41.7	1	1.76	40.8	44.8
1 1/8	2.03	48.5	53.0	1 1/8	2.23	52.1	57.0
1 1/4	2.50	60.0	65.0	1 1/4	2.75	64.5	70.4
1 3/8	3.03	73.5	81.0	1 3/8	3.33	79.0	87.1
1 1/2	3.60	88.5	96.0	1 1/2	3.96	95.1	103.0
1 5/8	4.23	103.0	113.0	1 5/8	4.65	111.0	122.0
1 3/4	4.90	119.0	130.0	1 3/4	5.39	128.0	140.0
1 7/8	5.63	138.0	152.0	1 7/8	6.19	148.0	163.0
2	6.40	154.0	169.0	2	7.04	166.0	182.0
2 1/4	8.10	193.0	210.0	2 1/4	8.91	208.0	226.0
2 1/2	10.00	235.0	260.0	2 1/2	11.00	253.0	280.0
2 3/4	12.10	280.0	305.0	2 3/4	13.30	301.0	328.0

Figure 11-5. 6×37 classification of wire rope.Table 11-3. Breaking strength of wire rope (6×37 classification).

6×37 (FC)				6×37 (IWRC)			
Rope diameter (in.)	Weight (lb per ft)	Breaking strength in tons of 2,000 lb		Rope diameter (in.)	Weight (lb per ft)	Breaking strength in tons of 2,000 lb	
		Plow steel	Improved plow steel			Plow steel	Improved plow steel
1/4	0.10	2.2	2.5	1/4	0.11	2.4	2.7
5/16	0.16	3.8	4.0	5/16	0.18	4.1	4.3
3/8	0.22	5.0	5.5	3/8	0.24	5.4	5.9
7/16	0.30	6.9	7.5	7/16	0.33	7.4	8.1
1/2	0.39	9.2	10.0	1/2	0.43	9.9	10.8
9/16	0.49	11.4	12.5	9/16	0.54	12.3	13.4
5/8	0.61	14.5	16.0	5/8	0.67	15.6	17.2
3/4	0.87	20.2	22.2	3/4	0.96	21.7	23.9
7/8	1.19	27.5	30.2	7/8	1.30	29.6	32.5
1	1.55	36.0	39.5	1	1.71	38.7	42.5
1 1/8	1.96	44.0	49.0	1 1/8	2.16	47.3	52.7
1 1/4	2.42	55.0	61.0	1 1/4	2.66	59.1	65.6
1 3/8	2.93	68.5	74.5	1 3/8	3.22	73.6	80.1
1 1/2	3.49	82.0	90.0	1 1/2	3.84	88.1	96.7
1 5/8	4.09	96.5	105.5	1 5/8	4.50	104.0	113.0
1 3/4	4.75	110.0	121.0	1 3/4	5.23	118.0	130.0
1 7/8	5.45	129.0	142.0	1 7/8	6.00	139.0	153.0
2	6.20	142.0	155.0	2	6.82	153.0	167.0
2 1/4	7.85	182.0	201.0	2 1/4	8.64	196.0	216.0
2 1/2	9.69	225.0	245.0	2 1/2	10.66	242.0	263.0
2 3/4	11.72	269.0	293.0	2 3/4	12.89	289.0	315.0
3	13.95	323.0	353.0	3	15.35	347.0	379.0

11.3 SLINGS

11.3.1 General

a. Slings shall have a minimum design factor appropriate to the type of material as specified in the appropriate section. Features that affect the rated capacity of the sling and that shall be considered in calculating the design factor are:

1. Nominal breaking strength of material from which it is constructed.
2. Splicing or end-attachment efficiency.
3. Number of parts in the sling.
4. Type of hitch (e.g., straight pull, choker hitch, or basket hitch).
5. Angle of loading and load center of gravity.
6. Diameter of curvature around which the sling is bent.

b. Published working loads for chain slings are usually based on 25–33 percent of the breaking strength.

c. The center of gravity of an object is a point around which the entire weight may be concentrated. To make a level lift, the crane hook or point of suspension must be directly above this point. While slight variations are usually permissible, if the crane hook is too far to one side of the center of gravity, dangerous tilting will result and should be corrected at once. For this reason, when the center of gravity is closer to one point of the sling attachment than to the other, the slings must be of unequal length. Sling stresses and sling angles will also be unequal (see Figure 11-6).

d. Rigging shall be configured such that slings do not reeve or slip through the hook. To attach the load, locate the center of gravity, position the crane hook directly above the center of gravity, and then rig the load so that it will lift level and true.

11.3.1.1 Load Angle Factor

a. The following is an example of selecting a sling using the load angle factors shown in Figure 11-7.

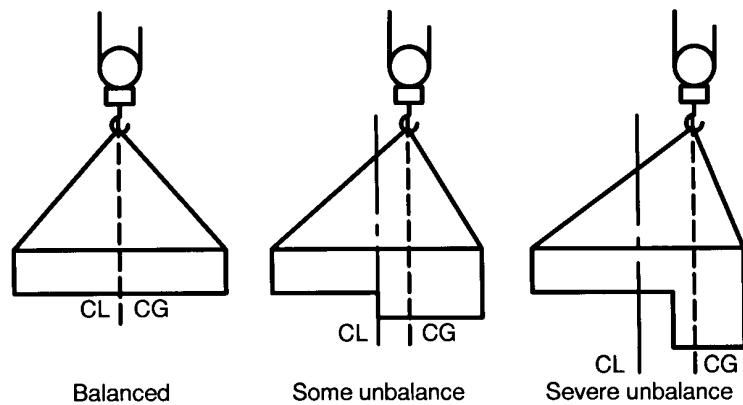
1. Load = 1,000 lb.
2. Sling = 2-legged bridle.
3. Angle with horizontal = 45 degrees.
4. Load angle factor from Figure 11-7 = 1.414.

b. Each of the two legs would lift 500 lb if a vertical lift were made. However, there is a 45° sling angle involved. Therefore, the 500-lb load would be multiplied by the load-angle factor in the chart, giving a total of 707 lb ($500\text{ lb} \times 1.414$) tension in each sling leg. Each sling leg, therefore, must have a rated capacity of at least 707 lb.

11.3.1.2 Safe Load

a. The rated capacity or working load limit (WLL) of a sling varies depending on the type of hitch. The rated capacity tables in this section show the applications for which the various safe loads apply when the slings are new. All ratings are in pounds (lbs).

b. Figures 11-8 and 11-9 provide information for determining the total rated capacity of 3-leg and 4-leg bridle slings. Select multiple-leg slings so as not to introduce a working load in direct tension in any leg greater than that permitted. Two legs should be considered to carry the load because in normal lifting practice, the load will not be uniformly distributed on all legs. If rigging techniques, verified by a qualified rigger, ensure that the load is evenly distributed then full use of three legs is allowed. Special rigging techniques verified by a member of a qualified engineering organization shall be required to prove that a load is evenly distributed over four or more sling legs.



Note:

CL = Centerline

CG = Center of Gravity

Figure 11-6. Balancing loads.

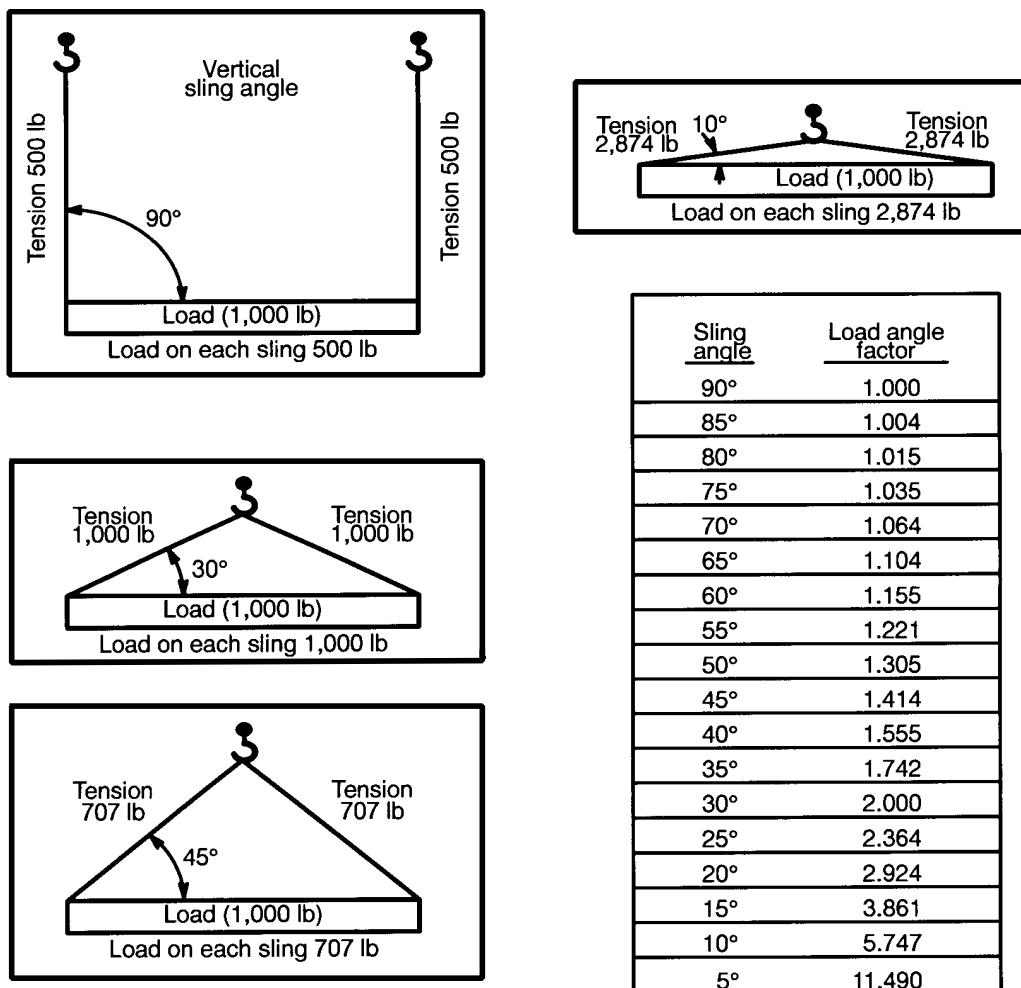


Figure 11-7. Relationship of load angle and lifting efficiency.

11.3.1.3 Design Factor

In general, a design factor of 5:1 is maintained throughout this section. However, certain sling fittings, such as hooks (which will straighten without breaking) or links (which will deform beyond usefulness before breaking) cannot be assigned a definite numerical design factor. In such cases, suitable safe loads are listed, based on wide experience and sound engineering practice.

11.3.1.4 Sling Care

Proper care and usage are essential for maximum service and safety. Wire-rope slings shall be protected from sharp bends and cutting edges by means of corner saddles, burlap padding, or wood blocking. Overloading shall be avoided, as shall sudden dynamic loading that can build up a momentary overload sufficient to break the sling.

11.3.1.5 Sling Storage

Personnel using slings shall ensure that they are stored properly as follows:

- a. Slings should be stored in racks (preferably vertical) and in designated locations when not in use. Do not store slings in a location where they will be subjected to mechanical damage, corrosive action, moisture, extreme heat, or kinking. Slings may require segregated storage as determined on a case-by-case basis.
- b. Before storage and periodically during storage, wipe slings clean to remove as much dirt and abrasive grit as possible and relubricate wire rope and chain slings to extend their useful life. Chains should not be lubricated when in use.
- c. Do not store metal-mesh slings in areas where the temperature exceeds 550 degrees F (288 degrees C) or 200 degrees F (93 degrees C) if elastomer covered.
- d. Do not store synthetic-web slings where the temperature exceeds 200 degrees F (93 degrees C).

11.3.2 Wire-Rope Slings

a. In general, wire-rope slings are made up of 6×19 or 6×37 classification wire rope. Rotation-resistant wire rope shall not be used for wire-rope slings. Different kinds of slings have been developed for specific purposes. These are divided into different groups or types as follows:

1. Endless-loop slings (grommet construction) and single-part slings with single-rope legs, double-rope legs, or multiple-part rope legs.
2. Two-leg bridle slings with single-rope legs, equalizing double-rope legs, or multiple-part rope legs.
3. Three-leg bridle slings.
4. Four-leg bridle slings.
5. Special slings and combinations.

b. The total load that can be safely lifted with slings depends on the rating of the slings and the manner in which they are attached to the load. Consult (load) Tables 11-4 through 11-9 and Figure 11-10.

c. Braided slings are made by braiding ordinary wire ropes together, thus making them more flexible than wire-rope slings. The size of a braided sling is determined by the diameter of one wire rope and the number of ropes in the cross section of the sling.

d. The design factor for wire-rope slings shall be a minimum of 5:1 based upon breaking strength.

e. When a wire rope sling is used in a choker hitch, the normal angle formed in the rope body as it passes through the choking eye is 120 degrees or greater [do not confuse the choke angle with the angle of inclination of the load (see Figure 11-10)]. Rated load in load capacity Tables 11-4 through 11-9 are for angles of 120 degrees or greater. For smaller angles, reduce the rated load to the percentages given in Figure 11-10.

When legs are not of equal length, use smallest H/L ratio

NOTE: Load may be supported on only 2 legs while 3rd leg balances it. Therefore, the required SWL is determined by the following:

$$\text{Total Rated Capacity} = \text{WLL} \text{ (of single vertical hitch)} \times H/L \times 2$$

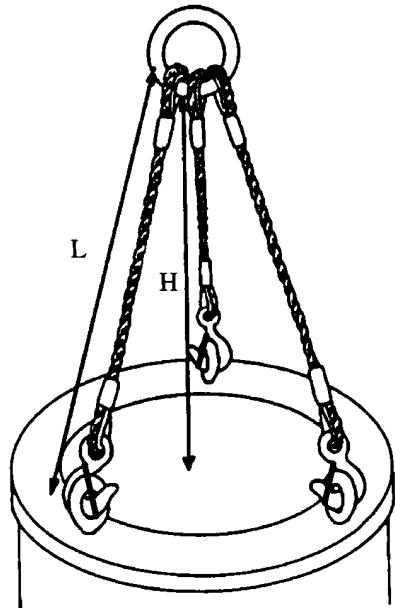


Figure 11-8. Determination of capacity—3-leg bridle sling.

When legs are not of equal length, use smallest H/L ratio.

NOTE: Load may be carried by only 2 legs while other 2 legs balance it. Therefore, the required SWL is determined by the following:

$$\text{Total Rated Capacity} = \text{WLL} \text{ (of single vertical hitch)} \times H/L \times 2$$

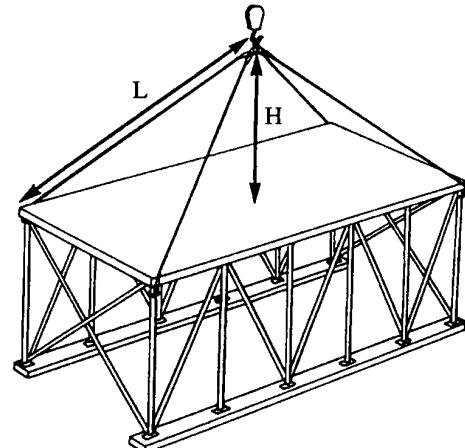


Figure 11-9. Determination of capacity—4-leg bridle sling.

**Table 11-4. Load capacity of wire-rope slings.
Hand tuck splice (IWRC) in pounds Design Factor = 5:1**

Dia. in inches	Vertical	Choker	Basket or two legs	60° Basket or two legs	45° Basket or two legs	30° Basket or two legs	Dia. in inches
1/4	1,100	820	2,200	1,800	1,500	1,100	1/4
5/16	1,600	1,280	3,200	2,800	2,200	1,600	5/16
3/8	2,400	1,840	4,800	4,000	3,200	2,400	3/8
7/16	3,000	2,400	6,000	5,400	4,400	3,000	7/16
1/2	4,000	3,200	8,000	6,800	5,600	4,000	1/2
9/16	5,000	4,000	10,000	8,600	7,000	5,000	9/16
5/8	6,000	5,000	12,000	10,400	8,400	6,000	5/8
3/4	8,400	7,200	16,800	14,600	11,800	8,400	3/4
7/8	11,000	9,600	22,000	19,200	15,600	11,000	7/8
1	14,000	12,600	28,000	24,000	20,000	14,000	1
1 1/8	18,000	15,800	36,000	32,000	26,000	18,000	1 1/8
*1 1/4	22,000	19,400	44,000	36,000	30,000	22,000	*1 1/4
*1 3/8	26,000	24,000	52,000	44,000	36,000	26,000	*1 3/8
*1 1/2	32,000	28,000	64,000	52,000	42,000	32,000	*1 1/2
*1 5/8	36,000	32,000	72,000	62,000	50,000	36,000	*1 5/8
*1 3/4	42,000	38,000	84,000	70,000	58,000	42,000	*1 3/4
*2	56,000	48,000	112,000	92,000	74,000	56,000	*2

Wire Rope/6 x 19 and *6 x 37 IPS IWRC

(CFR 1910.184/ANSI/ASME B30.9)

Notes:

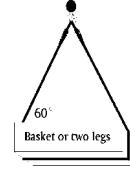
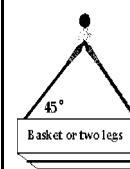
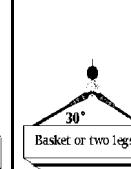
(1) These values only apply when the D/d ratio is 25 or greater (choker and basket hitches)

D = Diameter of curvature around which the body of the sling is bent

d = Diameter of rope

(2) Choker hitch values apply only to choke angles greater than 120 degrees.

**Table 11-5. Load capacity of wire-rope slings.
Hand tuck splice (Fiber Core) in pounds Design Factor = 5:1**

Dia. in inches	Vertical	Choker	Basket or two legs	60° Basket or two legs	45° Basket or two legs	30° Basket or two legs	Dia. in inches
							
1/4	980	760	1,960	1,700	1,400	980	1/4
5/16	1,500	1,200	3,040	2,600	2,200	1,500	5/16
3/8	2,200	1,700	4,400	3,600	3,000	2,200	3/8
7/16	2,800	2,400	5,600	5,000	4,000	2,800	7/16
1/2	3,600	3,000	7,200	6,400	5,200	3,600	1/2
9/16	4,600	3,800	9,200	8,000	6,400	4,600	9/16
5/8	5,600	4,600	11,200	9,600	8,000	5,600	5/8
3/4	7,800	6,600	15,600	13,600	11,000	7,800	3/4
7/8	10,400	9,000	20,800	17,800	14,600	10,400	7/8
1	13,400	11,800	26,800	22,000	18,800	13,400	1
1 1/8	16,800	14,800	33,600	28,000	24,000	16,800	1 1/8
*1 1/4	20,000	18,000	40,000	34,000	28,000	20,000	*1 1/4
*1 3/8	24,000	22,000	48,000	42,000	34,000	24,000	*1 3/8
*1 1/2	30,000	26,000	60,000	52,000	42,000	30,000	*1 1/2
*1 5/8	34,000	30,000	68,000	58,000	48,000	34,000	*1 5/8
*1 3/4	40,000	34,000	80,000	70,000	56,000	40,000	*1 3/4
*2	52,000	44,000	104,000	90,000	74,000	52,000	*2
Wire Rope/6 x 19 and *6 x 37 IPS FC							

(CFR 1910.184/ANSI/ASME B30.9)

Notes:

(1) These values only apply when the D/d ratio is 25 or greater (choker and basket hitches)

D = Diameter of curvature around which the body of the sling is bent

d = Diameter of rope

(2) Choker hitch values apply only to choke angles greater than 120 degrees.

**Table 11-6. Load capacity of wire-rope slings.
Mechanical splice (IWRC) in pounds Design Factor = 5:1**

Dia. in inches	Vertical	Choker	Basket or two legs	60° Basket or two legs	45° Basket or two legs	30° Basket or two legs	Dia. in inches
1/4	1,100	840	2,200	1,940	1,580	1,100	1/4
5/16	1,700	1,300	3,400	3,000	2,400	1,700	5/16
3/8	2,400	1,860	4,800	4,200	3,600	2,400	3/8
7/16	3,400	2,500	3,800	5,800	4,800	3,400	7/16
1/2	4,400	3,200	8,800	7,600	6,200	4,400	1/2
9/16	5,500	4,200	11,000	9,600	7,700	5,500	9/16
5/8	6,800	5,000	13,600	11,800	9,600	6,800	5/8
3/4	9,700	7,200	19,400	16,800	13,600	9,700	3/4
7/8	13,000	9,800	26,000	22,000	18,300	13,000	7/8
1	17,000	12,800	34,000	30,000	24,000	17,000	1
1 1/8	20,000	15,600	40,000	36,000	30,000	20,000	1 1/8
*1 1/4	25,000	18,400	50,000	42,000	34,000	25,000	*1 1/4
*1 3/8	30,000	24,000	60,000	52,000	42,000	30,000	*1 3/8
*1 1/2	36,000	28,000	72,000	64,000	50,000	32,000	*1 1/2
*1 5/8	42,000	32,000	84,000	70,000	58,000	42,000	*1 5/8
*1 3/4	50,000	38,000	100,000	82,000	66,000	50,000	*1 3/4
*2	64,000	48,000	128,000	106,000	86,000	64,000	*2

(CFR 1910.184/ANSI/ASME B30.9)

Notes:

(1) These values only apply when the D/d ratio is 25 or greater (choker and basket hitches)

D = Diameter of curvature around which the body of the sling is bent

d = Diameter of rope

(2) Choker hitch values apply only to choke angles greater than 120 degrees.

**Table 11-7. Load capacity of wire-rope slings.
8-part braided rope in pounds Design Factor = 5:1**

Dia. in inches	Vertical	Choker	Basket or two legs			Dia. in inches
*1/8	1,900	1,400	3,200	2,600	1,900	*1/8
*3/16	4,200	3,000	7,200	5,800	4,200	*3/16
3/16	3,400	2,600	6,000	4,800	3,400	3/16
1/4	6,200	4,600	10,600	8,600	6,200	1/4
5/16	9,600	7,200	16,600	13,400	9,600	5/16
3/8	13,600	10,200	24,000	19,400	13,600	3/8
7/16	18,000	13,800	32,000	26,000	18,600	7/16
1/2	24,000	18,000	42,000	34,000	24,000	1/2
9/16	30,000	22,000	52,000	42,000	30,000	9/16
5/8	38,000	28,000	64,000	52,000	38,000	5/8
3/4	54,000	40,000	92,000	76,000	54,000	3/4
7/8	72,000	54,000	124,000	102,000	72,000	7/8
1	94,000	70,000	162,000	132,000	94,000	1

Wire Rope/6 x 19 IPS and *7 x 7 Galvanized Aircraft Grade

(CFR 1910.184/ANSI/ASME B30.9)

Notes:

(1) These values only apply when the D/d ratio is 25 or greater (choker and basket hitches)

D = Diameter of curvature around which the body of the sling is bent

d = Diameter of rope

(2) Choker hitch values apply only to choke angles greater than 120 degrees.

**Table 11-8. Load capacity of wire-rope slings.
Cable laid grommet-hand tucked in pounds Design Factor = 5:1**

Dia. in inches	Vertical	Choker	Basket or two leg	60 degrees	45 degrees	30 degrees	Dia. in inches
*3/8	2,600	1,900	5,000	4,400	3,600	2,600	*3/8
*9/16	5,600	4,200	11,200	9,800	8,000	5,600	*9/16
*5/8	7,800	6,000	15,800	13,600	11,200	6,800	*5/8
3/4	10,200	7,600	20,000	17,600	14,400	10,200	3/4
15/16	15,800	11,800	32,000	28,000	22,000	15,800	15/16
1 1/8	22,000	16,800	44,000	38,000	32,000	22,000	1 1/8
1 5/16	30,000	22,000	60,000	52,000	42,000	30,000	1 5/16
1 1/2	38,000	28,000	78,000	66,000	54,000	38,000	1 1/2
1 11/16	48,000	36,000	98,000	84,000	68,000	48,000	1 11/16
1 7/8	60,000	44,000	120,000	104,000	84,000	60,000	1 7/8
2 1/4	84,000	62,000	168,000	146,000	118,000	84,000	2 1/4
2 5/8	112,000	84,000	224,000	194,000	158,000	112,000	2 5/8
3	144,000	108,000	286,000	248,000	202,000	144,000	3
Wire Rope/*7 x 6 x 7 and 7 x 6 x 19 IPS IWRC							

(CFR 1910.184/ANSI/ASME B30.9)

Notes:

(1) These values only apply when the D/d ratio is 10 or greater (choker and basket hitches)

D = Diameter of curvature around which the body of the sling is bent

d = Diameter of rope

(2) Choker hitch values apply only to choke angles greater than 120 degrees.

Table 11-9. Load capacity of wire-rope slings.
Strand laid grommet-hand tucked in pounds Design Factor = 5:1

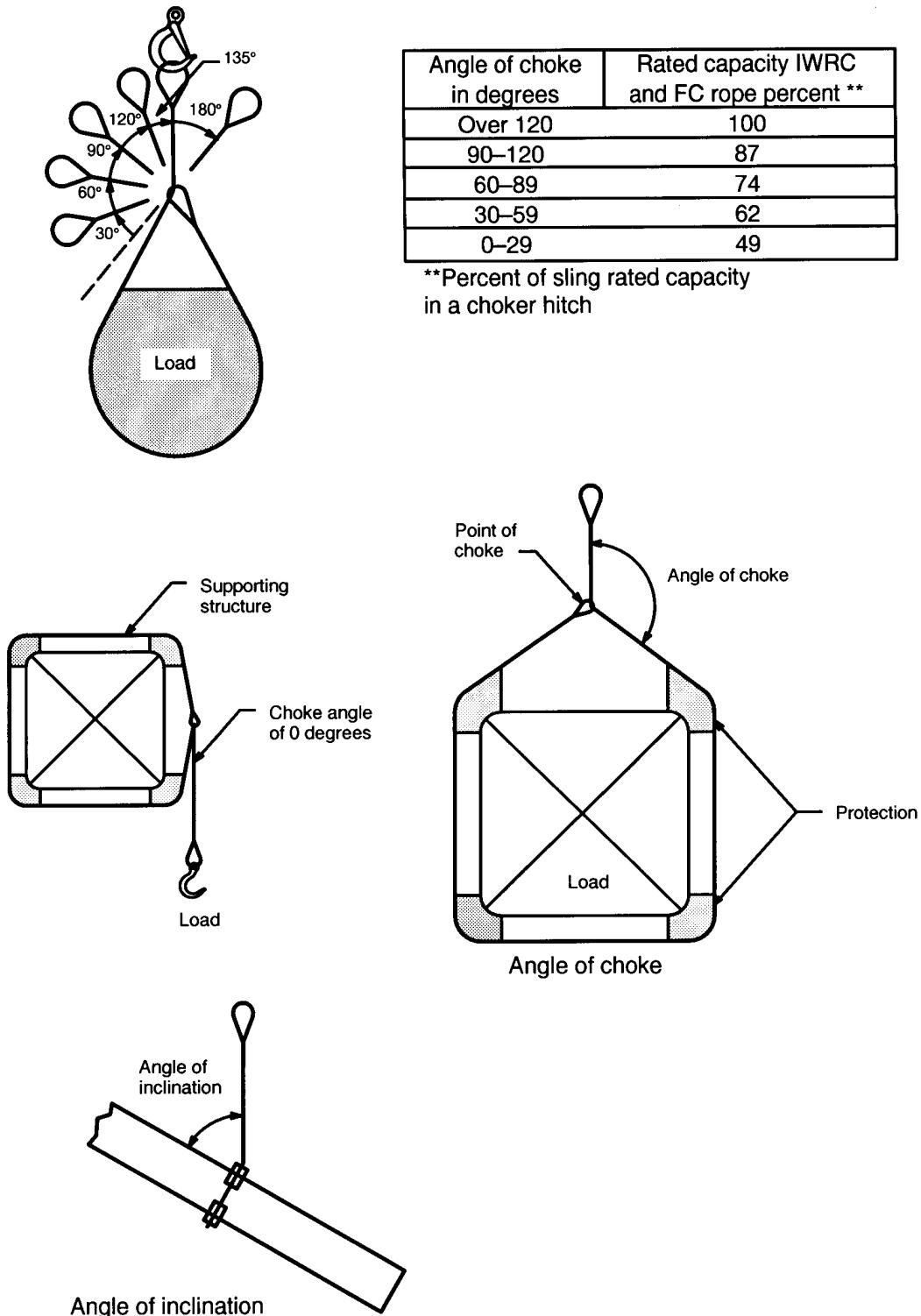


Figure 11-10. Choker hitch rated capacity adjustment.

11.3.2.1 Inspections

- a. Wire-rope sling users shall visually inspect all slings each day they are used or prior to use if the sling has not been in regular service (records are not required). In addition, a periodic inspection (with records) shall be made at least annually by a qualified inspector. More frequent intervals should be established if necessary as determined by a qualified person based on:
 - 1. Frequency of sling use.
 - 2. Severity of service conditions.
 - 3. Nature of lifts being made.
 - 4. Experience gained on the service life of slings used in similar circumstances.
- b. Users shall carefully note any deterioration that could result in an appreciable loss of original strength and determine whether further use of the sling would constitute a safety hazard.
- c. A sample annual inspection form is included as Exhibit I at the end of this section. This form is intended to be a sample only and is not intended to be mandatory.
- d. Inspection records shall be readily available.
- e. Slings shall be immediately removed from service if any of the following conditions are present:
 - 1. Ten randomly distributed broken wires in one rope lay or five broken wires in one strand in one rope lay.
 - 2. Wear or scraping of one-third the original diameter of the outside individual wire.
 - 3. Kinking, crushing, birdcaging, or any other damage resulting in distortion of the rope structure.
 - 4. Evidence of heat damage.
 - 5. End attachments that are cracked, deformed, or worn.
 - 6. Corrosion of the rope or end attachments.
- f. Hooks shall be inspected according to Chapter 12, "Rigging Accessories."

11.3.2.2 Proof-Testing

- a. All swaged socket and poured socket sling assemblies shall be proof-tested to the wire rope or fitting manufacturers recommendations but in no case greater than 50 percent of the component wire ropes' or structural strands' nominal strength. All other sling assemblies shall be proof-tested when specified by the purchaser.
- b. As a minimum, the proof load shall be equal to the rated capacity but shall not exceed:
 - 1. 125 percent of the vertical rated capacity for single-leg, hand-tucked slings.
 - 2. 200 percent of the vertical rated capacity for mechanical-splice single-leg slings and endless slings.
- c. The proof-load for multiple-leg bridle slings assemblies shall be applied to the individual leg and shall be in accordance with paragraph a. and b. as applicable.
- d. Master links to which multiple-leg slings are connected shall be proof-loaded to 200 percent times the force applied by the combined legs.
- e. Welded end attachments shall not be used unless proof-tested at 2 times rated capacity prior to initial use.
- f. Test loads described above shall be accurate to within -5 percent, +0 percent of stipulated values. A written letter of certification by the manufacturer or a pull test witnessed and certified in writing by a qualified person is acceptable.

11.3.2.3 Operation

- a. The following shall apply to all personnel who use wire-rope slings:
 - 1. Start and stop slowly; sudden starts and stops dramatically increase the stresses in hoist ropes and slings. Lift slowly until the load is suspended to minimize swinging.
 - 2. Loads shall be set on blocks. Do not pull a sling from under a load that is resting on the sling.
 - 3. Ensure that wire-rope slings are protected against weather, chemicals, solvents, and high temperatures.

4. Permanently remove from service fiber-core rope slings that have been exposed to temperatures in excess of 180 degrees F (82 degrees C).

5. Obtain the manufacturer's written approval for use of wire rope slings of any grade at temperatures between 400 degrees F (204 degrees C) and -60 degrees F (-51 degrees C).

6. Extremely low temperatures (less than 0 degrees F) may cause brittle fractures. Under these conditions, sudden loading should be avoided and the rope should be carefully observed while the load is being applied.

7. Do not use knotted slings.

8. Do not use single-leg wire-rope slings unless proper precautions are taken to prevent suspended loads from rotating.

9. Rigging shall be configured such that slings do not reeve or slip through the hook.

10. Do not make a complete turn of wire rope around the crane hook.

11. Use protector pads or blocking at sharp corners.

12. Keep hands and fingers out of the area between the sling and the load.

13. Ensure that the weight of the load is within the rated capacity of the sling.

14. Do not use damaged slings.

15. Ensure that all personnel stand clear of the suspended load.

16. Avoid shock loading.

17. In a basket hitch, ensure that the load is balanced to prevent slippage.

18. Avoid handling hot material with wire-rope slings.

19. Use shackles or adjustable choker hooks when making choker hitches.

20. Store slings on racks away from moisture and acids when not in use.

21. Ensure that damaged wire-rope slings are rendered unusable, removed from service, discarded, and replaced with new slings.

22. Before use and before storage, check wire-rope slings for:

- i. Broken or cut wires or strands.
- ii. Rust or corrosion.
- iii. Kinks.
- iv. Broken seizing wire.
- v. Damage to swaged fittings.
- vi. Other signs of damage or abuse.

23. The capacity of wire-rope slings is derated by the manufacturer by applying the efficiency factors such as those given in Figure 11-11.

24. Do not use wire-rope clips to fabricate wire-rope slings except where the application of slings prevents the use of prefabricated slings or where the specific application is designed by a qualified person. Slings made with wire rope clips should not be used as a choker hitch (see Figures 11-12 and 11-13).

25. When wire-rope clips are used, the rating of the sling must be derated to 80 percent of the wire-rope rating to allow for the inefficiency of the clips.

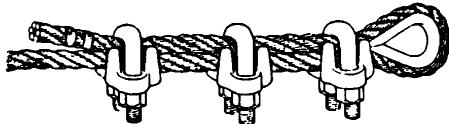
26. Double-saddle clips or fist-grip clips (Figure 11-14) may be used to make up general-purpose slings provided the sling is derated to 95 percent of wire-rope capacity.

27. Follow the requirements of 29 CFR 1926.251, Table H-20 or the manufacturer's recommendation (whichever offers the greater protection) for the number of clips required, correct spacing, and torque. After the initial load is applied to the rope, retighten the clip nuts to the recommended torque to compensate for any decrease in rope diameter caused by the load. Rope clip nuts should be retightened to the recommended torque periodically to compensate for further decrease in rope diameter during usage.

Figure 11-11. Wire-rope fastenings.

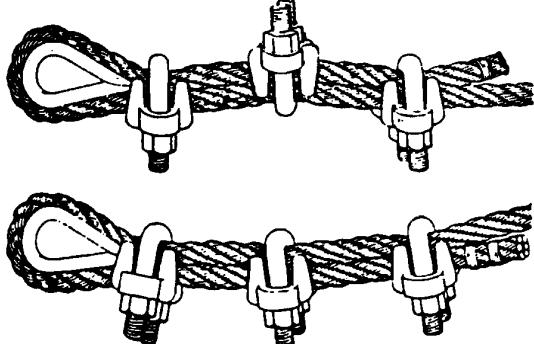
**Efficiencies of wire rope fittings or fastenings
in percentages of strength of rope:**

Open type	Closed type
	
Swaged socket 100%	Clips (number of clips varies with size of rope) 75–80%
	
Wire rope socket-spliter attachment 100%	Thimble spliced, hand tucked
	1/4 in. .. 90% 1/2 in. .. 86% 5/16 in. .. 89% 5/8 in. .. 84% 3/8 in. .. 88% 3/4 in. .. 82% 7/16 in. .. 87% 7/8 in. .. 80%
Pressed sleeve loop back thimble attachment	
1 in. diameter and smaller 95% 1 1/2 in. diameter and larger 92.5%	
	
Flemish loop with mechanical sleeve attachment	Loop splice, hand tucked
1 in. diameter and smaller 95% 1 1/2 in. diameter and larger 92.5%	Efficiencies of loop splice are the same as those given for thimble splice.



Note that the base of the clip bears against the live end of the wire rope, while the "U" of the bolt presses against the dead end.

Figure 11-12. Wire-rope clips—right way.



The "U" of the clips should not bear against the live end of the wire rope because of the possibility of the rope being kinked or crushed.

Figure 11-13. Wire-rope clips—wrong way.

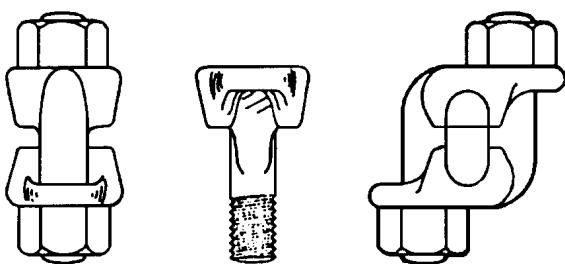


Figure 11-14. Double-saddle clips (drop-forged steel, galvanized).

28. As a minimum, mark wire-rope slings with the rated capacity and inspection due date. This information may be stenciled or stamped on a metal tag affixed to the sling. (Stenciling or stamping on the swages of a sling eye is not recommended.)

29. Slings made of rope with 6×19 and 6×37 construction and cable-laid slings shall have a minimum clear length of rope 10 times the rope diameter between splices, sleeves, or end fittings.

30. Braided slings shall have a minimum clear length of rope 40 times the component (individual) rope diameter between the loops or end fittings.

31. Grommets and endless slings shall have a minimum circumferential length of 96 times the body diameter of the grommet or endless sling.

11.3.2.4 Critical Lifts

See Chapter 2, "Critical Lifts," for critical lift requirements.

1. All provisions of paragraph 11.3.2.3.a, also shall apply to critical lifts.

2. Wire-rope slings used for critical-lift service shall have an initial proof load test. If proof testing cannot be verified, the wire-rope sling(s) shall be proof tested before being used to make a critical lift. As a minimum, the proof load shall be equal to the rated capacity but shall not exceed:

i. All swaged socket and poured socket sling assemblies shall be proof-tested to the wire rope or fitting manufacturers recommendations but in no case greater than 50 percent of the

- ii. component wire ropes' or structural strands' nominal strength.
- ii. 125 percent of the vertical rated capacity of single-leg, hand-tucked slings.
- iii. 200 percent of the vertical rated capacity for mechanical-spliced single-leg slings and endless slings.
- iv. The proof- load for multiple-leg bridle slings assemblies shall be applied to the individual leg and shall be in accordance with paragraph i, ii., and iii. as applicable.
- v. Master links to which multiple-leg slings are connected shall be proof-loaded to 200 percent times the force applied by the combined legs.
- vi. Test weights shall be accurate to within -5 percent, +0 percent of stipulated values.

3. Wire-rope sling eyes with thimbles shall be made with a thimble having a ratio of thimble diameter (D) to rope diameter (d) of 3 or more (D/d greater than or equal 3).

4. Do not use wedge sockets or wire-rope clips on slings used for critical lifts.

5. Ensure that working loads of wire-rope slings do not exceed their rated capacities.

6. Do not splice slings together.

7. Use thimble eyes for slings to be joined end-to-end.

8. Locate sling eyes so that:

- i. Adequate clearance is maintained between the attached slings and other parts or surfaces of the component or equipment.
- ii. There is no interference with the functioning of hoisting, rigging, or handling equipment.
- iii. Maximum accessibility to the eye is maintained.

- iv. Attached slings can converge over the center of gravity of the lift.
- v. Proper stability can be maintained during lifting and positioning of the item at the installation site.
- vi. The plane of the slinging eye is coincident with the plane of the sling under loaded conditions within ± 5 degrees.
- vii. Sling angles are not less than 45 degrees with the horizontal.

9. In addition to marking requirements listed for ordinary lifts, other items may need to be marked as determined on a case-by-case basis, such as the reach, type, weight of the sling assembly, and rated capacity.

11.3.3 Alloy Steel-Chain Slings

a. This section applies to slings made from grade 80 alloy chain manufactured and tested in accordance with National Association of Chain Manufacturers welded steel chain specifications—1990. If chain other than this is used, it shall be used in accordance with the recommendations of the chain manufacturer.

b. Alloy Steel-chain slings differ from wire-rope slings in that components using wire are replaced by link chain. Other sling components are similar. Chain slings are more rugged and flexible, but less shock resistant than wire-rope or braided slings. The size is measured by the link stock.

c. Two basic types with many variations are used: basket type and hook type. An example of each is shown in Figure 11-15.



Figure 11-15. Types of chain slings.

d. Alloy-steel-chain slings shall not be heated above 1,000 degrees F (537 degrees C) after being received from the manufacturer.

e. When exposed to service temperatures in excess of 600 degrees F (315 degrees C), reduce working load limits in accordance with the chain manufacturer's recommendations.

f. Extremely low temperatures (less than 0 degrees F) may cause brittle fractures. Under these conditions, sudden loading should be avoided and the load should be lifted a very short distance while the chains are carefully inspected.

g. The design factor for steel-chain slings shall be a minimum of 4:1 based upon breaking strength.

h. Chains should be stored in racks or in designated locations when not in use. Chains should never be stored in damp or dirty places, nor in places exposed to the weather. For long-term storage, they should receive a coating of oil. The ends of all empty chains should be hooked onto the hoist hook or bull ring.

i. Chains should not be lubricated when in use because this might make them dangerous to handle. Chains should be cleaned periodically to remove abrasive grit and to facilitate inspection.

j. The total load that can be lifted safely with steel-chain slings depends on the manner by which the slings are attached to the load. If all legs of a steel-chain sling are hooked back into the master link, the safe-load capacity of the whole sling may be increased by 100 percent if the capacity of the master link is not exceeded.

k. The safe-load level of any chain sling is a function of three basic factors: size and number of legs, condition of chain and other components, and sling angle between legs and horizontal. Table 11-10 shows safe loads in pounds per leg which can be carried by various chain-sling arrangements. Note the effect of very low hook height and wide leg spreads.

l. *Attachments:* Hooks, rings, oblong links, pear shaped links, welded or mechanical coupling links and other attachments shall have a rated capacity at least equal to that of the alloy steel chain with which they are used or the sling shall not be used in excess of the rated capacity of the weakest component.

11.3.3.1 Pre-Use Inspections

Steel-chain sling users shall visually inspect all slings before they are used as follows:

- a. Conduct a link-by-link inspection for the following defects: bent links, stretched links, cracks in any section of link, scores, abrasions, heat damage, or markings tending to weaken the links. Reject if discovered.
- b. Check rings and hooks for distortion, cracks in weld areas, corrosion, and scores, heat damage, or markings tending to weaken the links. Reject if discovered.
- c. Perform inspection on an individual-link basis. If any link does not hinge freely with the adjoining link, remove the assembly from service.
- d. Remove from service assemblies with deformed master links or coupling links.
- e. Remove from service assemblies if hooks have been opened more than 15 percent of the normal throat opening measured at the narrowest point or twisted more than 10 degrees from the plane of the unbent hook.
- f. Do not straighten deformed hooks or other attachments on the job. Assemblies with such defects shall be reconditioned by the manufacturer or discarded.
- g. Remove from service assemblies with cracked hooks or other end attachments; assemblies with such defects shall be reconditioned or repaired prior to return to service.

11.3.3.2 Annual Inspections

- a. A sample annual inspection form is included as Exhibit II at the end of this section. This form is intended to be a sample only and is not intended to be mandatory.
- b. Annual inspections shall be conducted by a qualified inspector. In addition to criteria for daily inspections, the qualified inspector shall do the following for annual inspections:

1. Hang chain in a vertical position, if practicable, for preliminary inspection. Chain should hang reasonably straight if links are not distorted.

2. Accurately measure the reach (inside of crane ring to inside of hook) under no load when new and at each inspection, and keep a record of increase in length; an increase in length may be due to stretch (sign of overload or wear).

3. Check for localized stretch and wear. Lift each link from its seat and visually inspect for grooving. If grooving is noticed, verify stock diameter of link to be within the minimum safe dimensions in the table below. Reject chain if it does not meet the requirements in the table.

4. Remove the assembly from service if wear at any point of any chain link exceeds that shown in Table 11-11.

5. Round out sharp transverse nicks by grinding. If the minimum dimensions are reduced below those values specified in Table 11-11, remove the assembly from service.

6. Check for evidence of heat damage.

11.3.3.3 Proof-Testing

- a. Single-leg and endless alloy-steel chain slings shall be certified as having been proof-tested to 200 percent of the rated capacity prior to initial use.
- b. The proof load for multiple-leg bridle slings shall be applied to the individual legs and shall be 200 percent of the vertical rated capacity of a single-leg sling.
- c. Master links to which multiple-leg slings are connected shall be proof-loaded to 200 percent multiplied by the force applied by the combined legs.
- d. Test loads shall be accurate to within -5 percent, +0 percent of stipulated values. Either certification by the manufacturer or a pull test certified by a qualified person is acceptable.

Table 11-10. Alloy steel chain slings in pounds Design Factor = 4:1

Size in inches	Single Leg	60° Two Legs	45° Two Legs	30° Two Legs	Size in inches
9/32	3,500	6,100	4,900	3,500	9/32
3/8	7,100	12,300	10,000	7,100	3/8
1/2	12,000	20,800	17,000	12,000	1/2
5/8	18,100	31,300	25,600	18,100	5/8
3/4	28,300	49,000	40,000	28,300	3/4
7/8	34,200	59,200	48,400	34,200	7/8
1	47,700	82,600	67,400	47,700	1
1 1/4	72,300	125,200	102,200	72,500	1 1/4

(CFR 1910.184/ANSI/ASME B30.9)

Notes:

- (1) Other grades of proof tested steel chain include Proof Coil (Grade 28), Hi-Test (Grade 43) Chain and Transport (Grade 70) Chain. These grades are not recommended for overhead lifting and therefore are not covered in the applicable standards.
- (2) Rating of multileg slings adjusted for angle of loading between the inclined leg and the horizontal plane of the load.

Table 11-11. Maximum allowable wear of chains.

Chain size (in.)	Maximum allowable wear (in.)
1/4	3/64
3/8	5/64
1/2	7/64
5/8	9/64
3/4	10/64
7/8	11/64
1	12/64
1-1/4	16/64

NOTE: For other sizes, consult chain or sling manufacturer.

11.3.3.4 Operation

a. The following shall apply to all personnel who use steel-chain slings:

1. Do not set a load on a sling or pull a sling from under a load. Place wooden blocks or other supports under the load to provide sufficient clearance for the chain.

2. Shorten chain slings by hooking back into the chain, into the master link, or with grab hooks. Do not shorten by knotting, twisting, bolting, or inserting the tip of the hook into a link.

3. Do not hammer a chain to force it into position.

4. Protect chain slings from sharp corners that might bend the links. Use a suitable pad to prevent gouging or bending of the chain links, as well as possible scarring of the load.

5. When making choker hitches with chain slings, always face the hook opening out and away from the pull of the sling so that the hooks will not slip out when slack is taken out of the sling.

6. Check steel-chain slings for:

- i. Nicks, cracks, gouges, and wear.
- ii. Bending, stretching, or shearing of links.
- iii. Bends or distortions in hooks.

- iv. Rust and corrosion.
- v. Uneven lengths when sling legs are hanging free.
- vi. Evidence of heat damage.

7. Do not weld or perform local repairs on chain slings. All defective chain slings should be returned, through a formal procedure, to the manufacturer for examination, repair, and recertification.

8. Avoid sudden loading of chain slings.

9. Maintain latches on hooks in good condition.

10. If a chain sling does not look safe, do not use it. Do not assume that a chain sling is safe because it looks new; look for stretched links. If in doubt, check with the supervisor.

11. Do not carry loads on the point or tip of a hook.

12. Avoid unbalanced loads.

13. Do not use homemade links, makeshift fasteners formed from bolts, rods, and the like, or other nonstandard attachments.

14. Do not use makeshift or field-fabricated hooks on steel-chain slings.

15. Hook the ends of all empty chain onto the hoist hook or bull ring.

16. Ensure that steel-chain slings used in DOE-controlled areas are marked, at a minimum, with:

- i. Size.
- ii. Manufacturer's grade.
- iii. Rated load and angle on which the rating is based.
- iv. Reach.
- v. Number of legs.
- vi. Sling manufacturer.
- vii. Inspection due date.

17. This information may be stenciled or stamped on a metal tag or tags affixed to the sling.

18. Where slings have more than one leg, ensure that the tag is affixed to the master link.

19. Ensure that the working load does not exceed the rated capacity of the sling.

11.3.3.5 Critical Lifts

See Chapter 2, "Critical Lifts," for critical lift requirements.

a. Single-leg and endless alloy-steel chain slings used for critical-lift service shall have an initial proof load test of 200 percent of the vertical rated capacity. If proof testing cannot be verified, the sling(s) shall be proof tested before being used to make a critical lift.

b. The proof load for multiple-leg bridle slings shall be applied to the individual legs and shall be 200 percent of the vertical rated capacity of a single-leg sling.

c. Master links to which multiple-leg slings are connected shall be proof-loaded to 200 percent multiplied by the force applied by the combined legs.

11.3.4 Metal-Mesh Slings

a. Metal-mesh slings (Figure 11-16) shall be classified with the designations shown in Table 11-12, based on types of duty and material classification.

Table 11-12. Metal-mesh sling designations.

Type Designation	Classification	
Heavy duty	Carbon steel	35-CS
	Stainless steel	35-SS
Medium duty	Carbon steel	43-CS
	Stainless steel	43-SS
Light duty	Carbon steel	59-CS
	Stainless steel	59-SS

b. The carbon steel used in metal-mesh slings shall be processed to produce the required mechanical properties.

c. The material used for stainless-steel metal-mesh slings shall conform, at least, to the American Iron and Steel Institute standards for Type-302 or Type-304 stainless steel. Other materials may be used. When metal-mesh slings are produced from such materials, however, the sling manufacturer should be consulted for specific data.

d. The handle shall be designed to ensure:

1. At least the same rated capacity as the fabric.

2. No visible permanent deformation after proof-testing.

e. The fabric and handles shall be so joined that:

1. The rated capacity of the sling is not reduced.

2. The load is evenly distributed across the width of the fabric.

3. Sharp edges do not damage the fabric.

f. Metal-mesh slings may be painted, plated, impregnated with elastomers such as neoprene or polyvinyl chloride (PVC), or otherwise suitably coated. The coating shall not diminish the rated capacity of a sling.

g. The design factor for metal-mesh slings shall be a minimum of 5:1 based upon breaking strength.

h. Metal-mesh slings shall not be used to lift loads greater than the rated capacity, properly derated for other than straight-pull configurations (Table 11-13).

i. Except for elastomer-impregnated slings, all metal-mesh slings covered by this section may be used without derating in a temperature range from -20 degrees F (-29 degrees C) to 550 degrees F (288 degrees C).

j. All metal-mesh slings covered by this section and impregnated with PVC or neoprene shall be used only in a temperature range from 0 degrees F (-18 degrees C) to 200 degrees F (93 degrees C).

k. For operation at temperatures outside these ranges or for other impregnations, consult the manufacturer for specific data.

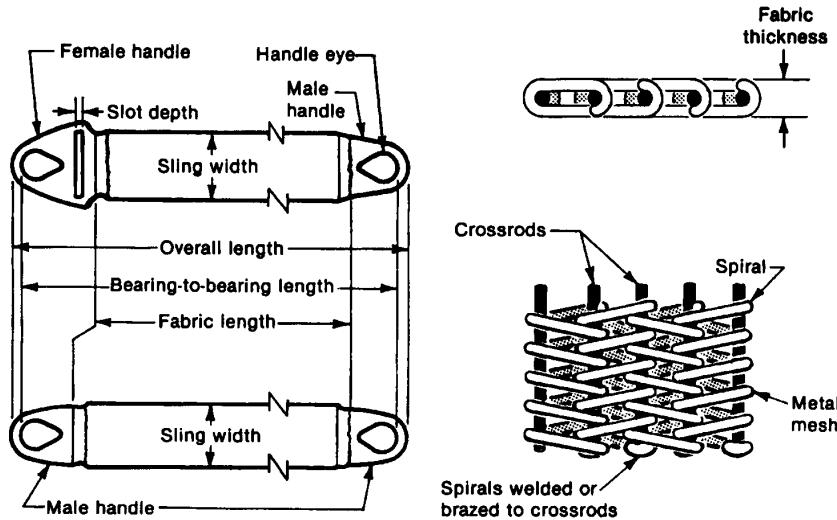


Figure 11-16. Typical metal-mesh sling.

11.3.4.1 Inspections

- a. Users of metal-mesh sling shall visually inspect all metal-mesh slings before each use.
- b. Annual inspections shall be made by a qualified inspector, and inspection records shall be kept on file and be readily available.
- c. Metal-mesh slings shall be removed from service if any of the following defects are present:
 1. A broken weld or brazed joint along the sling edge.
 2. A broken wire in any part of the mesh.
 3. Reduction in wire diameter of 25 percent due to abrasion or 15 percent due to corrosion.
 4. Lack of flexibility due to distortion of the mesh.
 5. Distortion of the female handle so the depth of the slot is increased by more than 10 percent.

6. Distortion of either end fitting so the width of the eye opening is decreased by more than 10 percent.

7. A 15 percent reduction of the original cross-sectional area of metal at any point around a handle eye.

8. Any distortion or twisting of either end fitting out of its plane.

9. Cracked end fitting.

10. Evidence of heat damage.

11.3.4.2 Proof-Testing

- a. Metal-mesh slings shall be certified as having been proof-tested to 200 percent of their rated capacity prior to initial use.
- b. Coated slings shall be proof-tested prior to being coated.
- c. Test loads shall be accurate to within -5 percent, +0 percent of stipulated values. Either certification by the manufacturer or a pull test certified by a qualified person is acceptable.

Table 11-13. Load capacity of carbon and stainless-steel metal-mesh slings in pounds
Design Factor = 5:1

Sling width(in.)	Vertical or choker	Basket or two legs	60° Basket or two legs	45° Basket or two legs	30° Basket or two legs	Sling width(in.)
Heavy duty 10-ga 35 spirals/ft of mesh width						
2	1,500	3,000	2,600	2,100	1,500	2
3	2,700	5,400	4,700	3,800	2,700	3
4	4,000	8,000	6,900	5,600	4,000	4
6	6,000	12,000	10,400	8,400	6,000	6
8	8,000	16,000	13,800	11,300	8,000	8
10	10,000	20,000	17,000	14,100	10,000	10
12	12,000	24,000	20,700	16,900	12,000	12
14	14,000	28,000	24,200	19,700	14,000	14
16	16,000	32,000	27,700	22,600	16,000	16
Medium duty 12-ga 43 spirals/ft of mesh width						
2	1,350	2,700	2,300	1,900	1,400	2
3	2,000	4,000	3,500	2,800	2,000	3
4	2,700	5,400	4,700	3,800	2,700	4
6	4,500	9,000	7,800	6,400	4,500	6
8	6,000	12,000	10,400	8,500	6,000	8
10	7,500	15,000	13,000	10,600	7,500	10
12	9,000	18,000	15,600	12,700	9,000	12
14	10,500	21,000	18,200	14,800	10,500	14
16	12,000	24,000	20,800	17,000	12,000	16
Light duty 14-ga 59 spirals/ft of mesh width						
2	900	1,800	1,600	1,300	900	2
3	1,400	2,800	2,400	2,000	1,400	3
4	2,000	4,000	3,500	2,800	2,000	4
6	3,000	6,000	5,200	4,200	3,000	6
8	4,000	8,000	6,900	5,700	4,000	8
10	5,000	10,000	8,600	7,100	5,000	10
12	6,000	12,000	10,400	8,500	6,000	12
14	7,000	14,000	12,100	9,900	7,000	14
16	8,000	16,000	13,900	11,300	8,000	16

(CFR 1910.184/ANSI/ASME B30.9)

11.3.4.3 Operation

- a. The following shall apply to all personnel who use metal-mesh slings:
 - 1. Ensure that the weight of the load is within the rated capacity of the sling.
 - 2. Ensure that metal-mesh slings have suitable characteristics and rated capacity for the load and environment.
- b. Metal-mesh slings should be long enough to provide the maximum practical angle between the sling leg and the horizontal (minimum practical angle at the crane hook if vertical angles are used).
- c. Do not shorten metal-mesh slings with knots, bolts, or other unapproved methods.
- d. Do not use damaged slings.
- e. Securely hitch metal-mesh slings to the load.
- f. Ensure that sharp corners are padded.
- g. Keep hands and fingers out of the area between the sling and the load.
- h. Ensure that all personnel stand clear of the suspended load.
- i. Avoid shock loading.
- j. Do not pull metal-mesh slings from under a load when the load is resting on the sling.
- k. Do not store metal-mesh slings in an area where they will be subjected to mechanical damage or corrosive action.
- l. Avoid twisting and kinking of the legs.
- m. In a choker hitch, ensure that metal-mesh slings are long enough so that the female handle chokes freely on the mesh, never on the handle.
- n. In a choker hitch, ensure that the load is balanced. When this cannot be done, consult the manufacturer for a derating factor or for other means of handling this type of load.
- o. In a basket hitch, ensure that the load is balanced to prevent slippage.
- p. Do not use metal-mesh slings in which the spirals are locked or are without free articulation.
- q. Never hammer a sling to straighten a spiral or cross rod or to force a spiral into position.

r. Metal-mesh slings used in pairs should be attached to a spreader beam.

s. Ensure that all metal-mesh slings have a permanently affixed metal identification tag or tags containing the following information:

- 1. Manufacturer's name or trademark.
- 2. Rated load in vertical, basket, and choker hitches.
- 3. Inspection due date.

11.3.4.4 Critical Lifts

See Chapter 2, "Critical Lifts," for critical lift requirements.

- a. Metal-mesh slings used for critical-lift service shall have an initial proof load test of 200 percent of the vertical rated capacity. If proof testing cannot be verified, the sling(s) shall be proof tested before being used to make a critical lift.
- b. The proof load for multiple-leg bridle slings shall be applied to the individual legs and shall be 200 percent of the vertical rated capacity of a single-leg sling.
- c. Master links to which multiple-leg slings are connected shall be proof-loaded to 200 percent multiplied by the force applied by the combined legs.

11.3.5 Synthetic-Web Slings

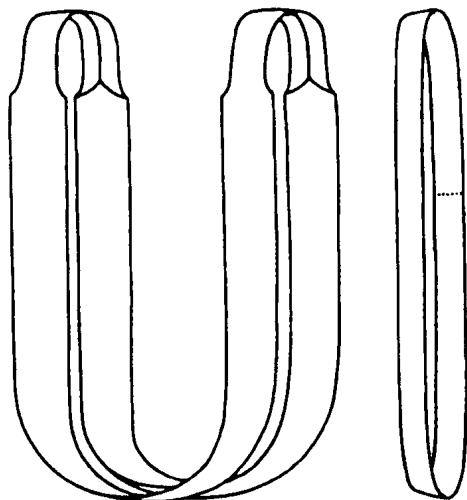
- a. Synthetic web shall possess the following qualities:
 - 1. Be of sufficient strength to meet the sling manufacturer's requirements.
 - 2. Have uniform thickness and width.
 - 3. Have selvage edges and not be split from its woven width.
- b. The thread used in the manufacture of a synthetic-web sling shall be of the same type of material as the web.
- c. Fittings shall be:
 - 1. Of sufficient strength to sustain twice the rated capacity without permanent deformation.
 - 2. Of a minimum breaking strength equal to that of the sling.

- 3. Free of all sharp edges that would in any way damage the mesh.
- d. The stitching in all load-bearing splices shall be of sufficient strength to maintain the sling design factor.
- e. Synthetic-web slings may be coated with elastomers or other suitable material that will provide characteristics such as abrasion resistance, sealing of pores, and increased coefficient of friction.
- f. The design factor for synthetic-web slings shall be a minimum of 5:1 based upon breaking strength.
- g. Rated capacities are affected by the type of hitch used and by the angle from the vertical when used as multilegged slings or in basket hitches. The sling manufacturer shall supply data on these effects.
- h. Synthetic-web slings are available in a number of configurations as follows (see Figure 11-17):
 - 1. *Endless or Grommet Sling*—Both ends of one piece of webbing are lapped and sewn to form a continuous piece. They can be used as vertical hitches, bridle hitches, in choker arrangements, or as basket slings. Because load contact points can be shifted with every lift, wear is evenly distributed and sling life is extended.
 - 2. *Standard Eye and Eye*—Webbing is assembled and sewn to form a flat-body sling with an eye at each end and the eye openings in the same plane as the sling body. The eyes may either be full web width or may be tapered by being folded and sewn to a width narrower than the webbing width.
 - 3. *Twisted Eye*—An eye-and-eye type that has twisted terminations at both ends. The eye openings are at 90 degrees to the plane of the sling body. This configuration is also available with either full-width or tapered eyes.
 - i. In place of the sewn eyes, synthetic-web slings are also available with metal end fittings (see Figure 11-18). The most common are triangle and choker hardware. Combination hardware consists of a triangle for one end of the sling and a triangle/rectangle choker attachment for the other end. With this arrangement, both choker and basket hitches, as well as straight hitches, may be rigged. They help reduce wear in the sling eyes and thus lengthen sling life.

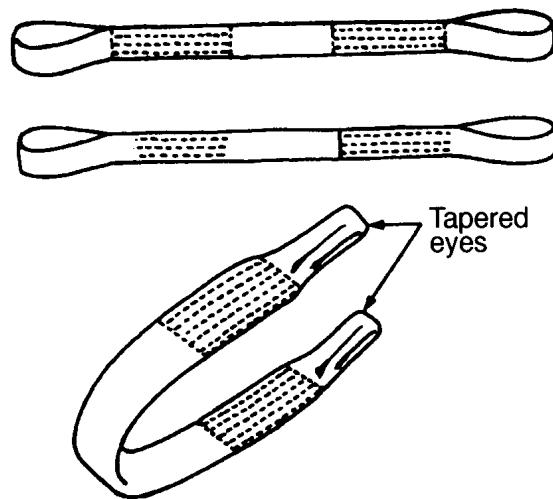
j. Despite their inherent toughness, synthetic-web slings can be cut by repeated use around sharp-cornered objects. They eventually show signs of abrasion when they are repeatedly used to hoist rough-surfaced products. There are, however, protective devices offered by most sling manufacturers that minimize these effects (see Figure 11-19). Other protective devices include:

- 1. Buffer strips of leather, nylon, or other materials that are sewn on the body of a sling protect against wear. Leather pads are the most resistant to wear and cutting, but are subject to weathering and gradual deterioration. They are not recommended in lengths over 6 ft due to the different stretching characteristics of leather and webbing. On the other hand, nylon-web wear pads are more resistant to weathering, oils, grease, and most alkalis; and they stretch in the same ratio as the sling body.
- 2. Edge guards consist of strips of webbing or leather sewn around each edge of the sling. This is necessary for certain applications where the sling edges are subject to damage.
- 3. Sleeve- or sliding-tube-type wear pads are available for slings used to handle material having sharp edges. They can be positioned on the sling where required, do not move when the sling stretches, adjust to the load, and cover both sides of the sling.
- 4. Reinforcing strips that double or triple the eye's thickness and greatly increase its life and safety can be sewn into the sling eyes.
- 5. Coatings can be applied to provide added resistance to abrasion and chemical damage. These treatments also increase the coefficient of friction, affording a better grip when loads with slippery surfaces are to be handled. These coatings can be brightly colored for safety or load-rating purposes.
- 6. Cotton-faced nylon webbing can be used for hoisting rough-surfaced material.

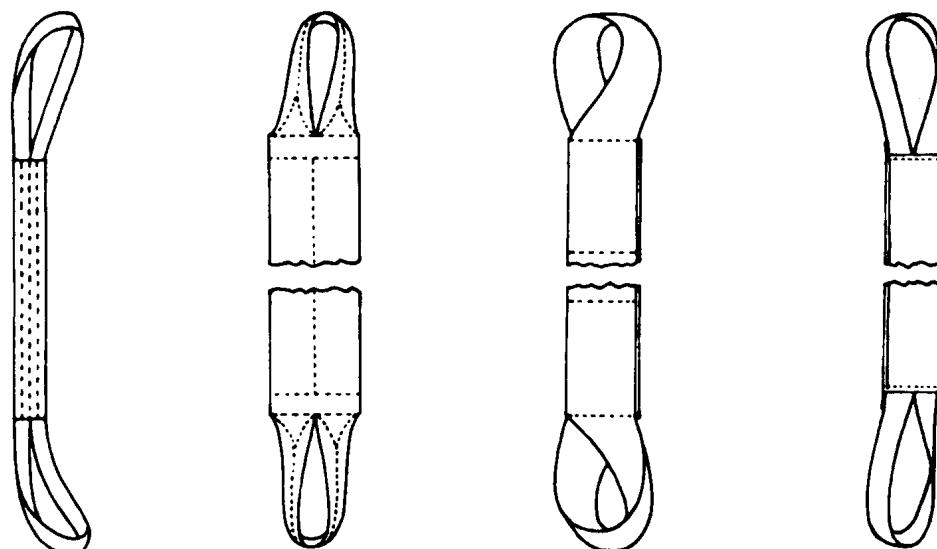
k. The synthetic-web sling capacities listed in Tables 11-14 and 11-15 are approximate only and are based on nylon webbing having breaking strengths between 6,000 and 9,000 lb/in. of webbing width. The capacities are also based on a 5:1 design factor and assume that the end fittings are of adequate strength.



Endless or grommet slings



Standard eye-and-eye slings



Twisted-eye slings

Figure 11-17. Synthetic-web sling types.

l. Although safe working loads for bridle hitches in the choker or double-basket configuration are provided, they should be used only with extreme caution because, as the sling angle decreases, one edge of the web will take all the load, producing a risk of tearing (see Figure 11-20).

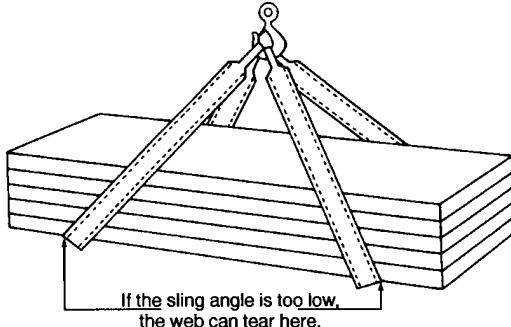


Figure 11-20. Effect of low sling angle.

m. Synthetic-web slings, other than those described in this section [i.e., polyester round and kevlar fiber (yarn) slings], shall be used in accordance with the sling manufacturer's recommendation.

n. Conventional three-strand natural or synthetic fiber rope slings are NOT recommended for lifting service and should be used only if conventional sling types are not suitable for a unique application. The requirements of ASME B30.9 ("Slings"), Section 9-4, and 29 CFR 1910.184(h) shall be followed.

CAUTION: Tiedown and/or ratchet strap shall not be used as synthetic-web slings. Only synthetic-web slings constructed from webbing approved for sling construction by the manufacturer or other qualified person shall be used at DOE locations.

11.3.5.1 Inspections

a. Users of synthetic-web sling shall visually inspect all slings before each use.

b. Annual inspection shall be made by a qualified inspector, and inspection records shall be kept on file and readily available.

c. When it is necessary to use a nylon or polyester sling in a radiation area, the responsible manager shall ensure that radiation exposure does not exceed 100,000 rad during the life of the sling.

d. Slings shall be removed from service if any of the following defects are visible:

1. Acid or caustic burns.
2. Melting or charring of any part of the surface.
3. Snags, punctures, tears, or cuts.
4. Broken or worn stitches.
5. Wear or elongation exceeding the amount recommended by the manufacturer.
6. Distortion of fittings.
7. Knots in any part.
8. Missing or illegible sling identification.

A sample periodic inspection form is included as Exhibit III at the end of this section. This form is intended to be a sample only and is not intended to be mandatory.

11.3.5.2 Proof-Testing

a. When specified by the purchaser, web slings of all types shall be certified as having been proof-tested prior to initial use.

1. The proof load for single-leg slings and endless slings shall be 200 percent of the vertical rated capacity.

2. The proof load for multiple-leg bridle slings shall be applied to the individual legs and shall be 200 percent of the vertical rated capacity of a single-leg sling. Master links to which multiple-leg slings are connected shall be proof-loaded to 200 percent times the force applied by the combined legs.

b. Test loads shall be accurate to within -5 percent, +0 percent of stipulated values. Either certification by the manufacturer or a pull test certified by a qualified person is acceptable.

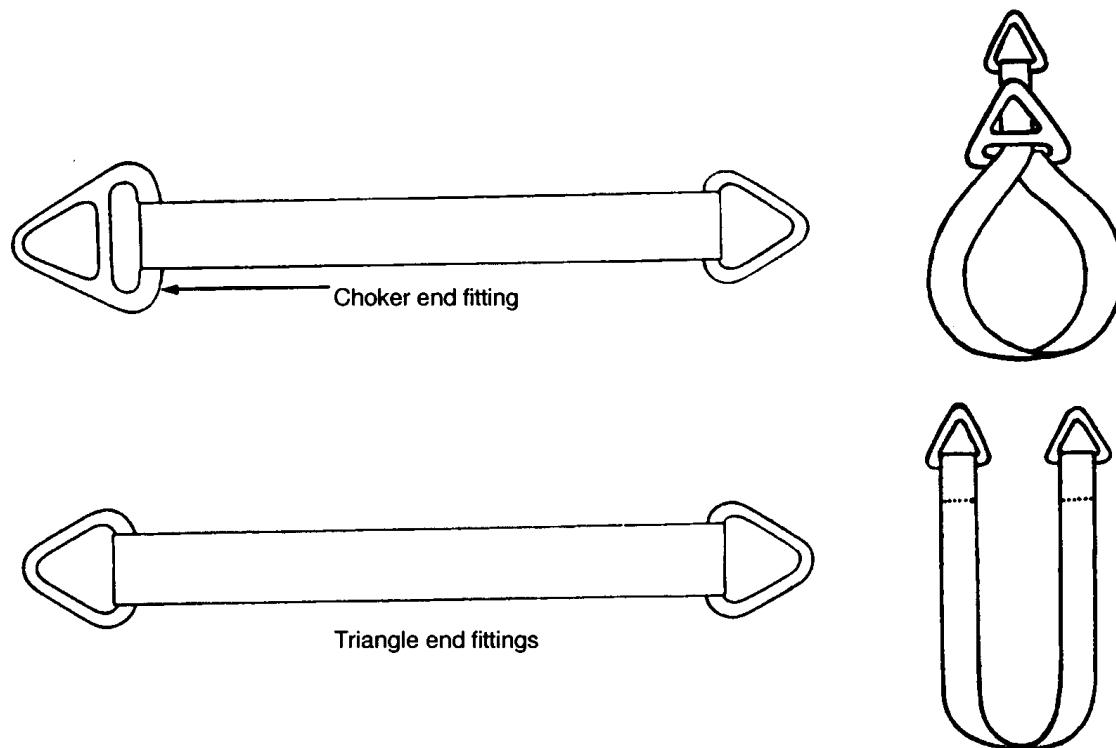
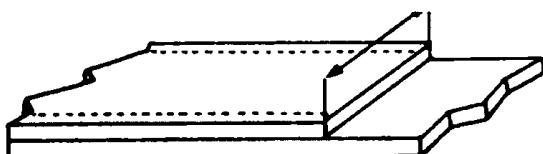
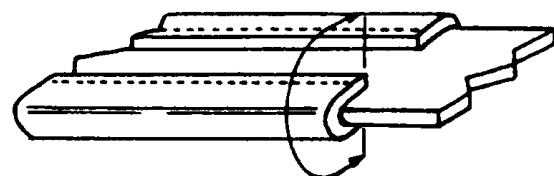


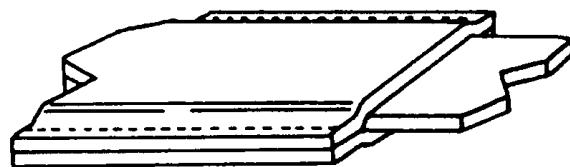
Figure 11-18. Metal end fittings.



REGULAR. This is the type of edge protection that is sewn on to give fixed protection at expected wear points. They can be sewn anywhere on the sling, at any length on one side, or on both sides.



EDGE GUARD. A strip of webbing or leather is sewn around each edge of the sling. This is necessary for certain applications where the sling edges are subject to damage.



SLEEVE. Sometimes called sleeve or sliding-tube type wear pads, these pads are ideal for handling material with sharp edges because the sleeve does not move when the sling stretches and adjusts to the load. Sleeves cover both sides of the sling and can be shifted to points of expected maximum wear.

Figure 11-19. Web and edge protectors.

Table 11-14. Load capacity of synthetic web slings in pounds Design Factor = 5:1 (eye and eye, twisted eye, triangle fittings, choker fittings)

Web width (in.)	Vertical	Choker	Basket or two legs	60° Basket or two legs	45° Basket or two legs	30° Basket or two legs	Web width (in.)
Nylon Single Ply Web Slings (6,000 lb/in. material)							
1	1,200	900	2,400	2,080	1,700	1,200	1
2	2,400	1,800	4,800	4,160	3,400	2,400	2
3	3,600	2,700	7,200	6,240	5,100	3,600	3
4	4,800	3,600	9,600	8,300	6,800	4,800	4
5	6,000	4,500	12,000	10,400	8,500	6,000	5
6	7,200	5,400	14,400	12,500	10,200	7,200	6
Nylon Double Ply Web Slings (6,000 lb/in. material)							
1	2,400	1,800	4,800	5,600	3,400	2,400	1
2	4,800	3,600	9,600	8,320	6,800	4,800	2
3	7,200	5,400	14,400	12,480	10,200	7,200	3
4	9,600	7,200	19,200	16,600	13,600	9,600	4
5	12,000	9,000	24,000	20,800	17,000	12,000	5
6	14,400	10,800	28,800	25,000	20,400	14,400	6

(CFR 1910.184/ANSI/ASME B30.9)

- (1) For an endless sling with vertical hitch carrying a load of such size as to throw the legs more than 5 deg. off vertical use rated load data for eye and eye sling, basket hitch and corresponding leg angles.
- (2) Follow manufacturer's capacities, they vary from manufacturer to manufacturer.
- (3) Choker hitch values apply only to choke angles greater than 120 degrees.

**Table 11-15. Load capacity of synthetic web slings in pounds Design Factor = 5:1
(eye and eye, twisted eye, triangle fittings, choker fittings)**

Web width (in.)	Vertical	Choker	Basket or two legs	60° Basket or two legs	45° Basket or two legs	30° Basket or two legs	Web width (in.)
Nylon Single Ply Web Slings (9,000 lb/in. material)							
1	1,600	1,280	3,200	2,770	2,260	1,600	1
2	3,200	2,560	6,400	5,540	4,520	3,200	2
3	4,800	3,840	9,600	8,320	6,780	4,800	3
4	6,400	5,120	12,800	11,090	9,040	6,400	4
5	8,000	6,400	16,000	13,860	11,300	8,000	5
6	9,600	7,680	19,200	16,640	13,560	9,600	6
Nylon Double Ply Web Slings (9,000 lb/in. material)							
1	3,200	2,560	6,400	5,540	4,520	3,200	1
2	6,400	5,120	12,800	11,090	9,040	6,400	2
3	8,880	7,100	17,760	15,390	12,540	8,880	3
4	11,520	9,210	23,040	19,660	16,270	11,520	4
5	14,000	11,200	28,000	24,260	19,775	14,000	5
6	16,320	13,050	32,640	28,280	23,050	16,320	6

(CFR 1910.184/ANSI/ASME B30.9)

- (1) For an endless sling with vertical hitch carrying a load of such size as to throw the legs more than 5 deg. off vertical use rated load data for eye and eye sling, basket hitch and corresponding leg angles.
- (2) Follow manufacturer's capacities, they vary from manufacturer to manufacturer.
- (3) Choker hitch values apply only to choke angles greater than 120 degrees.

**Table 11-16. Load capacity of Single Leg Polyester Roundslings in pounds
Endless and Eye to Eye Type Design Factor = 5:1**

Size (Note 1)	Vertical	Choker	Basket or two leg	60 degrees	45 degrees	30 degrees	Size (Note 1)
1	2,600	2,100	5,200	4,500	3,700	2,600	1
2	5,300	4,200	10,600	9,300	7,500	5,300	2
3	6,400	6,700	16,800	14,500	11,900	6,400	3
4	10,600	8,500	21,200	18,400	15,000	10,600	4
5	13,200	10,600	26,400	22,900	18,700	13,200	5
6	16,800	13,400	33,600	29,100	23,800	16,800	6
7	21,200	17,000	42,400	36,700	30,000	21,200	7
8	25,000	20,000	50,000	43,300	35,400	25,000	8
9	31,000	24,800	62,000	53,700	43,800	31,000	9
10	40,000	32,000	80,000	69,300	56,600	40,000	10
11	53,000	42,400	106,000	91,800	74,900	53,000	11
12	66,000	52,800	132,000	114,300	93,300	66,000	12
13	90,000	72,000	180,000	155,900	127,300	90,000	13

(CFR 1910.184/ANSI/ASME B30.9)

NOTES:

1. Roundslings are identified by the vertical rated load shown on the tag. The Size Number in this column have been adopted by the Web Sling and Tiedown Association to describe certain polyester roundslings. They are included for reference only. Other polyester roundslings may have different vertical rated loads.

2. Color guidelines for polyester roundsling covers are widely used to indicate the vertical rated load of roundslings; however, this is not followed by some manufacturers. Always select and use roundslings by the rated load as shown on the tag, never by color.

15.2 DEFINITIONS

APPOINTED: Assigned specific responsibilities by the employer or the employer's representative.

AUTHORIZED: Assigned by a duly constituted administrative or regulatory authority to perform a specific function.

CRANE, MOBILE: For the purposes of this chapter, mobile cranes are defined as wheel-mounted cranes, truck cranes, and crawler cranes.

- o A **wheel-mounted** crane consists of a rotating structure with power plant, operating machinery, and boom, mounted on a base or platform equipped with axles and rubber-tired wheels for travel. The base is usually propelled by an engine in the superstructure, but it may be equipped with a separate engine controlled from the superstructure (see Figures 15-1, 15-3, 15-5, 15-6, 15-7, 15-9, and 15-10).
- o A **truck-mounted crane** consists of a rotating superstructure with power plant that operates machinery and boom, mounted on an automotive truck equipped with a power plant for travel. Commercial truck-mounted cranes are included in this category (see Figures 15-3, 15-7, 15-9, and 15-10).
- o A **crawler crane** consists of a rotating superstructure with power plant, operating machinery and boom, mounted on a base equipped with crawler treads for travel (see Figures 15-2 and 15-8).

DESIGNATED: Selected or assigned by the employer or the employer's representative as being qualified to perform specific duties.

DESIGNATED LEADER: “An individual assigned responsibility for hoisting and rigging activities requiring more than one person”.

FORKLIFT TRUCK: A high-lift self-loading truck equipped with load carriage and forks for transporting and tiering loads (see Figure 15-11).

LIFT, CRITICAL: A lift for which the application of requirements applicable to ordinary lifts would not adequately eliminate or control the likelihood or severity of the following:

- o personnel injury or significant adverse health impact (onsite or offsite).
- o significant release of radioactivity or other hazardous material or other undesirable conditions.
- o undetectable damage that would jeopardize future operations or the safety of a facility.
- o damage that would result in delay to schedule or other significant program impact such as loss of vital data.

LIFT, ORDINARY: Any lift not designated as a critical lift.

PERSON-IN-CHARGE (PIC): The manager or other responsible person (other than the equipment operator) known to be qualified and appointed to be responsible for the safe handling of critical loads.

Note: In the text, use of the imperative voice (as in “Ensure that the load is balanced”) or of the term “shall” refers to mandatory actions, whereas the term “should” refers to recommended actions.

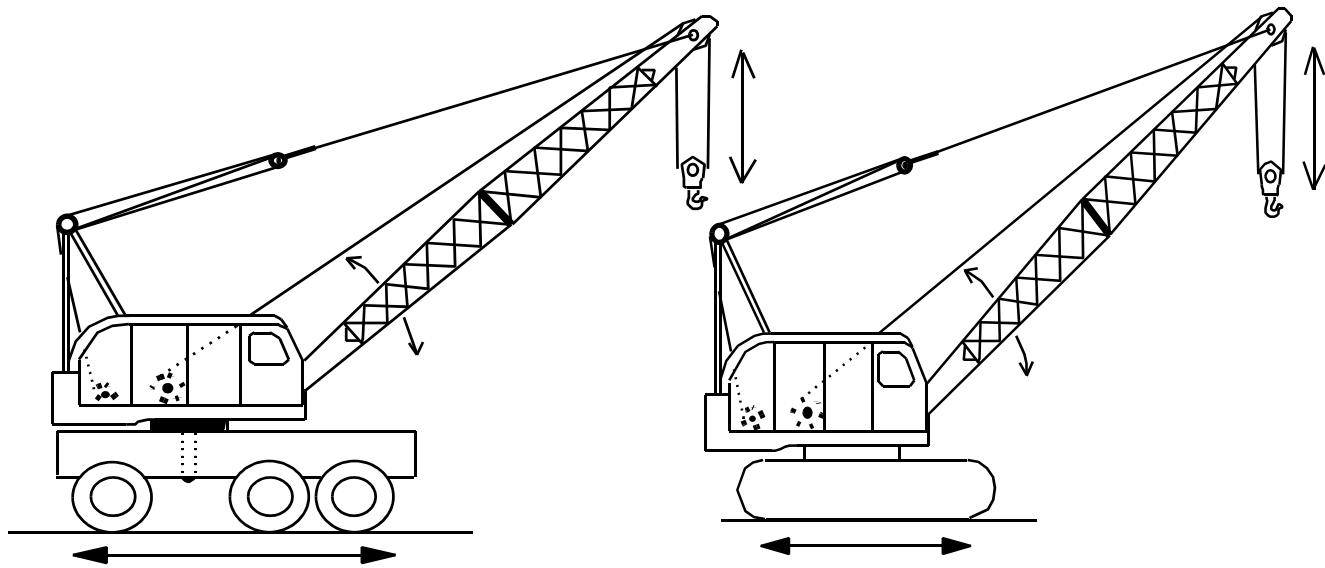


Figure 15-1. Wheel-mounted crane (single control station).

Figure 15-2. Crawler crane

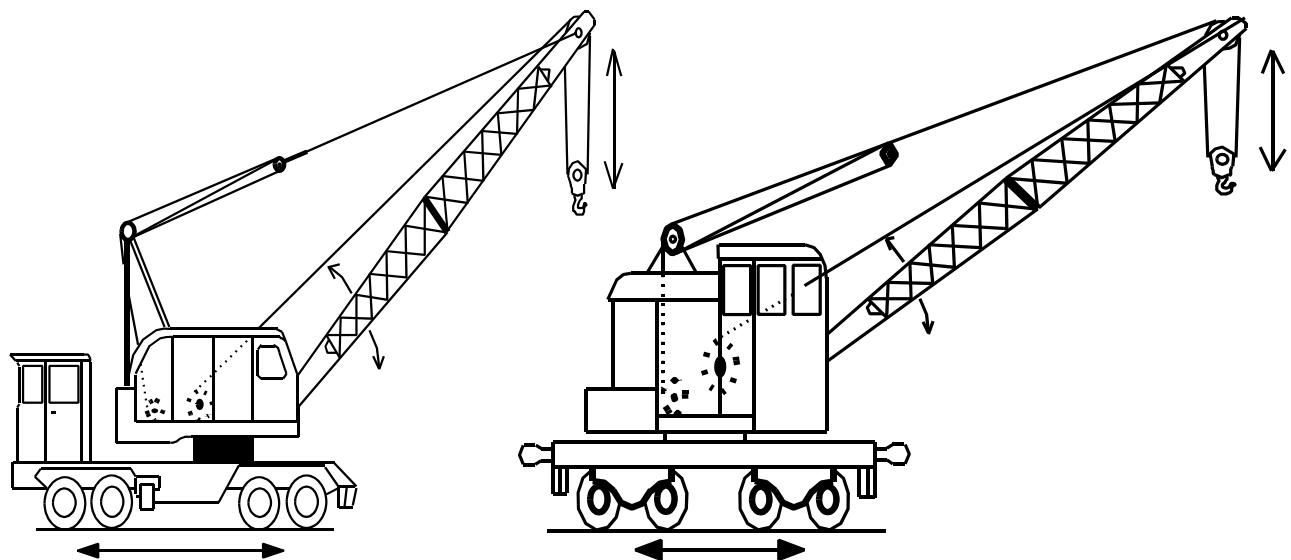


Figure 15-3. Wheel-mounted crane (Multiple control station).

Figure 15-4. Locomotive crane.

General note for Figures 15-5 through 15-10:

The boom may have a base boom structure of sections (upper and lower) between or beyond which additional sections may be added to increase its length, or it may consist of a base boom from which one or more boom extensions are telescoped for additional length. These illustrations show some types.

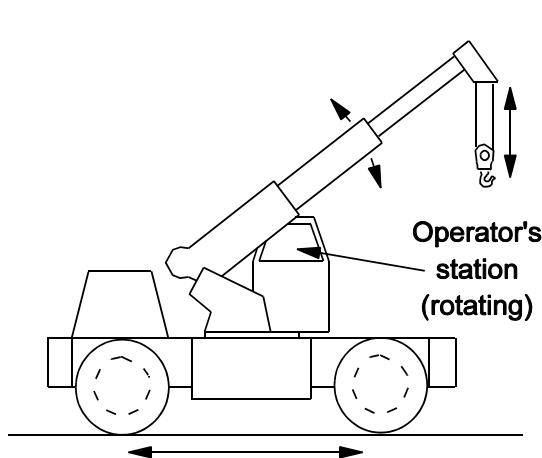


Figure 15-5. Wheel-mounted crane -- telescoping boom (Single control station).

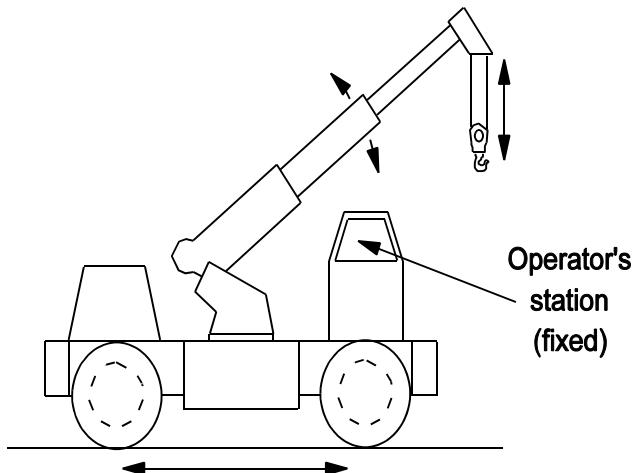


Figure 15-6. Wheel-mounted crane -- telescoping boom (Single control station).

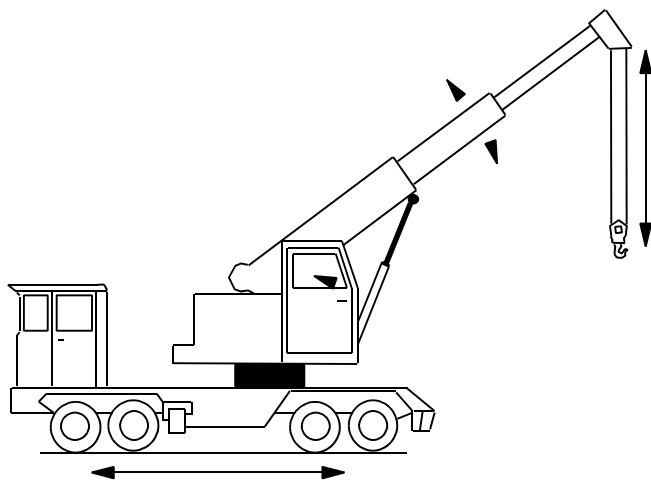


Figure 15-7. Wheel-mounted crane -- telescoping boom (Multiple control station).

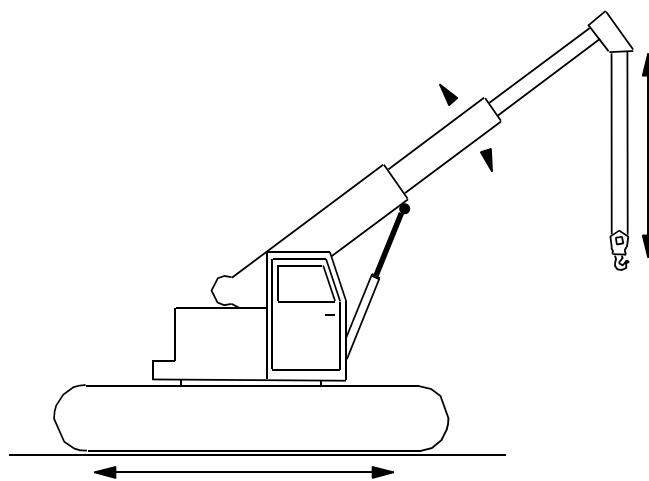


Figure 15-8. Crawler crane -- telescoping boom.

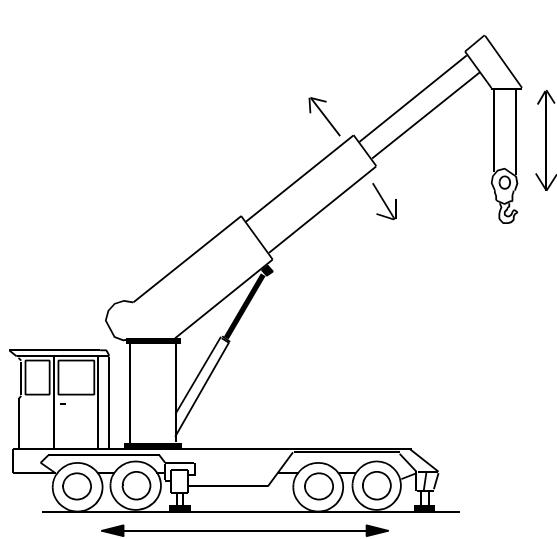


Figure 15-9. Commercial truck-mounted crane -- telescoping boom.

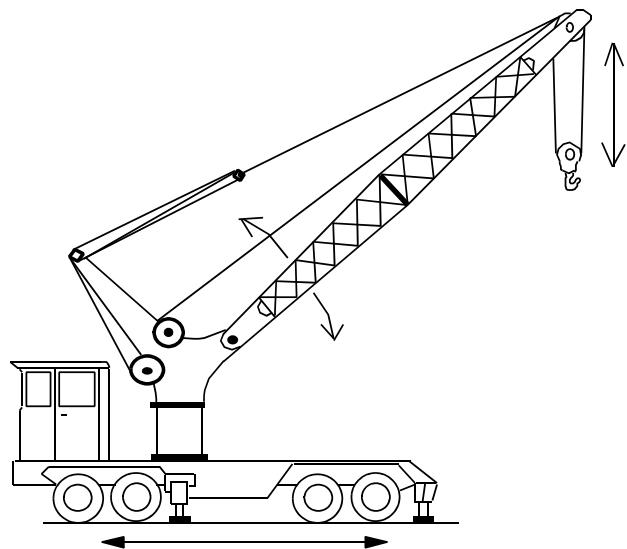


Figure 15-10. Comerical truck-mounted crane -- non-telescoping boom.

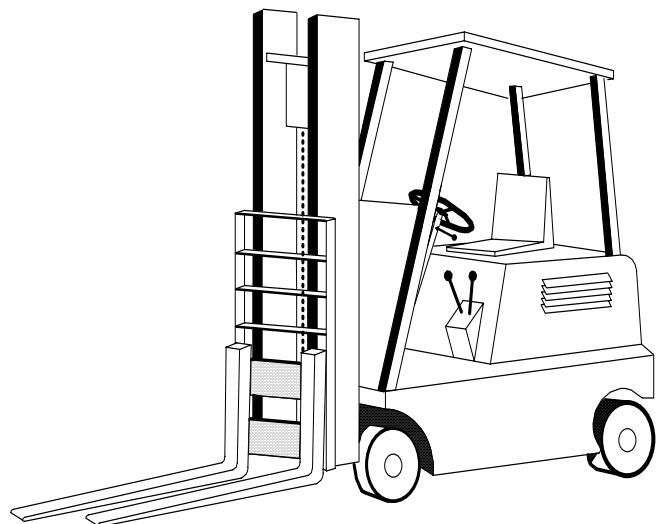


Figure 15-11. High-lift truck, counterbalanced truck, Cantilever truck, rider truck, forklift truck.

QUALIFIED: A person, who, by possession of a recognized degree or certificate, or by professional standing, or who, by extensive knowledge, training, and experience, has successfully demonstrated an ability and competence to solve problems relating to the subject matter and work.

QUALIFIED ENGINEER/QUALIFIED ENGINEERING ORGANIZATION: An engineer or engineering organization whose competence in evaluation of the type of equipment in question has been demonstrated to the satisfaction of the responsible manager.

QUALIFIED INSPECTOR: One whose competence is recognized by the authority having jurisdiction and whose qualification to perform specific inspection activities has been determined, verified, and attested to in writing.

QUALIFIED OPERATOR: One whose competence to operate equipment safely and effectively (including the ability to accurately spot and control loads) can be demonstrated to and accepted by responsible management.

QUALIFIED RIGGER: One whose competence in this skill has been demonstrated by experience accepted as satisfactory by the responsible manager.

15.6 LIFTING PERSONNEL

15.6.1 Mobile Cranes/Boom Trucks

This section specifies the operation, design, testing, and inspection requirements for the use of personnel lift platforms or baskets suspended from mobile cranes and/or boom trucks. This section implements the requirements of 29 CFR 1926.550(g) "Cranes and Derricks" and ASME B30.23, "Personnel Lifting Systems."

15.6.1.1 Personnel Lifting Evaluation

- a. The use of a crane to hoist employees on a personnel lift platform is prohibited, except when the erection, use, and dismantling of conventional means of reaching the worksite, such as a personnel hoist, ladder, stairway, aerial lift, elevating work platform or scaffold, would be more hazardous or is not possible because of structural design or worksite conditions.
- b. The manager specifically responsible for the overall work function to be performed shall determine that the erection, use, and dismantling of conventional means of reaching the work site (i.e., scaffold, ladder, stairway, aerial lift, or elevating work platform) would be more hazardous or is not possible because of structural design or worksite conditions.
- c. For each personnel lifting procedure, the manager responsible for the task shall authorize the use of a crane-suspended work platform and attest to the need for the operation through a written justification attesting to that need. A statement describing the operation and its time frame shall be included. The statement, after being approved by the authorizer, shall be retained at the job site.
- d. The manager specifically responsible for the overall work function shall not allow or require any operator to lift personnel under the following circumstances:
 - 1. The operator does not feel physically or mentally fit to perform the operation.
 - 2. The operator has been working for more than 10 hours prior to the start of the lift or the lift will not be completed before the operator has been working for 12 hours.

- 3. The operator did not have at least eight hours off, immediately prior to the work shift containing the person.

15.6.1.2 Designated Leader

- a. The Authorizing Manager shall appoint a Designated Leader for the entire personnel lifting operation.
- b. The Designated Leader shall ensure that a pre-job plan is prepared that defines the operation. The Designated Leader shall ensure:
 - 1. At each new job site prior to hoisting personnel, the personnel lift platform, rigging, and hook block shall be proof-tested by a qualified inspector to 125 percent of the personnel platform's rated capacity by holding it suspended for 5 minutes with the test load suitably distributed on the personnel platform.
 - 2. After proof-testing, any deficiencies revealed by inspection, or by the proof test, shall be corrected and another proof-test conducted.
 - 3. Any modification to the personnel lift platform or rigging shall require retesting.
 - 4. Test reports shall be kept on file and shall be readily available to appointed personnel.
 - 5. A meeting is held prior to the trial lift with the designated leader, qualified operator, signaler, persons to be lifted, and the person responsible for overall worksite safety to plan and review procedures to be followed. Procedures for entering and leaving the personnel platform and the points at which persons will enter and leave the device shall be reviewed. This meeting shall be held at each new work location, and shall be repeated for any employees newly assigned to the operation.
 - c. The designated leader and the crane operator shall determine that:
 - 1. The crane shall be uniformly level within 1 percent of level grade and firm footing exist under both crawler tracks or under each outrigger float. Cribbing mats under tracks or blocks under outrigger floats are used as necessary to provide a firm and substantial footing.

2. Cranes equipped with outriggers shall have outriggers extended in accordance with the manufacturer's instructions.

3. Crane systems, controls, operator aids, and safety devices are activated and functioning properly.

4. No interferences exist.

5. The total weight of the loaded personnel lift platform (including personnel) and related rigging shall not exceed 50 percent of the crane rating under the planned conditions of use.

6. The personnel lift platform shall not be loaded in excess of its rated load capacity. The number of employees occupying the platform shall not exceed the number required for the work being performed.

15.6.1.3 Trial Lift

a. Each shift, before personnel initially enter the personnel lift platform, the operator and signaler shall conduct a trial lift. The trial lift shall include:

1. Loading the unoccupied personnel platform to at least the maximum anticipated load. Materials and tools to be used during the actual lift, if secured to prevent displacement, can be in the platform for the trial lift.

2. The trial lift shall be made from the location where personnel will enter the platform to each location where the platform will be hoisted and positioned. It is acceptable to perform a single trial lift on each shift for all locations to be reached from a single setup position.

3. The trial lift shall be repeated whenever:

- i. The crane (mobile) is moved and set up in a new location or returned to a previously used location.
- ii. When the lift route is changed, unless the operator determines that the safety of the hoisted personnel is not affected.
- iii. If a different crane operator is assigned.

15.6.1.4 Lifting Operations

15.6.1.4.1 Pre-Lift Meeting

a. A meeting attended by the operator, the ground crew, signaler(s), person(s) to be lifted, and the designated leader shall be held each shift to plan and review procedures to be followed, including:

- 1. Points at which persons will enter and leave the platform.
- 2. Procedures for entering and leaving the platform.
- 3. Special precautions if personnel will perform work from the suspended platform.

b. This meeting shall be held at each new work location, and shall be repeated for any employees newly assigned to the operation.

15.6.1.4.2 Pre-Lift Inspection

a. After the trial lift, prior to lifting personnel:

1. A visual inspection of the crane, rigging, and personnel lift platform shall be conducted by a qualified inspector. Any defects found that create a safety hazard shall be corrected prior to hoisting personnel.

2. The platform shall be lifted a few inches and inspected to ensure that it is secure and properly balanced.

15.6.1.4.3 Lifting Personnel

a. Prior to hoisting personnel in a personnel lift platform ensure that:

1. No hazardous conditions exist with the platform and its associated rigging.

2. The hoist line is not wrapped around any part of the platform.

3. Hoist ropes are free of kinks.

4. Multiple-part lines are not twisted around each other.

5. The primary attachment is centered over the platform.

6. Ropes are properly seated on drums and sheaves.

7. The crane is within 1 percent of level.

8. The crane has an anti two-block device installed and operational.

b. Employees being hoisted or working in a personnel lift platform shall:

1. Remain in continuous sight of, and in direct communication with, the operator or signaler. In situations where direct visual contact with the operator is not possible and the use of a signaler would create a hazard for that person, direct communication alone (such as a two-way radio) may be used.
2. Keep all parts of their bodies inside the suspended personnel lift platform during raising, lowering, and positioning to avoid pinch points.
3. Wear body harnesses with lanyards attached to the lower load block or overhaul ball, or to a structural member within the platform that is capable of supporting a fall impact.
4. Not stand on or work from the top rail, midrail, or toe board of the suspended personnel platform.
5. When working above water, the requirements of 29 CFR 1926.106 (Occupational Safety and Health Regulations for Construction) shall also apply.
6. When welding is being performed from the personnel lift platform, the electrode holders shall be protected from contact with metal components of the personnel platform.

c. Operators of cranes hoisting personnel in a personnel lift platform shall:

1. Before commencing or continuing the lift, consult with the designated leader when ever there is any doubt as to the safety of the lift.
2. Remain at the controls when the personnel lift platform is occupied.
3. Operate the crane so that lowering will be power-controlled (no free-fall).
4. Ensure movement of the personnel lift platform is performed in a slow, controlled, cautious manner with no sudden movements of the crane or the platform. The lifting or

lowering speed shall not exceed 100 ft/min (30 m/min).

5. After the personnel lift platform is positioned, set all brakes and locks on the lift crane before personnel perform any work.

6. If the personnel lift platform cannot be landed, ensure it is tied to the structure before personnel get off or on.

7. Ensure that no lifts are made on another of the crane's load lines while personnel are suspended on the personnel lift platform.

d. Suspended personnel lift platforms shall be used only for personnel, their tools, and sufficient materials to do their work. They shall not be used for transporting bulk materials.

e. Personnel lift platforms should not be used in winds greater than 20 mph (32.2 km/hr), electric storms, snow, ice, sleet, or other adverse weather conditions that could affect the safety of personnel.

f. Use tag lines to control motion of occupied personnel lift platforms unless their use creates an unsafe condition.

g. Cranes shall not travel while personnel are in the platform. Exceptions to this provision shall be approved by the manager specifically responsible for the overall work function and precautions to be taken documented in the personnel lift plan.

15.6.1.5 Mobile Cranes/Boom Trucks

Mobile cranes are designed and intended for handling materials, not personnel. In addition to the general requirements in Section 15.5.3.1, "Operating the Unit," the following requirements shall be met when lifting personnel with a mobile crane:

a. Personnel are permitted to ride only in one of the following:

1. A personnel lift platform that is supported from the crane's hook which meets the requirements of Section 15.6.1.6, "Personnel Platform."
2. A personnel basket attached directly to the boom which is approved by the crane manufacturer.

b. Cranes and derricks with variable-angle booms shall be equipped with a boom-angle indicator that is readily visible to the operator.

- c. Cranes with telescoping booms shall be equipped with a device to indicate clearly to the operator, at all times, the boom's extended length, or an accurate determination of the load radius to be used during the lift shall be made prior to hoisting personnel.
- d. A positive-acting device shall be used that prevents contact between the load block or overhaul ball and the boom tip (anti-two-blocking device), or a system shall be used that deactivates the hoisting action before damage occurs in the event of a two-blocking situation (two-block damage-prevention feature).
- e. Cranes having booms in which lowering is controlled by a brake without aid from other devices which slow the lowering speeds is prohibited.
- f. Crane load lines shall be capable of supporting, without failure, at least seven times the maximum intended load, except where rotation resistant rope is used, the lines shall be capable of supporting without failure, at least ten times the maximum intended load.
- g. Hydraulic cranes shall have check valves or other devices that will prevent uncontrolled movement in the event of system failure, engine failure, or hose rupture.
- h. Cranes shall have a means to prevent retraction of hydraulically or pneumatically activated outriggers or stabilizers in the event a hydraulic or pneumatic line fails.

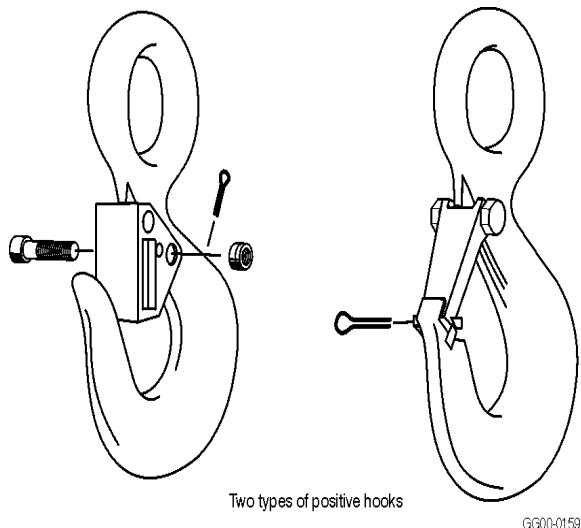


Figure 15-18. Positive Hooks

- i. Pendant supported, jib type, boom extensions without positive stops are prohibited for personnel lifting.
- j. Hooks on overhaul ball assemblies, lower load blocks, or other attachment assemblies shall be of the type that can be closed and locked, eliminating the hook throat opening. (Figure 15-18). Alternatively, an alloy anchor type shackle with a bolt, nut and retaining pin may be used.

15.6.1.6 Personnel Lift Platform

15.6.1.6.1 Platform Design and Construction

There is no attempt to comprehensively address platform design and construction in this section. Nevertheless, because many platform design and construction features can be observed and should be known by the platform user, (See Figures 15-19) the following key design and construction requirements are presented:

- a. The personnel lift platform and suspension system shall be designed by a qualified person competent in structural design and familiar with national consensus standards governing personnel platform design.
- b. All welding of the platform shall be performed by a qualified welder in accordance with ANSI/AWS D1.1. Where special steels or other materials are used, the manufacturer shall provide welding procedures. Welds shall be inspected by a qualified inspector.
- c. The personnel lift platform shall have:
 1. A minimum design factor of five.
 2. A plate specifying its empty weight and its rated load capacity or maximum intended load.
 3. Perimeter protection consisting of a top rail approximately 45 in. (115 cm) high, a toe board at least 4 in. (10 cm) high, and a midrail approximately halfway between the top rail and the toe board.
 4. A grab rail inside the personnel lift platform to minimize hand exposure.
 5. Anchorage points within the platform for attaching personnel fall protection lanyards.
 6. The sides of the platform enclosed from the toe board to the midrail with solid

construction or expanded metal having openings no greater than $\frac{1}{2}$ in. (1.27 cm).

7. Platform access gates, including sliding or folding types, if installed, shall have a positive acting device to restrain the gate from accidental opening. Swinging type access gates shall open only to the interior of the personnel lift platform.

8. Rough edges exposed to contact by employees surfaced (ground smooth) to prevent injury.

9. High-visibility color or marking for easy identification.

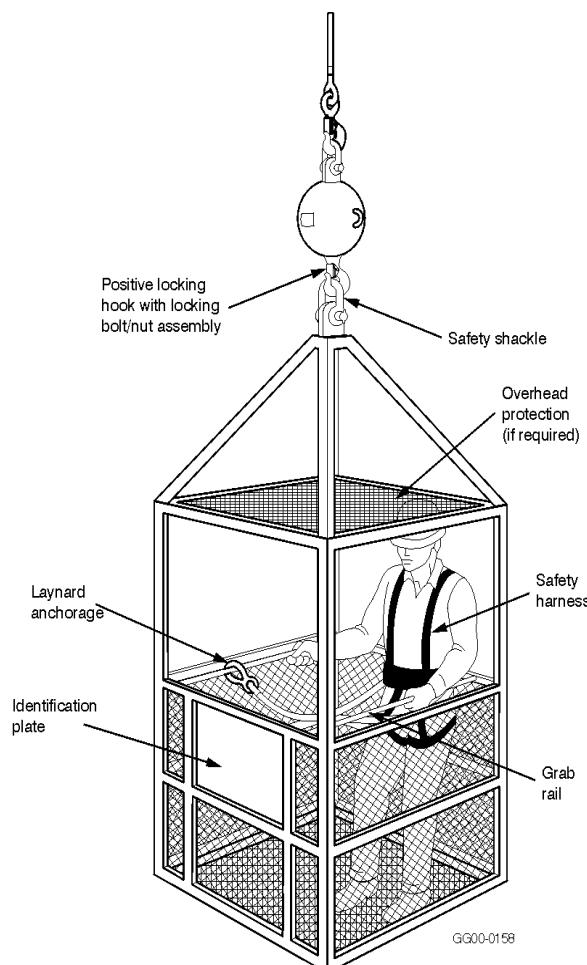


Figure. 15-19. Personnel Lift Platform

d. In addition to wearing hard hats, personnel shall be protected by overhead protection on the personnel lift platform when there is an overhead hazard. Sufficient headroom shall be provided to allow employees to stand upright in the platform.

15.6.1.6.2 *Platform Suspension System*

a. Wire rope, shackles, rings, master links, and other rigging hardware must be capable of supporting, without failure, at least five times the maximum intended load applied or transmitted to that component and guided by the following:

1. One-leg system - design factor of seven.

2. Two or three-leg system - design factor of five for each leg.

3. Four-leg system - design factor of five with only three legs under stress.

4. Where rotation resistant rope is used, the slings shall be capable of supporting without failure at least ten times the maximum intended load.

b. Sling suspension systems shall utilize a master link or safety type shackle to connect the personnel lift platform to the load line to ensure that the load is evenly divided among the suspension system legs.

c. The suspension system shall be designed to minimize tipping of the platform due to movement of employees occupying the platform.

d. The sling suspension system attaching the personnel lift platform to the hoist line shall not be used for any other purpose when not hoisting personnel.

e. Shackles used in any part of the suspension system shall be a safety type (bolt-type shackle with nut and cotter pin).

f. All eyes in wire rope slings shall be fabricated with thimbles.

g. Wire rope clips, wedge sockets, or knots shall not be used in suspension system sling assemblies.

h. Synthetic webbing, natural or synthetic fiber rope shall not be used for the suspension systems.

i. Chain sling suspension systems shall use a minimum of grade 80 chain.