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# Crane and Hoist Safety

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# Crane Safety

The main four causes of crane accidents are **contact with power lines, overturns, falls,** and **mechanical failure.**

Improper maintenance and failure to conduct regular inspections can also be harbingers of trouble, and dropped loads, boom collapse, rigging failures, workers being struck by the chassis as it rotates, lack of training, lack of communication, and other mishaps cause accidents as well. Following safe work practice and complying with OSHA's standards for crane safety can help minimize these risks.

There are a number of different types of cranes for both general and more specific uses, including:

- Mobile
- Hydraulic
- Overhead
- Gantry
- Tower

## Preparation Before Startup – The Seven Sisters of Safety

Before beginning to use any crane, all the steps on the checklist below need to have been completed.

1. Level the crane and ensure the support surface is firm and able to support the load.
2. Contact power utility owners and determine precautions, including whether lines will need to be deenergized for safety's sake. Know the location and voltage of the overhead power lines!
3. Know the capacities of your crane and its limitations, as well as any restrictions particular to your job site such as unstable soil, the location of underground power lines, utilities, or a predisposition for high-winds.
4. Make sure other personnel on the site are aware of hoisting activities and the operational range of the boom (swing radius).
5. Barricade areas within the swing radius of the boom.
6. Ensure cranes have been properly maintained and inspected. Remember that the competent person must inspect all machinery and equipment prior to and during each use to make sure it is in safe operating condition. If it needs fixing, take it out of service and don't use it until it is fixed!
7. Determine safe areas to store materials and place machinery.

## Mobile Cranes – The Four Lifting Principles You Must Know

- Center of Gravity
- Leverage

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- Stability
- Structural Integrity

In general, clearance of at least 10 feet should be maintained between power lines and any part of the crane or load.

***Proper training of crane operators in the mandatory use of load charts is important for safe hoisting operations. Crane operators need to know and understand how to use load charts provided by the crane manufacturer. LMI devices are an important safety feature on modern cranes. However, these devices cannot replace the judgment of a trained and qualified operator who has knowledge of safe practices regarding hoisted loads, swing radius, and load chart information. LMI devices should be checked per the manufacturer's recommendations and if not working properly, tagged out-of service until repairs are made.***

***Crane operators and workers must follow the manufacturer's recommendations for crane set-up and rigging.***
***Workers must use caution so that they do not place themselves in dangerous areas where they can be struck by falling loads or by falling or collapsing crane components.***

***Managers and safety professionals need to consider safe work practices for workers who are required to work on or near operating cranes. All workers should use and follow established hand signals such as the standard hand signals listed in ANSI B30.5–2004.***

## Personnel Platforms

A qualified engineer, or another competent specialist qualified in structural design, should design all lifting platforms. The platforms should meet the following requirements:

- Support platform weight and at least five times the maximum intended load.
- Minimize tipping caused by personnel movement on platforms by having an appropriate suspension system.
- Keep tools, materials, and equipment from falling on employees below by having a standard guardrail system that is enclosed from the toeboard to the mid-rail.

## Platform loading standards require that:

- Personnel platforms must not be loaded in excess of their rated load capacity or maximum intended load as indicated on permanent markings.

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- 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.
- All materials and tools must be secured and evenly distributed to balance the load while the platform is in motion.

## Material Hoists

As with personnel hoists, employees and contractors should always be aware of the manufacturer's specifications as well as any limitations applicable to the operation of all hoists and elevators. Safe work practice requires the rated load capacities, recommended operating speeds, and any warnings or instructions about special hazards to be posted on hoist cars and platforms.

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CDC Workplace Safety and Health

# NIOSH ALERT

# Preventing Worker Injuries and Deaths from Mobile Crane Tip-Over, Boom Collapse, and Uncontrolled Hoisted Loads

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

NIOSH

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**Safer • Healthier • People™**

NIOSH ALERT

# Preventing Worker Injuries and Deaths from Mobile Crane Tip-Over, Boom Collapse, and Uncontrolled Hoisted Loads

**WARNING!**

**Construction and industrial workers are frequently injured or killed when working on or around mobile cranes because of tip-over, boom collapse, and uncontrolled hoisted loads.**

**The National Institute for Occupational Safety and Health (NIOSH) requests assistance in preventing injuries and deaths of workers exposed to mobile crane tip-over, boom collapse, and uncontrolled hoisted loads. Recent NIOSH investigations suggest that workers may not fully recognize the hazards associated with operating or working near mobile cranes. Crane tip-overs can result from operating a crane outside the manufacturer's recommended safe lifting capacity. Booms can collapse for reasons such as overloading, improper disassembly procedures, and improper rigging. Both crane tip-over and boom collapse can result in workers being struck by parts of the crane or uncontrolled hoisted loads.**

**This Alert describes six incidents resulting in the deaths of eight workers and injuries to two others that were either working near or operating mobile cranes. In each incident, these injuries or deaths could have been prevented by using proper safety procedures such as not exceeding the crane's lift capacity; following proper set-up, maintenance and dismantling procedures; and not working under a suspended load.**

**NIOSH requests that the information in this Alert be brought to the attention of all employers, managers, supervisors, crane operators, riggers, and ground workers in companies that own or rent mobile cranes. NIOSH requests assistance from safety and health officials, construction companies, unions, crane and rigging manufacturers, crane rental facilities, building material suppliers and manufacturers, editors of trade journals, and those positioned to communicate prevention information to employers and workers.**

## BACKGROUND

Mobile cranes are used to hoist loads to meet various construction and industrial needs. All cranes use cables and pulleys or hydraulics to raise and lower the desired load. The Construction Safety Association of Ontario's Mobile Crane Manual [Dickie 1999] lists the basic operational characteristics of all mobile cranes as follows:

- Ability to lift and lower loads
- Ability to swing loads around an axis of rotation
- Adjustable boom lengths
- Adjustable boom angles
- Ability to travel about the job site under their own power

Mobile cranes come in a variety of types and configurations such as the following:

- Boom trucks
- Industrial cranes
- Carrier-mounted lattice boom cranes
- Crawler-mounted lattice boom cranes
- Carrier-mounted telescopic boom cranes
- Crawler-mounted telescopic boom cranes
- Rough terrain cranes
- Mobile tower cranes
- Heavy-lift mobile cranes

Cranes are able to lift heavy loads by applying the principle of leverage. The crane's own weight is balanced against the object or load being hoisted at the tipping point (or tipping axis) [Figure 1]. The crane remains stable and can safely lift and move the load so long as the crane's leverage on the load is greater than the load's leverage on the crane [Dickie 1999].

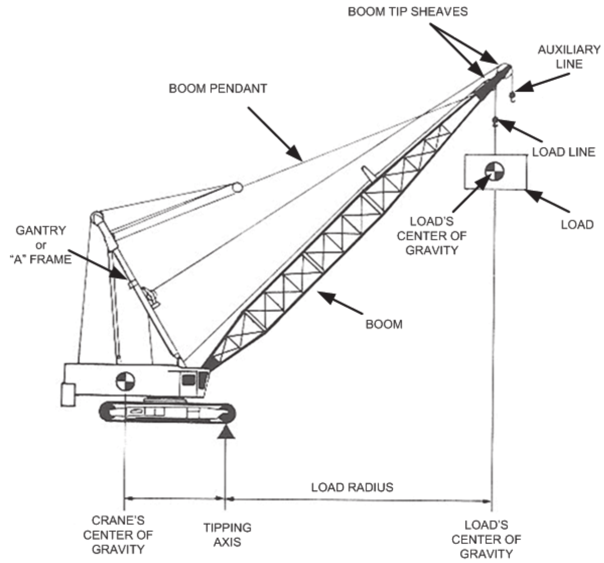


**Figure 1.** Key components of a typical crawler-propelled crane. The crane's weight is balanced against the weight of the lifted load. The diagram is courtesy of the Construction Safety Association of Ontario and may not be reproduced without their written permission.

The crane's ability to lift a heavy load, swing it in any direction, and raise it high overhead also contributes to the many reported incidents of crane tip-over when the cranes are not set up correctly or proper procedures are not followed. During a lift, the distance from the load's center of gravity to the crane's tipping axis changes as the boom angle changes, the boom is extended, and as the crane's upper deck rotates to swing the load. These changes can lead to instability if the crane's lift capacity is exceeded. Proper inspection, setup, and operation by the crane operator, along with proper maintenance, are necessary to ensure safe crane operation.

A crane's lifting capacity is reduced as the boom is lowered because the distance from the load's center of gravity to the tipping axis is increased. Increasing the load's distance to the tipping axis reduces the ability of the crane's weight to counteract or "leverage" the load's weight.

Extending the boom at any given angle has the same effect.

A crane is a complex machine requiring considerable knowledge for safe operation. This knowledge can only be gained through proper training and hands-on experience. The ability to understand and correctly use a crane's load chart is critical to the safe operation of a mobile crane. Each crane's load chart specifies the rated (maximum) capacity of that machine for every permissible configuration. The load chart also specifies the machine's operational limitations and conditions necessary for safe operation. An operator must always use these load charts to determine capacity for a lift and know or be able to calculate the weight of each load. Modern cranes may incorporate computerized load-moment indicators (LMI), which monitor hoisting data and provide the crane operator with a readout of lift conditions. These LMI devices may be designed to interrupt the hoist operation when the hoisted load reaches a set limit to prevent crane overloading. These devices require periodic maintenance, verification, and recertification by a knowledgeable person. LMI devices are not intended to take the place of a load chart. The LMI alone does not ensure a safe lift; it is simply an indicator to advise a competent operator of load parameters to consider when making operational judgments during the lift [Shapiro 2000].

A number of factors are involved with making a safe lift. For example, if a crane is equipped with outriggers, it is strongly recommended that they be fully extended to the manufacturer's specifications and used on every lift following load capacity charts supplied by the manufacturer, regardless of the weight of the load. If all outriggers are not fully extended, lift capacity drops sharply [Dickie 1999; Shapiro 2000; ASME 2004]. Unless the manufacturer has supplied specific load charts for partial outrigger extension, load charts designated for *on rubber* or *lifting without outriggers deployed* must be followed [AEM 2002].

Cranes must be located on solid, stable ground capable of supporting the weight of the crane plus the suspended load. Crane operators often encounter ground at the construction site that has recently been worked or backfilled. A professional engineer should evaluate such conditions to ensure that ground pressures generated by the crane's weight do not exceed the load-bearing capacity of the soil. Extreme caution is needed to ensure cribbing blocks placed under outrigger pads are firmly supported and of adequate size. When multiple lifts are made from the same location, the condition of the ground and the blocking under the outrigger pads should be checked often to ensure the timbers have not shifted or deteriorated. Some companies use long bolts to join cribbing timbers together to create a more solid base for outriggers to set on, thus preventing timber rollout.

A mobile crane mounted on a barge acts differently than when being operated on land [Shapiro 2000]. This phenomenon is due to the way in which forces applied to the crane by the weight of the lift are transmitted to the barge. When a barge-mounted crane lifts a load that is not on the barge, the forces applied to the crane are transmitted to the barge and the barge will lean toward the load. Landing a load (resting the load on the ground or another surface) causes the barge to momentarily lean away from the load as the forces applied to the crane are reduced. This leaning or tilting of the barge is known as *list*. Lifting a load that is already on the barge can also cause the barge to list when the crane swings or changes the boom angle, changing the equilibrium between the weight of the crane and the weight of the load. The listing of the barge will also cause the suspended load to swing. The crane operator must expect and compensate for this swinging motion.

Proper maintenance is important to ensure cranes operate safely and efficiently. The Mobile Crane Manual [Dickie 1999] lists a number of factors that contribute to poor crane performance and reduce a crane's rated capacity. These factors include lack of proper maintenance, machine configuration not in compliance with manufacturer's specifications, eccentric reeving of cables, and excessive duty cycle operations.* Eccentric reeving occurs when the hoist line is not centered over the boom tip and causes torque (twisting) in the boom. Load charts only apply when the boom is symmetrically rigged (load line centered). Follow the manufacturer's specifications when reeving cables.

The North Carolina Department of Labor estimates that one crane upsets (tips over) during every 10,000 hours of crane use in the United States [NC DOL 2004]. Nearly 80% of all crane upsets (tip-overs) are attributed to operators exceeding the crane's operational capacity [Kay 2004]. Approximately 54% of these incidents are the result of swinging the boom or making a lift without the outriggers fully extended [NC DOL 2004; Kay 2004].

*___Duty cycle___: Steady work at a fairly constant short cycle time with fairly consistent loading levels for one or more daily shifts.

## Critical Lifts

NIOSH and others have identified certain types of hoisting operations that require special considerations to ensure worker safety. In the crane and rigging community, the term *critical lift* is commonly used to describe these situations. A critical lift generally identifies hoisting operations for which the margin for error is reduced. Critical lifts include the following situations:

- The weight of the hoisted load approaches the crane's maximum capacity (70% to 90%).
- Two or more cranes simultaneously lift the same load.
- Personnel are being hoisted.
- Nonstandard or specially modified crane configurations are used.
- Special hazards are associated with the lift, such as
  - — the crane is located inside an industrial plant;
  - — the crane(s) is mounted on floating barges;
  - — loads are lifted close to powerlines; and
  - — high winds or other environmental conditions are present.

However, the definition of a critical lift is not as important as the planning necessary to safely perform the lift.

Load ratings developed by crane manufacturers are based on the principal factors affecting crane stability and include the weight of the hoisted load, the structural strength of the crane, and the crane's boom length and load-radius. Crane load charts specify maximum lifting capacities for every configuration permitted by the manufacturer and specify the limitations and conditions necessary for safe operation [Dickie 1999]. These ratings are based on crane operation under ideal conditions. The actual hoisted load includes the weights of the lifted materials, hook block, slings, and other lifting accessories. However, additional loads may be imposed on the crane by factors present in the work environment. These factors may include wind forces acting on the crane structure and the lifted materials, dynamic forces due to movement of the crane and lifted materials, and side loads due to out-of-level or unstable ground conditions [Dickie 1999; Shapiro 2000]. When a hoisted load exceeds 85% to 90% of a crane's rated capacity, little reserve is available to counter unanticipated loads.

Special hoisting precautions are necessary to ensure worker safety during critical lifts [Dickie and Hardy 2000]. Critical lifts should follow engineered lift plans that are based on a comprehensive evaluation of the most accurate information available for all factors affecting crane stability. Critical lift plans should be in writing [Ritchie 2005]. Because a thorough understanding of the relationship between the crane design and the dynamic effects of traveling and moving with hoisted loads is crucial to the development of these plans, the plan should be designed by a registered professional engineer specializing in hoisting operations [NIOSH 1999]. Currently, several Federal agencies require written lift plans for critical lifts conducted under their jurisdiction, including the U.S. Army Corps of Engineers, Department of the Army [DOA 2003], the U.S. Department of Energy (DOE) [DOE 2004], the National Aeronautics and Space Administration (NASA) [NASA 2002], and the U.S. Navy [Navy 2003].

To prevent crane tip-over, the critical lift plan should be based on the operational limitations specified by the crane load chart, measured (as opposed to calculated) weights for the materials to be hoisted, thorough studies of wind speed and its effect on the crane and hoisted load, and consideration of the effects of ground conditions and dynamic forces on the crane's stability.

## INJURY DATA

The Census of Fatal Occupational Injuries (CFOI) is a multisource data system maintained by the U.S. Bureau of Labor Statistics (BLS) to identify work-related deaths in the United States. A NIOSH review of CFOI data identified 719 cases between 1992 and 2002 in which a mobile crane[†] was the primary or secondary source of a fatal injury [NIOSH 2004]. Incidents in which the victim was struck by an object such as an uncontrolled hoisted load or part(s) of a mobile crane accounted for 290 (40.3%) of these fatalities (Table 1). Electrocution fatalities due to cranes contacting overhead power

[†]The following occupational injury and illness source codes for cranes were included: unspecified (3430); floating (3431); hammerhead (3433); mobile, truck, and rail mounted (3434); portal, tower, and pillar (3437); and N.E.C (3439). These specific codes were selected to limit the analysis to types of mobile cranes. Excluded crane types include gantry (3432); monorail and underhung (3435); overhead (3436); and storage and retrieval hoist systems (3438).

lines or other electrical sources accounted for 173 (24.1%) of the 719 CFOI cases. A previous NIOSH Alert [NIOSH 1995] addressed crane-related electrocution hazards. This Alert primarily addresses injuries and deaths when workers are struck by falling or swinging objects resulting from crane stability issues related to tip-over, boom collapse, and uncontrolled hoisted loads. According to CFOI data, 153 (52.8%) of 290 mobile crane-related fatalities in which the victim was struck by an object (such as an uncontrolled hoisted load or crane part) occurred in construction. Forty-four (15%) occurred in manufacturing (Table 2).

**Table 1. Events resulting in mobile crane-related occupational injury deaths: United States, 1992–2002**

| | Number of deaths | Percent |
|---|---|---|
| Struck by falling or swinging object (e.g., crane part or hoisted load) | 290 | 40.3 |
| Contact with electrical current (e.g., overhead power lines) | 173 | 24.1 |
| Fall from crane structure or cab | 88 | 12.2 |
| Transportation (e.g., moving crane from site to site) | 76 | 10.6 |
| Caught in crane moving parts | 73 | 10.2 |
| Other | 19 | 2.6 |
| Total | 719 | 100.0 |

**Table 2. *Struck by* mobile crane-related occupational injury deaths by industry: United States, 1992–2002**

| | Number of deaths | Percent |
|---|---|---|
| Construction | 153 | 52.8 |
| Manufacturing | 44 | 15.2 |
| Transportation and public utilities | 35 | 12.0 |
| Services | 20 | 6.9 |
| Wholesale trade | 14 | 4.8 |
| Mining | 12 | 4.1 |
| Agriculture, forestry, and fishing | 6 | 2.1 |
| Other | 6 | 2.1 |
| Total | 290 | 100.0 |

# CURRENT STANDARDS

## Occupational Safety and Health Administration (OSHA)

Mobile crane and hoisting hazards are addressed by the following OSHA standards found in Title 29 CFR[‡]: general industry (29 CFR 1910.180), maritime (29 CFR 1918.66), marine (29 CFR 1917.45), longshoring, and construction (29 CFR 1926.550).

These Federal standards cover a wide range of safety issues including procedures for safe crane operation, posted instruction and warning signs, daily and annual crane inspections, maintenance, wire rope and cable requirements, clearance from overhead energized power lines, and the use of spotters. Current Federal standards do not consider crane-hoisting circumstances with reduced margin for error such as operating at or near crane capacity, operating without outriggers fully extended, operating on unstable ground conditions, etc.

Title 29, CFR 1910.180 and 1926.550 require rated load capacities, recommended operating speeds, special hazard warnings, and instructions to be conspicuously posted on all equipment and visible to the operator while at the control station. Title 29, CFR 1910.180(e)(2)(ii) requires that test loads must not exceed 110% of the rated capacity for a particular boom length and radius.

In June 2003, OSHA established a committee of experts representing crane operators, owners, manufacturers, and other interested parties to revise the construction industry standard covering cranes and derricks (29 CFR 1926.550), using a negotiated rulemaking process. This committee addressed key issues such as crane inspection and testing, record keeping requirements, crane operator certification, work near energized power lines, the use of qualified signal persons and spotters, and working under suspended loads. In July 2004, OSHA announced this consensus draft regulation was submitted to the Assistant Secretary of Labor for Occupational Safety and Health for promulgation through the Federal rulemaking process [DOL 2004].

## Certification and Licensure

Current Federal laws do not require crane operators to be licensed or certified. At present, 12 States and 6 cities require crane operators to be licensed[§]. Certification is usually a voluntary process initiated by a nongovernmental agency through which people are recognized for their knowledge and skill. Licensing is more restrictive and usually refers to mandatory governmental requirements based on a combination of examination, testing, and demonstration of the appropriate skills, knowledge, and experience [NCCCO 2004].

The draft regulation for crane and derrick safety in construction submitted by the negotiated rulemaking committee to OSHA

[‡] *Code of Federal Regulations*. See CFR in references.

[§] States that require licensure: California, Connecticut, Hawaii, Massachusetts, Montana, Nevada, New Jersey, New Mexico, New York, Oregon, Rhode Island, West Virginia. Minnesota has pending legislation scheduled to take effect in 2006. Cities that require licensure: Chicago, Los Angeles, New York, New Orleans, Omaha, Washington, DC.

requires crane operator testing and certification. Employers should consider implementing an operator testing and certification program even before this new requirement becomes law.

## ANSI/ASME

The American National Standards Institute (ANSI) has approved and designated the ASME B–30.5 Safety Standard for Mobile and Locomotive Cranes, developed by the American Society of Mechanical Engineers (ASME) as an American National Standard in August 2000. This standard was revised in 2004 [ASME 2004] and is one of a series of safety standards that are collectively known as the ANSI Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings.

ASME B30–5, Chapter 5–2, Section 5–2.4 and the Society of Automotive Engineers (SAE) J959–1966 standards specify requirements for wire rope and cable inspection, replacement, and maintenance when used on cranes to hoist loads.

ASME B30.5, Chapter 5–3, Section 5–3.3 identifies standard hand signals to be used by spotters to signal crane operators during the lift cycle (see Appendix A).

## Fair Labor Standards Act

The Fair Labor Standards Act (FLSA) is the primary law governing workers under age 18. FLSA prohibits work for youths under age 18 in occupations declared by the Secretary of Labor to be especially hazardous—Hazardous Orders (HO). Youths under age 16 are prohibited from working in construction and manufacturing under Child Labor Regulation No. 3 [29 CFR 570.33(a) and (f)(4)]. Hazardous Order No. 7 *(Power-Driven Hoisting Apparatus)* prohibits anyone under age 18 from performing “work of operating an elevator, crane, derrick, hoist…”, as well as “work of assisting in the operation of a crane, derrick, or hoist performed by crane hookers, crane chasers, hookers-on, riggers, rigger helpers, and like occupations.” Other types of work that are prohibited for workers under age 18 that frequently involve the use of cranes include demolition (HO 15), roofing (HO 16), and excavation (HO 17) [DOL 2001]. For more information, refer to DOL Fact Sheet No. 043 Child Labor Provisions of the Fair Labor Standards Act (FLSA) for nonagricultural types of work [DOL 2002].

# CASE REPORTS

The following cases were investigated by the NIOSH Fatality Assessment and Control Evaluation (FACE) program and NIOSH-supported, State-based FACE programs. The cases were selected to present a variety of circumstances in which workers were fatally injured because of mobile crane tip-over; boom collapse caused by improper disassembly and improper reeving; or contact with the hoisted load. Through 2005, the FACE program investigated 22 incidents in which workers were fatally injured because of crane tip-overs, collapse, or uncontrolled hoisted loads. Complete FACE reports are available on the NIOSH Web site: www.cdc.gov/niosh/face.

## Case 1

On July 14, 1999, 3 male ironworkers (the victims), ages 39, 40, and 52 died after falling approximately 300 feet to the ground when the suspended personnel platform they were occupying was struck by the uncontrolled load of a heavy-lift crane (Figure 2).

**Figure 2.** Heavy-lift crane after tip-over at stadium project. *(Photo courtesy of John Thraen)*

**Figure 3.** Crane tip-over at library expansion project. *(Photo courtesy of The Blade/Toledo Ohio)*

The victims were working in windy conditions during the construction of a county sports stadium. The firm responsible for the assembly and erection of the stadium roof had contracted with the victims' employer to provide ironworkers and had also contracted with a multinational contractor for the use of a heavy-lift crane. The 3 ironworkers were suspended above the ground to observe the hoisting of a 450-ton roof section. The roof section had been hoisted to about 330 feet and transported over its connection location by the heavy-lift crane crew. As the roof section was being lowered into place, the heavy-lift crane began to tip over. The crane continued tipping and the roof section collided with the personnel platform, knocking it and the victims to the ground. Evaluation of investigative information indicated that the weight of the hoisted load, side loads from wind, out-of-level ground conditions, and the swinging motion of the hoisted load as the crane moved sideways combined to tip the crane [NIOSH 1999].

## Case 2

On October 13, 1999, a 50-year-old male carpenter at a municipal construction site died after he was struck by a loaded concrete bucket during a crane tip-over (Figure 3). The victim was removing forms from a newly constructed concrete wall while a concrete finishing crew was filling empty forms approximately 20 feet away. Concrete was being hoisted from street level with a crawler-mounted mobile crane and landed under the direction of a roof-top spotter. The victim's employer had contracted with a crane rental company to supply the crane and a certified crane operator with 26 years of experience. As the crane operator hoisted a 1-cubic-yard bucket load of concrete, swung it over the roof, and boomed out toward the empty forms, the crane lost stability, tipping toward the victim. When the crane operator realized the crane was tipping, he radioed a warning to the spotter who yelled out a warning to the roof-top workers. The victim had just started to react when the uncontrolled concrete bucket swung toward him, striking his head and shoulder. The victim was pronounced dead at the scene from blunt force head and chest injuries. Evaluation of the crane configuration, the distance of the intended landing site from the crane's center pin, and the manufacturer's load chart indicated that the crane's recommended capacity had been exceeded. In addition, investigators found that the crane's LMI had been known to indicate false readings in the past and had not been repaired/recalibrated. This malfunctioning

LMI may have contributed to the incident by providing the operator with false information [NIOSH 2000].

## Case 3

On October 8, 1997, a 56-year-old truck driver was crushed when a crane tipped over and the crane's boom landed on the cab of the dump truck in which he was sitting (Figure 4). The 50-ton, all-terrain crane had been set up near the access road to a construction site in preparation for unloading components of a tower crane that would soon arrive on-site. The crane operator had set up parallel to the access road and had fully extended the crane's left outriggers. The right outriggers had been set but not fully extended, as they would have blocked truck access to the construction site. This set-up was intended to be temporary until building materials and equipment could be moved to make more room for the all-terrain crane. The crane operator began to clear the area by lifting an empty 4-yard concrete bucket over the rear of the crane. The operator swung the bucket over the right side of the crane, moving it between the victim's truck and another truck waiting in line. As he swung the crane's boom to the right, he also began to "boom down" to extend the load radius for more clearance (i.e., lowered the crane boom to increase the distance between the load and the crane's center of rotation). When the bucket reached the area near the right front fender of the victim's dump truck, the operator lowered it to the ground. The crane tipped toward the load. The operator attempted to regain stability by lowering the bucket more quickly, but was unable to drop it fast enough, and the crane continued to tip. The crane's boom hit the truck cab directly over the driver's seat, pushing the roof onto the victim and crushing him forward in the seat. Measurements taken after the incident showed the crane's load lift capacity had been exceeded for the boom length and angle used [NIOSH 1998].

**Figure 4.** Crane tip-over at construction site. Note that the right outriggers were set, but not extended. *(Photo courtesy of OSHA)*

## Case 4

On December 14, 2000, a 38-year-old stevedore (the victim) was fatally injured while working at a river-port materials-handling facility after being struck by the collapsing boom of a mobile crane (Figure 5). The victim and a coworker had been previously lowered from the dock level via a crane-suspended personnel platform and landed on a barge. After they had disembarked from the personnel platform, the port manager, who was operating the crane, began to hoist it back to the dock. The platform had reportedly been raised about 2 feet when the right-side boom pendant (cable supporting the boom) rode out of the boom tip pendant sheave, immediately introducing 200 feet of slack into the boom-hoist system and causing the boom to fall. The victim apparently observed the boom falling and pushed his coworker out of the way. The boom hit the edge of the dock, broke over the dockside,

**Figure 5.** Boom collapse at river facility. *(Photo courtesy of OSHA)*

**Figure 6.** Mobile tower crane tip-over attempting to hoist water tank. *(Photo courtesy of Iowa FACE Program)*

and struck the victim. Investigation after the incident revealed that ice that had formed on the boom pendants during a recent severe storm, built up at the boom pendant sheaves, and forced the boom pendants to ride out of the sheave, allowing the boom to become unsupported [NIOSH 2001].

## Case 5

On July 20, 2000, a 29-year-old worker for a water tank company was killed when the partially assembled water tower he was working on was struck by a portable tower crane as it overturned (Figure 6). The victim was part of a three-man crew that reconditions and relocates used water towers. A crane company had been hired to help the crew erect the water tower supports and lift the tank to its final position on the tower. Two months before the incident, the ground in the construction area had been graded, compacted, and certified for a load of 2,000 pounds per square foot. When the crane was set up, the front and rear outriggers had been set on timbers resting directly on the ground. No plywood or steel plates were used under the timbers to distribute the load, nor were bolts or other rigging used to secure the timbers together. The victim was sitting on a horizontal strut of the water tower base, approximately 80 feet in the air, preparing to adjust and tighten rod braces once the tank had been set in position. After the operator had hoisted the empty 28,000-pound tank to about 130 feet and was swinging it into position over the tower, the crane's rear outrigger facing the water tower slipped between the cribbing timbers and sank into the ground. The tower crane and its load fell, striking the tower. The victim was killed during the tower collapse. During the incident, two others were injured: a member of the tank crew positioned inside the water tower ladder cage and the crane operator inside the crane's operating station [Iowa FACE 2000].

## Case 6

On March 17, 1997, a 42-year-old master mechanic was fatally injured while dismantling a crane boom (Figure 7). The victim and two coworkers were dismantling the crawler-mounted lattice boom crane in preparation for transport. The crane boom had been lowered to 8½ feet off the ground and was supported by the boom pendants. The victim positioned himself under the pinned connections between the inner (heel or

**Figure 7.** Boom collapse during crane disassembly.

base) section and the center section of the boom. The victim removed the pins from the bottom connections. When the victim removed the last of the two pins, the boom sections fell, striking and pinning the victim underneath [NIOSH 1997].

## CONCLUSIONS

Proper training of crane operators in the mandatory use of load charts is important for safe hoisting operations. Crane operators need to know and understand how to use load charts provided by the crane manufacturer. LMI devices are an important safety feature on modern cranes. However, these devices cannot replace the judgment of a trained and qualified operator who has knowledge of safe practices regarding hoisted loads, swing radius, and load chart information. LMI devices should be checked per the manufacturer's recommendations and if not working properly, tagged out-of-service until repairs are made.

Crane operators and workers must follow the manufacturer's recommendations for crane set-up and rigging.

Workers must use caution so that they do not place themselves in dangerous areas where they can be struck by falling loads or by falling or collapsing crane components.

Managers and safety professionals need to consider safe work practices for workers who are required to work on or near operating cranes. All workers should use and follow established hand signals such as the standard hand signals listed in ANSI B30.5–2004 (see Appendix A).

## RECOMMENDATIONS AND DISCUSSION

NIOSH recommends that employers, workers, and crane rental companies take the following actions to minimize the risk of injury and death to those who work on or near mobile cranes:

### Employers

- **Make sure your work sites comply with safety requirements found in pertinent regulations and standards including OSHA 29 CFR 1910.180 (general industry cranes); 29 CFR 1917.45 (marine terminals); 29 CFR 1918.66 (maritime, cranes and derricks other than vessel's gear); 29 CFR 1926.550 (construction industry cranes and derricks); and ASME B30.5–2004, mobile and locomotive cranes.**
  - — Inspect and maintain each crane following the manufacturer's recommendations.
  - — Make sure operators are properly trained and qualified.

— Coordinate communications between the crane operator and riggers, spotters, supervisors, and others working near the crane.

— Use standard hand signals and provide training for signal persons (see Appendix A).

— Follow manufacturer's guidelines for crane assembly and disassembly.

— Make sure wire rope is in good working order.

— Keep workers clear of hoisted loads.

— Follow safe work practices when working near energized power lines.

- **Conduct training to ensure that crane operators understand safe crane operation (for example, reading and comprehending load charts) as well as the principles of set-up, rigging, hoisting, extending the boom, swinging a load, pinching and crushing points, swing radius warning barriers, power line safety, etc.**

— Consider requiring operator testing and certification as a prerequisite for employment, even if not required by law.

— Consider using fatality case reports in your training programs.**

— Include principles of crane operation, such as the fact that raising and lowering the boom changes the distance from the load's center of gravity to the tipping axis of the crane.

- **Review your occupational safety programs and standard operating procedures to ensure that they include safe practices for lifting loads.**

- **Conduct training to ensure that riggers and ground workers understand the hazards of working around mobile cranes and that they remain vigilant and watch for signs of problems at all times, especially if power lines are nearby.**

— Use a spotter whenever the crane operator's view of the lift area, swing radius, or the landing area is obstructed.

— Notify workers before a lift begins.

— Make sure workers are not located within the swing radius or under a suspended load at any time.

— Thoroughly evaluate ground conditions, wind speed, travel distance, proximity to overhead power lines, and other obstructions.

— Follow all pertinent OSHA regulations.

— Follow manufacturers' recommendations for safe crane operation and maintenance.

- **Develop and follow a written engineered lift plan for all critical lifts.**

— Make sure that critical lift plans are (1) developed by registered professional engineers with specialized knowledge of hoisting operations and (2) based on a thorough evaluation of the following:

  - The rated capacity and operational limitations specified by the crane's load chart [NIOSH 1999]
  - Measured (as opposed to calculated) weights for the materials to be hoisted [NIOSH 1999]

**The NIOSH Web site www.cdc.gov/niosh/face is one source of fatality case reports.

- Thorough studies of wind speed and its effect on the crane and hoisted load [NIOSH 1999]
- Consideration of the effects of ground conditions and dynamic forces on the crane's stability [Dickie and Hardy 2000; Shapiro 2000; NIOSH 1999]

— Include specifications for communication during the lift. All parties involved in the lift, including crane operator(s), riggers, signal persons, and supervisors must have a thorough understanding of how communication will take place [Dickie and Hardy 2000].

— Identify a single person to direct all operations during the lift [Dickie and Hardy 2000; NASA 2002; DOE 2004].

- **When multiple lifts are made from one location, such as during duty cycle operations, check the condition of the ground and blocking materials regularly and as often as possible to ensure the crane remains on firm stable ground.**

— Watch for signs of soft or unstable ground compressing or deflecting (pushing out) from underneath blocking due to the downward pressure exerted by the crane's outriggers or the crane's tracks or wheels.

— Watch for signs of previously level or unsecured cribbing blocks rolling out from under the outrigger pads.

— Do not exceed the manufacturer's recommended load chart.

— Pay special attention when working around construction and excavation sites, backfilled areas, underground drains and culverts, poorly drained areas, and sandy soils.

— When in doubt, have the stability of the ground evaluated by a qualified professional engineer to ensure the area will support the weight of the crane plus the suspended load over the entire lift cycle.

- **Make sure mobile cranes located on floating barges are positively secured to the barge and barge list is accounted for when determining safe load capacity.**

— Reduce load rating charts whenever list exceeds 1 percent [Shapiro 2000]. Consult the crane manual or crane manufacturer for chart reductions and maximum list for the crane configuration.

— Positively secure mobile cranes located on floating barges according to OSHA standard 29 CFR 1926.550(f)(1)(iv).

- **Follow the manufacturer's recommended assembly and disassembly and maintenance procedures when working on cranes.**

— Use proper blocking methods to adequately support crane components during these operations.

— Block boom sections under each section's support members to ensure the weight of the section is safely supported.

— Do not block between the support members, as this may cause damage to the boom section.

— Always check to ensure boom pendants (boom suspension cables or lines) are properly located before removing a connecting pin. The boom pendant should be between the pin and the crane body so that it supports the boom section closest to the crane body.

- When removing pins, block or support the remaining boom section(s) to prevent their collapse. Refer to the manufacturer's recommendations for long booms and booms with jibs.

- **Comply with child labor laws that prohibit construction and manufacturing work by persons under age 16 and that prohibit workers under age 18 from operating or assisting in the operation, repair, servicing, assembly, disassembly and similar activities associated with mobile cranes. For more information about Federal child labor laws, visit www.dol.gov/dol/topic/youthlabor/index.htm; or call 1–866–4–USADOL.**
  - Do not assign workers under age 16 to any aspect of construction or manufacturing work.
  - Do not assign workers under age 18 to work as crane operators or to perform any crane maintenance, set-up, assembly or disassembly operations.
  - Make sure all workers are aware of any workers under age 18 in the work setting. Inform them about the types of work young workers are allowed to perform and where they should report questionable tasks.
  - Consult a U.S. Department of Labor Wage and Hour Division office for assistance, if needed. For information about Federal child labor laws, visit www.dol.gov/dol/topic/youthlabor/index.htm or call 1–866–4–USADOL. For links to State labor offices, visit www.ilsa.net or www.youthrules.dol.gov/states.htm or call 1–866–4–USWAGE.

## Crane Operators

- **Take training in safe crane operation offered by your employer.**
- **Always use the crane manufacturer's load chart provided for each crane.**
  - Do not exceed the crane's lift capacity.
  - Do not operate a crane if the load chart is not available.
- **Be sure you know or can calculate the weight of each load.**
- **Never use visual signs of tipping as an indicator of lift capacity.**
- **If necessary, use a spotter to ensure workers are protected from the struck-by hazards of hoisting and swinging loads.**
- **Follow the manufacturer's procedures for proper outrigger deployment to ensure that cranes are properly set up and level with their outrigger pads supported on firm stable surfaces before beginning a lift.**
  - Use extreme caution whenever working around trenches, excavations, backfilled locations next to new building construction, sewers, and underground pipes since the weight of the crane can cause these areas to shift or collapse.
  - Use specially designed mats, steel plates, timber pads, or concrete rafts under cranes to distribute the

load if the ground is too soft, wet, or irregular to provide solid footing. Make timber mats by joining solid timbers or cribbing blocks with long bolts passed through each timber forming a solid mat to prevent individual blocks from rolling out from under the outrigger.

— Make sure blocking placed under outrigger pads is at least 3 times larger than the outrigger pad it is supporting.

— Place blocking so that the entire outrigger pad is supported.

— Make sure blocking is level and at a right angle (90 degree) with the outrigger pad to prevent blocking from slipping out from under the outrigger [Dickie 1999].

- **When multiple lifts are made from one location, such as during duty cycle operations, check the condition of the ground and blocking materials regularly and as often as possible to ensure the crane remains on firm stable ground.**
- **Always check for overhead power lines and other obstructions. Comply with OSHA regulations for safe working distances around power lines.**
- **Avoid hoisting or moving suspended loads over workers and other people within the crane's swing radius.**
- **Barricade the swing radius to keep unauthorized persons from entering areas of pinch points.**
- **Follow a written engineered lift plan for all critical lifts.**
- **If you are under age 18, do not operate a crane or assist in tasks being performed on cranes such as repairing, servicing, assembling, or disassembling the machine.**

— For information about Federal child labor laws, visit www.dol.gov/dol/topic/youthlabor/index.htm or call 1-866-4-USADOL. For links to State labor offices, visit www.ilsa.net or www.youthrules.dol.gov/states.htm or call 1-866-4-USWAGE.

## Riggers and Ground Workers Located near Hoisting Operations

- **Be aware that the job site is always changing and be observant of hoisting operations in your work area.**
- **Never work or position yourself directly under a suspended load.**
- **Be observant and watch for signs of problems during each lift.**
- **Always check for overhead power lines and other obstructions. Comply with OSHA regulations for safe working distances around power lines.**
- **Barricade the swing radius to keep unauthorized persons from entering areas of pinch points.**
- **Follow a written engineered lift plan for all critical lifts.**
- **Follow the correct assembly and disassembly procedures when setting up or dismantling a crane. Make sure boom sections are blocked or supported before removing pins. Do not stand under the boom.**
- **If you are under age 16, do not perform any type of construction or manufacturing work. If you are under age 18, do not operate a crane or assist in tasks being performed on cranes such as repairing, servicing, assembling, and disassembling the machine.**

— For information about Federal child labor laws, visit www.dol.gov/dol/topic/youthlabor/index.htm or call 1–866–4–USADOL. For links to State labor offices, visit www.ilsa.net or www.youthrules.dol.gov/states.htm or call 1–866–4–USWAGE.

## Crane Rental Companies

- **Make sure cranes are serviced and maintained following manufacturers' specifications.**
- **Make sure each crane is provided with the correct operator's manual as well as load charts, safety decals, maintenance, inspection, and instructional decals, crane signal charts, and other safety information provided by the manufacturer.**
  - — Periodically inspect each crane to ensure warning labels are present and replace as necessary to ensure labels are legible and properly identify the appropriate hazards associated with moving parts, machine guards, pinch points, walkways, handrails, etc.
  - — Replace labels and decals that were damaged or removed during repair work or maintenance (e.g., cleaning, painting, replacement of parts).
- **Make sure that LMI and other safety devices are functioning properly.**

## ACKNOWLEDGMENTS

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Please direct any comments, questions, or requests for additional information to the following:

Dr. Nancy A. Stout, Director
Division of Safety Research
National Institute for Occupational Safety and Health
1095 Willowdale Road
Morgantown, WV 26505–2888

Telephone: 304–285–5894; or call
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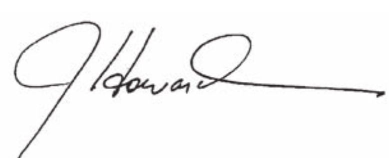

John Howard, M.D.
Director, National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention

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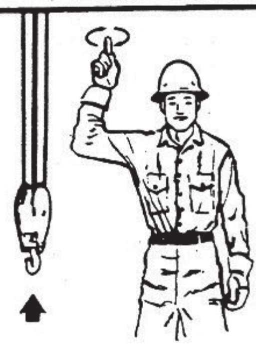
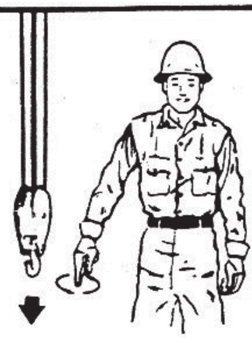
# APPENDIX A

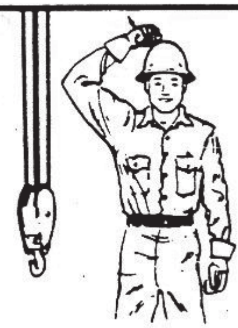
## STANDARD CRANE HOISTING HAND SIGNALS*



HOIST. With forearm vertical, forefinger pointing up, move hand in small horizontal circle.

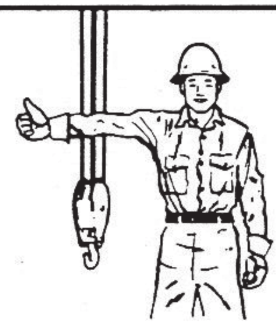


LOWER. With arm extended downward, forefinger pointing down, move hand in small horizontal circle.

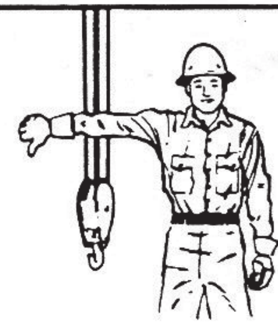


USE MAIN HOIST. Tap fist on head; then use regular signals.

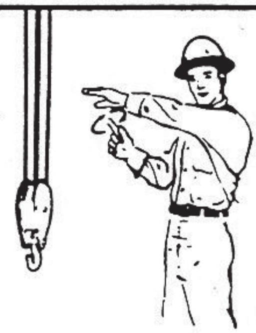
USE WHIPLINE. (Auxiliary Hoist). Tap elbow with one hand; then use regular signals.



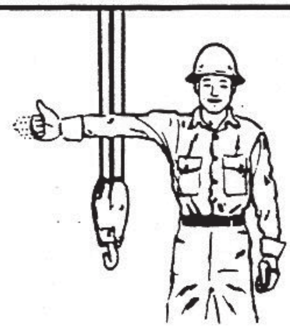
RAISE BOOM. Arm extended, fingers closed, thumb pointing upward.



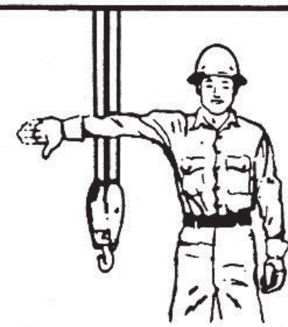
LOWER BOOM. Arm extended, fingers closed, thumb pointing downward.



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.

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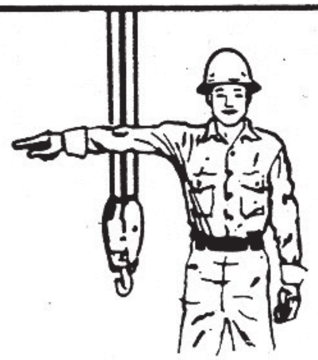
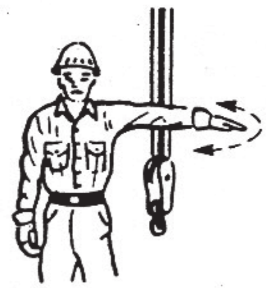
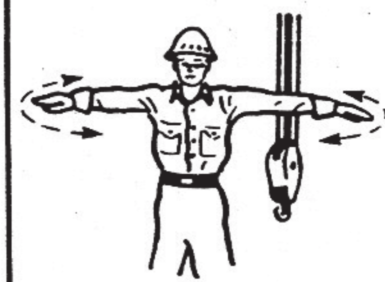


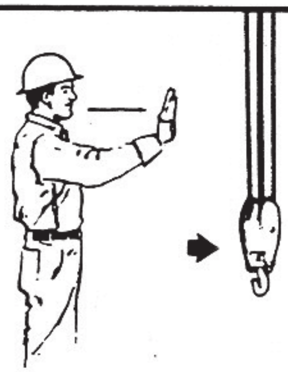
SWING. Arm extended, point with finger in direction of swing of boom.



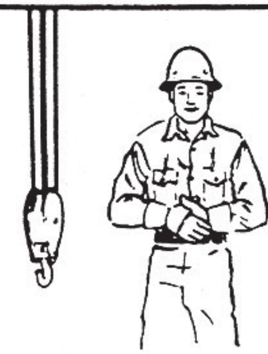
STOP. Arm extended, palm down, move arm back and forth horizontally.



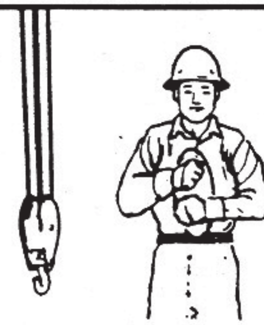
EMERGENCY STOP. Both arms extended, palms down, move arms back and forth horizontally.



TRAVEL. Arm extended forward, hand open and slightly raised, make pushing motion in direction of travel.

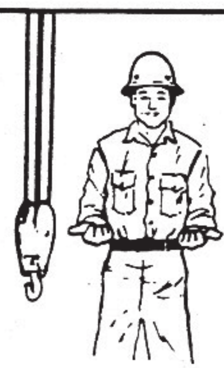


DOG EVERYTHING. Glasp hands in front of body.

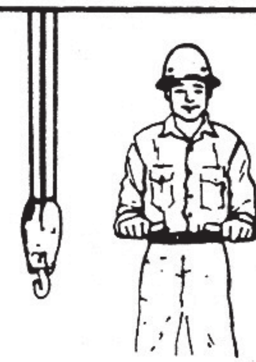


TRAVEL (Both Tracks). Use both fists in front of body, making a circular motion about each other, forward and backward. (For land cranes only.)

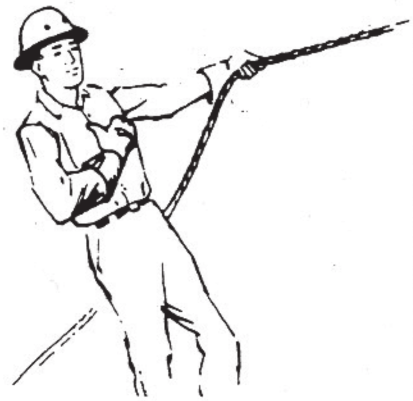
TRAVEL. (One Track) Lock the track on side indicated by raised fist. Travel opposite track in direction indicated by circular motion of other fist, rotated vertically in front of body. (For land cranes only.)



EXTEND BOOM (Telescoping Booms). Both fists in front of body with thumbs pointing outward.



RETRACT BOOM (Telescoping Booms). Both fists in front of body with thumbs pointing toward each other.



EXTEND BOOM (Telescoping Boom). One Hand Signal. One fist in front of chest with thumb tapping chest.

RETRACT BOOM (Telescoping Boom). One Hand Signal. One fist in front of chest, thumb pointing outward and heel of fist tapping chest.

# NOTES

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# Mobile Crane Inspection Guidelines for OSHA Compliance Officers

US. Department of Labor
Occupational Safety and Health Administration

June 1994

# Mobile Crane Inspection Guidelines for OSHA Compliance Officers

US. Department of Labor
Robert B. Reich, Secretary

Occupational Safety and Health Administration
Joseph Dear, Assistant Secretary

Office of Construction and Engineering
Charles G. Culver, Director

June 1994

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## ABSTRACT

This document provides b3ckground information about lifting principles and serves as a guideline for inspecting mobile construction cranes. The relationship of many components of cranes and their inter-dependence in lifting operations, OSHA requirements for proper maintenance schedules, and safe crane operations will be discussed in this document.

This document contains a listing and description of major components or operations to be considered or examined when inspecting lifting equipment. Two types of commonly used cranes, a crawler lattice boom crane and a hydraulic rough terrain crane, were selected as examples in developing these guidelines. Descriptive text and photographs illustrate 18 inspection items critical to most crane inspections.

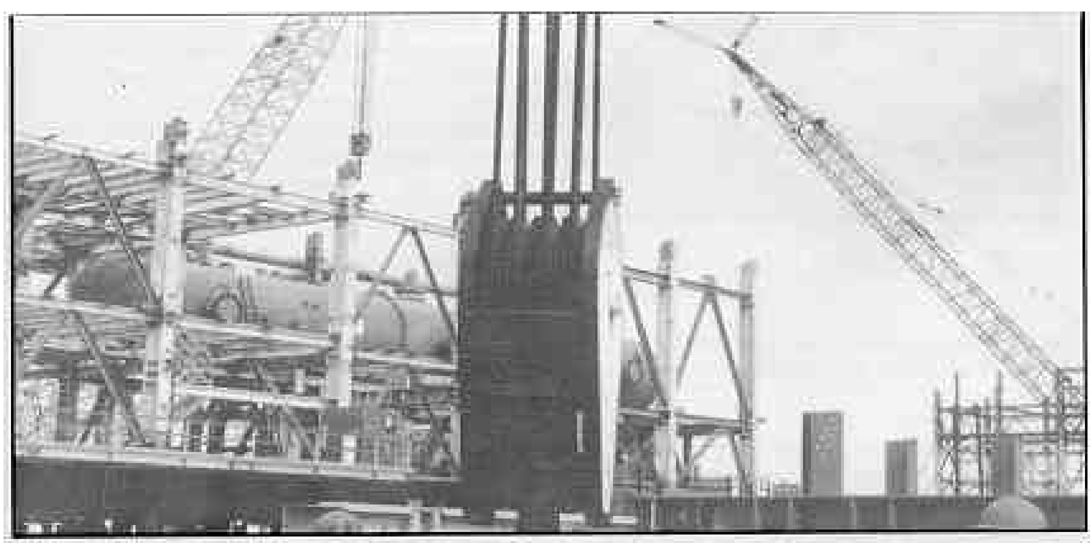
EXECUTIVE SUMMARY

OSHA compliance officers, project safety and health managers, and insurance inspectors are often required to inspect construction cranes. Inspections normally include lengthy checklists that identify mechanical components and maintenance schedules without adequate descriptions or explanations, pertinent to the relationship between these components and the crane's overall function. Although some crane inspection checklist items are self-explanatory, it must be recognized that due to increasing applications of developing technology in the design and manufacture of cranes, OSHA compliance officers need a better understanding of crane operations and their basic lifting principles, and to keep abreast of related developments in today's construction industry.

Since cranes affect a large segment of work at any construction site, crane inspections by the compliance officer and project safety manager must include a survey of the entire operation questions on how the crane will be operating and how other crafts will be affected by working with and around the crane.

Observing crane operations prior to an inspection, or asking questions about how it will or has been operating, can indicate possible problem areas that may need a closer review during the inspection process.

This document provides an overview and background information on lifting principles of mobile cranes for OSHA inspectors. Also discussed is the relationship between various components of mobile cranes to their lifting capacity and the manufacturers' requirements for conducting proper maintenance schedules are also discussed.



TYPICAL CONSTRUCTION SITE
LOAD BLOCK LOWERED FOR INSPECTION

## 1.0 INTRODUCTION

Construction sites are often communities within themselves consisting of a variety of activities with numerous pieces of equipment and tools in use simultaneously. An important piece and one of the most expensive pieces of equipment in use on most construction sites is the crane. Statistics indicate that a significant number of construction injuries and fatalities are crane related accidents that also cost hundreds of thousands of dollars in equipment damage and other related costs. An example of the tremendous loss potential occurred a few years ago when two cranes, working in tandem, while traveling, dropped their load onto a sports stadium under construction and some other construction equipment. Although no personal injuries were experienced, the cost due to equipment damage and the project delays was extremely high. For instance, the cost of one 150 - 200 ton mobile crawler crane alone is in excess of $800,000.00, and, depending upon capacity and added components, can sell for more than $1,000,000.00. Construction delays and investigative costs can easily run the cost into the millions of dollars.

Over the past few decades, there has been a significant increase in the cost of cranes due in part to improved engineering design and specific job site requirements.


MODERN RINGER CRANE
500 TON CAPACITY

Today, Manufacturers design and build stronger and lighter cranes in response to specific industry needs. Speed, utility, capacity, and reach (radius) have been improved to the point that the crane has become an indispensable workhorse for construction. Therefore, a more thorough under-standing of cranes, their capabilities and limitations is critically important for everyone involved in construction today. The crane can perform safely and economically when operated within the design parameters set by the manufacturer.

Due to significant advances in lifting technology, crane operators, site supervisors, safety professionals, and OSHA compliance officers need to keep abreast of modern crane technology and changes in operating procedures to help them recognize problems before potentially unsafe conditions lead to accidents that result in injuries and/or fatalities, as well as equipment damages.

With these factors in mind, the need for a better understanding of crane operations and the implementation of appropriate maintenance schedules is evident in preventing accidents. A recent study by Don Dickie, a recognized crane authority with the Construction Safety Association of Ontario, indicates that although mechanical failures represent only 11% of the causes of crane accidents, they usually result in the major accidents involving injuries, fatalities, substantial material costs, and usually spectacular media coverage. Studies and analyses of crane accidents involving mechanical failure show they are frequently due to a lack of preventive maintenance or adequate training and/or experience on the part of the personnel involved. It is important that not only crane operators but also other personnel working with cranes receive training in crane operations. Cranes and associated rigging equipment must be inspected regularly to identify any existing or potentially unsafe conditions. In addition, preventive maintenance must be performed as required by the crane manufacturer and/or the supplier to ensure safe crane operation. The inspections performed by OSHA compliance officers and/or other safety professionals also can play an important role by identifying hazards as well as safe crane operations.

This report addresses major issues related to the crane itself and provide some basic information on crane capacities and inspection criteria for OSHA compliance officers. Since it would be difficult for a single report to fully address all types of cranes available in today's market, two types of cranes typically found on construction sites are discussed in this report. Some of the issues encountered during inspections cover the following three areas:

1. **Basic Crane Operations** – Lifting principles/mechanics and some operational criteria.

2. **Typical Crane Inspection Checklist** -- Listing of critical items and components recommended for periodic inspection.

3. **Regulations** -- Federal OSHA regulations and applicable ASME/ANSI and PCSA standards.

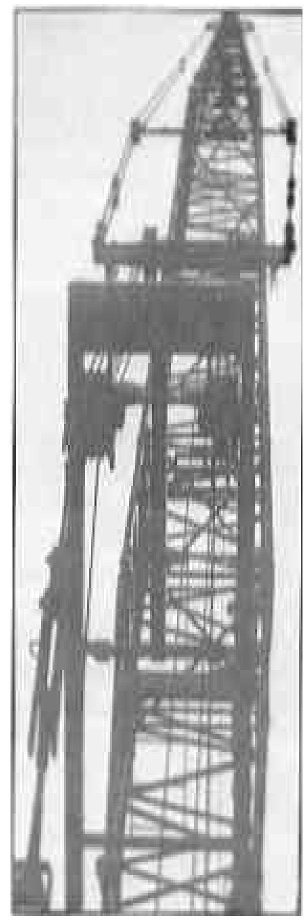
This report also contains general guidelines for crane inspections, as well as, some suggested operational considerations and inspection items recognized by a number of construction companies.

Cranes are designed for both general use and for specific purposes. Similar to the vast automobile industry, crane manufacturers produce similar models or types of cranes for the same purpose, often with different sizes of the same model of crane. Each type, model, or size of crane manufactured, may have different operating controls and require specialized operator training, individualized inspection criteria, and different preventive maintenance schedules.

Two commonly used cranes, a hydraulic rough terrain crane and a crawler lattice boom friction crane, are shown as examples for developing this document. There are several significant differences between these two cranes, primarily in boom hoist and load line controls. The somewhat smooth operation of the boom control adjustments on the hydraulic cranes may suggest falsely to the novice operator or inspector that it is a simple crane to operate. On the other hand, the lattice boom friction cranes' movement in its' boom, or its' adjustment in load position tend to be a little jerky requiring more skill and experience to operate smoothly. Another clear difference between the two types of cranes is their load charts. Due to the fixed boom length, the lattice boom friction crane has a somewhat simplified load chart.  This requires extensive motion control and an anticipation of boom movement to accurately lift or place loads.  Conversely, the hydraulic crane's load charts are more extensive or complicated due to the variations in boom length thus requiring more training in the multiple charts available.  The differences between these two types of cranes are significant enough to require specific training on each type of crane.  Crane operators cannot be expected to be totally knowledgeable and proficient in the operation of the many diverse types of cranes available today. They cannot be expected to move from one type of crane to another without adequate education and training on the specifics of each piece of equipment.

VARITY OF HYDRAULIC R/T CRANES

MOBILE CRAWLER CRANE



OPERATOR'S VIEW
LATTICE BOOM

## 2.0 MOBILE CRANES

### 2.1 Lifting Principles

There are four basic lifting principles that govern a crane's mobility and safety during lifting operations:

1. Center of Gravity The center of gravity of any object is the point in, the object where its weight can be assumed to be concentrated or, stated in another way, it is the point in the object around which its weight is evenly distributed. The location of the center of gravity of a mobile crane depends primarily on the weight and location of its heaviest components (boom, carrier, upperworks and counterweight).

2. Leverage Cranes use the principle of leverage to lift loads. Rotation of the upperworks (cab, boom, counterweight, load) changes the location of the crane's center of gravity, its' leverage point or fulcrum.

As the upperworks rotates, the leverage of a mobile crane fluctuates. This rotation causes the crane's center of gravity to change and causes the distance between the crane's center of gravity and its tipping axis to also change. Stability can be effected by the fluctuating leverage the crane exerts on the load as it swings. The crane's rated capacity is therefore altered in the load chart to compensate for those changes in leverage.

Provided the ground is capable of supporting the load, a crane can be made more stable by moving the tipping axis further away from its center of gravity. The extra stability gained by moving the tipping axis can then be used to carry larger/heavier loads.

INCREASED STABILITY = MORE LOAD

3. Stability is the relationship of the load weight, angle of the boom and its radius (distance from the cranes center of rotation to the center of load) to the center of gravity of the load. The stability of a crane could also be effected by the support on which the crane is resting. A crane's load rating is generally developed for operations under ideal conditions, i.e., a level firm surface. Unlevel surfaces or soft ground therefore must be avoided. In areas where soft ground poses a support problem for stability, mats and or blocking should be used to distribute a crane's load and maintain a level stable condition.

In addition to overturning (stability failure), cranes can fail structurally if overloaded enough. Structural failure may occur before a stability failure. In other words, a mobile crane's structure may fail long before it tips. As loads are added beyond its rated capacity, a crane may fail structurally before there is any sign of tipping. Structural failure is not limited to total fracture; it includes all permanent damage such as over stressing, bending and twisting of any of the components. When a crane is over stressed, the damage may not be apparent. Nevertheless, a structural failure has occurred and over stressed components are then subject to catastrophic failure at some future time.

4. Structural Integrity The crane's main frame, crawler track and/or outrigger supports, boom sections, and attachments are all considered part of the structural integrity of lifting. In addition, all wire ropes, including stationary supports or attachment points, help determine lifting capacity and are part of the overall structural integrity of a crane's lifting capacity. The following elements may also affect structural integrity:

- The load chart capacity in relationship to stability;
- The boom angle limitations which affect stability and capacity; and
- The knowledge of the length of boom and radius in determining capacity.

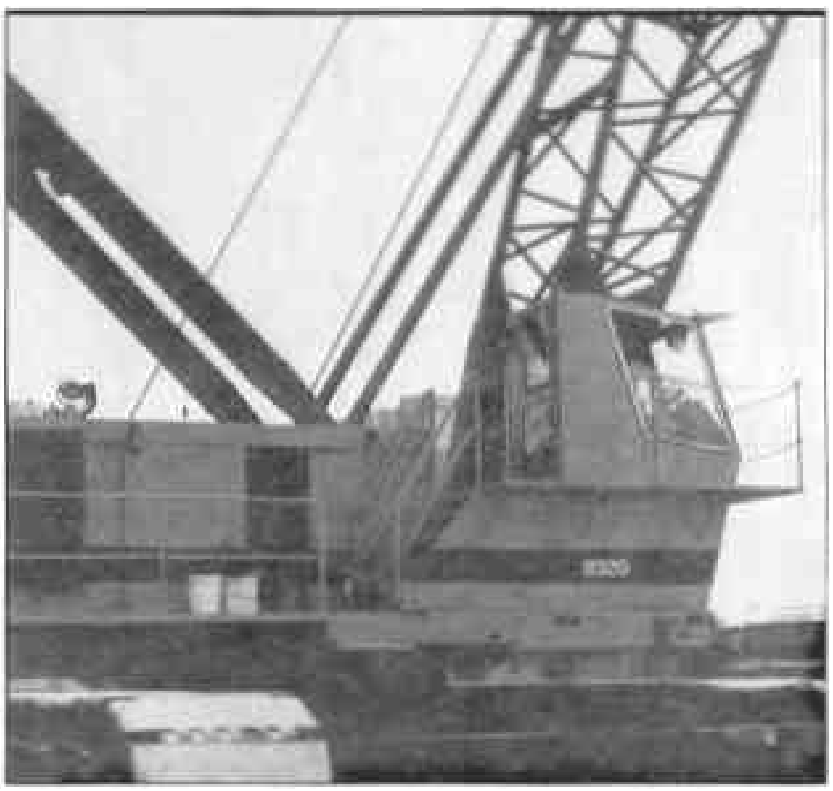
Stability failures are foreseeable, but in structural failure it is almost impossible to predict what component will fail at any given time. No matter what the cause, if the crane is overloaded, structural failure can occur.

## 2.2 Operational Considerations

Cranes are carefully designed, tested, and manufactured for safe operation. When used properly they can provide safe reliable service to lift or move loads. Because cranes have the ability to lift heavy loads to great heights, they also have an increased potential for catastrophic accidents if safe operating practices are not followed.

Crane operators and personnel working with cranes need to be knowledgeable of basic crane capacities, limitations, and specific job site restrictions, such as location of overhead electric power lines, unstable soil, or high wind conditions. Personnel working around crane operations also need to be aware of hoisting activities or any job restrictions imposed by crane operations, and ensure job site coordination of cranes. Crane inspectors therefore should become aware of these issues and, prior to starting an inspection, take time to observe the overall crane operations with respect to load capacity, site coordination, and any job site restrictions in effect.


ROUGH TERRAIN (R/T) 45 TONE CRANE
(HYDRAULIC CRANE)



150-TON CRAWLER LATTICE BOOM FRICTION CRANE

## 3.0 REQUIREMENTS FOR MOBILE CRANES

### 3.1 OSHA Construction Requirements

A review of the OSHA crane standards provide a basis for a crane inspection. Construction crane standards requirements are found in Subpart N, 29 CFR 1926 550. Some key requirements state that:

(1) The employer shall comply with the manufacturer's specifications and limitations applicable to the operation of any and all cranes and derricks. Where manufacturer's specifications are not available, the limitations assigned to the equipment shall be based on the determinations of a qualified engineer competent in this field and such determinations will be appropriately documented and recorded. Attachments used with cranes shall not exceed the capacity, rating, or scope recommended by the manufacturer.

(2) Rated load capacities, and recommended operating speeds, special hazard warnings, or instruction, shall be conspicuously posted on all equipment. instructions or warnings shall be visible to the operator while he is at his control station.

(5) The employer shall designate a competent person who shall inspect all machinery and equipment prior to each use, and during use, to make sure it is in safe operating condition. Any deficiencies shall be repaired, or defective parts replaced, before continued use.

(6) A thorough, annual inspection of the hoisting machinery shall be made by a competent person, or by a government or private agency recognized by the U.S. Department of Labor. The employer shall maintain a record of the dates and results of inspections for each hoisting machine and piece of equipment.

(15) Except where electrical distribution and transmission lines have been de-energized and visibly grounded at point of work or where insulating barriers, not a part of or an attachment to the equipment or machinery, have been erected to prevent physical contact with the lines, equipment or machines shall be operated approximate to power lines only in accordance with the following:

   (i) For lines rated 50 kV or below, minimum clearance between the lines and any part of the crane or load shall be 10 feet;

   (ii) For lines rated over 50 W, minimum clearance between the lines and any part of the crane or load shall be 10 feet plus 0.4 inch for each 1 kV over 50 W, or twice the length of the line insulator, but never less than 10 feet;

(iv) A person shall be designated to observe clearance of the equipment and give timely warning for all operations, where it is difficult for the operator to maintain the desired clearance by visual means;

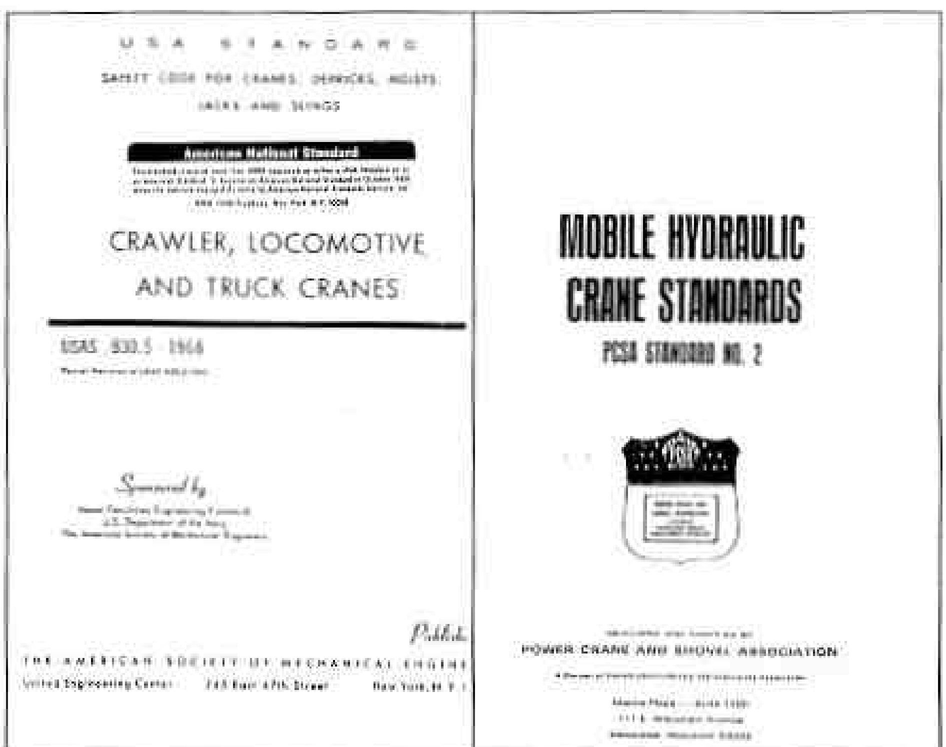
(vi) Any overhead wire shall be considered to be an energized line unless and until the person owning such fine or the electrical utility authorities indicate that it is not an energized line and it has been visibly grounded.

(16) No modifications or additions which effect the capacity or safe operation of the equipment shall be made by the employer without the manufacturer's written approval. In no case shall the original safety factor of the equipment be reduced.

To supplement the OSHA standards for Cranes and Derricks, references are made to applicable ASME/ANSI and PCSA standards. The ASME/ANSI "B30" series of standards address: "Cranes", "Cableways", "Derricks", "Hoists", "Hooks", "Jacks", and "Stings". For the purpose of this document, ASME/ANSI B30.5, "Mobile and Locomotive Cranes" will be the reference document for the crane inspection criteria.

References also are made to the Power Crane Shovel Association (PCSA), Standard No. 2, "Mobile Hydraulic Crane Standards."

### 3.2 ASME/ANSI and PCSA Requirements




| ASME/ANSI B30.5 | PCSA STANDARD #2 |
|---|---|

## 4.0 INSPECTING A MOBILE CRANE

Since cranes impact such a large segment of work going on at any job site, crane inspections (to the OSHA Compliance Officer and Project Safety Managers) must include a survey, or walk around, of the entire operation that questions how the crane will be operating and how other crafts will be effected by working with and around the crane? Observation of crane operations prior to an inspection, or simply asking how cranes have or will be used, can indicate possible problem areas that may need a closer review during the inspection process.

### 4.1 Preinspection

Before the actual inspection, some general information about the crane operator's qualifications and the crane's certifications should be gathered, such as:

Operator Qualifications Observe the operator in action and when the opportunity permits ask a few question concerning the cranes capacity and restrictions imposed, either due to activity involved in or functional limitations.

Crane Records Ask for inspection and maintenance records and verify that the appropriate operator's manual and load charts are available for that particular crane in use.

### 4.2 Crane Setup

In your initial survey of crane operations, look for crane stability, physical obstructions to movement or operation, and proximity of electrical power lines, as well as the following:

A. Leveling Has the crane operator set the crane up level and in a position for safe rotation and operation?

B. Outriggers Are the outriggers, where applicable, extended and being used in accordance with manufacturer's recommendations?

C. Stability The relationship of the load weight, angle of boom, and its radius (the distance from the cranes center of rotation to the center of load) to the center of gravity of the load. Also, the condition of crane loading where the load moment acting to overturn the crane is less than the moment of the crane available to resist overturning.

D. Structural Integrity The crane's main frame, crawler, track and outrigger supports, boom sections, and attachments are all considered part of structural components of lifting. In addition, all wire ropes, including stationary supports, help determine lifting capacity and are part of the structural elements of crane operations.

### 4.3 Electrical Hazards

Working around or near electrical power lines is one of the most dangerous practices for crane operations. The OSHA requirements limit crane operations to a minimum clearance of 10 feet. Cranes should not be used to handle materials or loads stored under electric power lines. in addition, operation of mobile cranes near de-energized electric power lines is not recommended until the following steps have been taken:

- The power company or owner of the power line has deenergized the lines.
- The lines are visibly grounded and appropriately marked at jobsite.
- Durable warning signs are installed at the operator's station and on the outside of the crane identifying the clearance requirements between the crane/load and electrical power lines.
- A qualified representative of the power company or owner of the electrical power line are on the job site to verify that the power lines have been de-energized or properly grounded.

### 4.4 Load Charts

Load Charts are the principle set of instructions and requirements for boom configurations and parts of line which establish crane capacity for safe crane operations.*

- Availability The crane operator must have in his/her possession the appropriate load charts related to the crane in use and for the loads being lifted.

- Correct Use The crane operator must show adequate understanding and proficient use of the load charts as related to the equipment in use and the loads being lifted.

### 4.5 Safe Operating Precautions

As stated above, cranes are carefully designed, tested, and manufactured for safe operations. When used properly they can provide safe reliable service to lift or move loads. Because cranes have the ability to lift heavy loads to great heights, they also have an increased potential for catastrophic accidents if safe operating practices are not followed.

Accidents can be avoided by careful job planning. The person in charge must have a clear understanding of the work to be performed and consider all potential dangers at the job site. A safety plan must be developed for the job and must be explained to all personnel involved in the lift.

Before operations begin for the day, a walk around inspection needs to be conducted to ensure that the machine is in proper working condition. Only qualified and properly designated people shall operate the crane. Regular inspections are important, they provide a means of detecting potential hazards or conditions that could contribute to a sequence of events leading to an accident. Safe, reliable, and the economic operation of lifting equipment, cannot be ensured

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*See Load Chart, Appendix B.

without regular safety inspections and thorough preventive maintenance programs. A thorough inspection program can forecast maintenance needs or potential equipment failures or malfunctions. The lack of such a program could result in serious deterioration of the equipment which might lead to excessive replacement, or repair charges, as well as an increased potential for accidents.

TOWER CRANE COLLAPSE
(CLEANING UP DEBRIS)

Due to the wide variation of conditions under which a crane may operate, it is impossible for the manufacturer to determine inspection intervals appropriate for every situation. inspection intervals recommended in manufacturer's publications represent minimum intervals for average operating conditions. More frequent inspection intervals should be required if use and site conditions are severe and warrant it. Inspections are also designed as maintenance checks and/or as a verification that proper repairs or modifications of equipment have been completed which, if not checked could affect capacities as well as personnel safety. Since the initial load rating for cranes was determined and set under ideal conditions, inspections are required by manufacturers to guarantee optimal operating efficiency and capacity as determined by the load charts.

The American National Standards institute, ANSI B30.5, 1968, and OSHA both require inspections be divided into two categories: frequent and periodic. In addition to the performance of these regular inspections, equipment is required to be inspected and tested to ensure that it is capable of safe and reliable operation when initially set or placed in service and after any major repairs or any design modification.

CRAWLER CRANE
PREPARED FOR INSPECTION

## 4.6 Inspection Types

A. Frequent Inspections (daily to monthly intervals) - Frequent inspections are usually performed at the start of each shift by the operator who walks around the crane looking for defects or problem areas. Components that have a direct bearing on the safety of the crane and whose status can change from day to day with use must be inspected daily, and when possible, observed during operation for any defects that could affect safe operation. To help determine when the crane is safe to operate, daily inspections should be made at the start of each shift. Frequent inspections should include, but are not limited to the following:

1. Check that all exposed moving parts are guarded. A removed guard may indicate that a mechanic is still working on part of the crane.

2. Visually inspect each component of the crane used in lifting, swinging, or lowering the load or boom for any defects that might result in unsafe operation.

3. Inspect all wire rope (including standing ropes), sheaves, drums rigging, hardware, and attachments. Remember, any hook that is deformed or cracked must be removed from service. Hooks with cracks, excessive throat openings of 15%, or hook twists of 10 degrees or more, must be removed from service.

4. Check for freedom of rotation of all swivels.

5. Visually inspect the boom and jib for straightness and any evidence of physical damage, such as cracking, bending, or any other deformation of the welds. Look for corrosion under any attachments that are connected to the chords and lacing. Watch carefully for cracking or flaking of paint. This may indicate fatigue of the metal which often precedes a failure. On lattice booms, look for bent lacing. If they are kinked or bent, the main chord can lose substantial support in that area. When lacing is bent, the ends also tend to draw together which pulls the main chords out of shape. This precaution is especially important on tubular booms where every component must be straight and free from any dents. Do not attempt to straighten these members by hammering or heating them and drawing them out. They must be cut out and replaced with lacing to the manufacturer's specifications, procedures, and approval.

6. Inspect tires for cuts, tears, breaks, and proper inflation.

7. Visually inspect the crane for fluid leaks, both air and hydraulic.

8. Visually check that the crane is properly lubricated. The fuel, lubricating oil, coolant and hydraulic oil reservoirs should be filled to proper levels.

9. Check that the crane is equipped with a fully charged fire extinguisher and that the operator knows how to use it.

10. Check all functional operating mechanisms such as: sheaves, drums, brakes, locking mechanisms, hooks, the boom, jib, hook rollers brackets, outrigger components, limit switches, safety devices, hydraulic cylinders, instruments, and lights.

11. Check the turntable connections for weld cracks and loose or missing bolts. If they are loose, there is a good chance that they have been stretched.

12. When checking the outriggers be sure that neither the beams nor the cylinders are distorted. Check that the welds are not cracked and that both the beams and cylinders extend and retract smoothly and hold the load. Check the condition of the floats, and check that they are securely attached.

13. Inspect and test all brakes and clutches for proper adjustment and operation.

14. Always inspect boom hoist lockout and other operator aids, such as anti-two-block devices (ATB) and load moment indicators (LMI), for proper operation and calibration.

15. While the engine is running, check all gauges and warning lights for proper readings and operate all controls to see that they are functioning properly.

16. Check for any broken or cracked glass that may affect the view of the operator.

B. <u>Periodic Inspections</u> (1 to 12 month intervals) - The periodic inspection procedure is intended to determine the need for repair or replacement of components to keep the machine in proper operating condition. It includes those items listed for daily inspections as well as, but not limited to, structural defects, excessive wear, and hydraulic or air leaks.

Inspection records of the inspected crane shall be maintained monthly on critical items inuse, such as brakes, crane hooks, and ropes. These inspection records should include, the date of inspection, the signature of the person who performed the inspection, and the serial number, or other identifier. This inspection record should be kept readily available for review. The manufacturer's maintenance and inspection records, forms/checklist, or equivalent should be used.

1. Inspect the entire crane for structural damage. Be careful to check for distortion or cracks in main frame, outrigger assemblies, and structural attachments of the upperworks to the carrier.

2. Inspect all welded connections for cracks. Inspect the main chords and

lacings and other structural items for paint flaking and cracking which may indicate potential failure, as well as for dents, bends, abrasions, and corrosion. Check hydraulic booms for bending, side sway, or droop.

3. Check for deformed, cracked, or corroded members in the load/stress bearing structure. Magnetic particle or other suitable crack detecting inspection should be performed at least once each year by an inspection agency retained by the owner. Inspection reports should be requested and retained in the crane file.

4. Inspect cracked or worn sheaves and drums.

5. Inspect for worn, cracked, or distorted parts such as: pins, bearings, shafts, gears, rollers, locking devices, hook roller brackets, removable outrigger attachments lugs, and welds.

6. Inspect for excessive wear on brake and clutch system parts, linings, pawls, and ratchets.

7. Inspect all indicators, including load and boom angle indicators, for proper operation and calibration.

8. Inspect all power plants for proper operation.

9. Inspect for excessive wear on drive sprockets and/or chain stretch.

10. Inspect for correct action of steering, braking, and locking devices.

11. Check that the counterweight is secure.

12. Check that the identification number is permanently and legibly marked on jibs, blocks, equalizer beams, and all other accessories.

13. Inspect all hydraulic and pneumatic hoses, fittings, and tubing. Any deterioration of any system component should cause the inspector to question whether further use would constitute a safety hazard. Conditions, such as the following, require replacement of the part in question:

    a. Any evidence of oil or air leaks on the surfaces of flexible hoses or at the point at which the hose in question joins the metal end couplings.

    b. Any abnormal deformation of the outer covering of hydraulic hose, including any enlargement, local or otherwise.

    c. Any leakage at connections which cannot be eliminated by normal tightening.

d. Any evidence of abrasive wear that could have reduced the pressure retaining capabilities of the hose or tube effected. The cause of the rubbing or abrasion must be immediately eliminated.

## 4.7 Starting The Inspection

Since most crane inspections begin with a general walk around and observation of the overall crane set up and operation, followed by a specific inspection of items or components, the following guidelines are presented in that order. The first section addresses the general items and operational considerations when inspecting any type of crane, followed by the specific inspection items for two specific types of cranes; Grove Rough Terrain 45 Ton (hydraulic) and Manitowoc 4100 150 Ton Crawler (lattice boom friction) cranes.

In general, the following should be considered when inspecting any crane

1. Request for and review all inspection and maintenance documents for the crane being inspected, including the crane manufacturer's inspection and maintenance requirements.

2. Conduct a walkaround inspection, 'paying particular attention to mechanical systems leaks or damage (oil, hydraulic, air) and structural deficiencies.

3. Look at crane cab for properly marked controls, damaged instruments and for properly displayed and legible load charts.

4. Ask the operator, ground crew (riggers), and/or supervisors appropriate questions on load charts, rigging and load weight. determinations, and capacities.

5. Request the operator to raise and lower the boom/load line, where practical, and inspect, from the cab position, the running line or rope of the main hoist drum and secondary line or jib line. Check brake action and. its ability to stop.

6. If practical, request the operator to lower boom to look at the condition of boom’s sections, lacing, lifting components, anti-two-block devices, jib back stops, and the condition of the hook.

7. Check crane set up and stability of outriggers on hydraulics and/or the effectiveness of cribbing on crawlers. If possible, request that the crane be rotated to check all clearances and overall stability.

## 4.8 Specific Inspection Items and References

The following table identifies the specific inspection items for cranes as well as a brief description and purpose to help the inspector to have a better understanding of what and why the item is being inspected.

| Table 4.8A -- Inspection Items and Description | |
|---|---|
| **ITEM** | **DESCRIPTION/PURPOSE** |
| **(1) Manufacturer's Operating and Maintenance Manuals** | Manufacturer's operating and maintenance manuals shall accompany all mobile hoisting equipment. These manuals set forth specific inspection, operation and maintenance criteria for each mobil crane and lifting capacity. |
| **(2) Guarding** | All exposed moving parts such as gears, chains, reciprocating or rotating parts are guarded or isolated. |
| **(3) Swing Clearance Protection** | Materials for guarding rear swing area. |
| **(4) High-Voltage Warning Sign** | High-voltage warning signs displaying restrictions and requirements should be installed at the operator's station and at strategic locations on the crane. |
| **(5) Boom Stops** | Shock absorbing or hydraulic type boom stops are installed in a manner to resist boom overturning. |
| **(6) Jib Boom Stops** | Jib stops are restraints to resist overturning. |
| **(7) Boom Angle Indicator** | A boom angle indicator readable from the operator station is installed accurately to indicate boom angle. |
| **(8) Boom Hoist Disconnect, Automatic Boom Hoist Shutoff** | A boom hoist disconnect safety shutoff or hydraulic relief to automatically stop the boom hoist when the boom reaches a predetermined high angle. |
| **(9) Two-Blocking Device** | Cranes with telescoping booms should be equipped with a two- blocking damage prevention feature that has been tested on-site in accordance with manufacturers requirements. All cranes hydraulic and fixed boom used to hoist personnel must be equipped with two- blocking devices on all hoist lines intended to be used in the operation. The anti-two-blocking device has automatic capabilities for controlling functions that may cause a two-blocking condition. |
| **(10) Power Controlled Lowering** | Cranes for use to hoist personnel must be equipped for power controlled lowering operation on all hoist lines. Check clutch, chains, and sprockets for wear. |
| **(11) Leveling Indicating Device** | A device or procedure for leveling the crane must be provided. |
| **(12) Sheaves** | Sheave grooves shall be smooth and free from surface defects, cracks, or worn places that could cause rope damage. Flanges must not be broken, cracked, or chipped. The bottom of the sheave groove must form a close fitting saddle for the rope being used. Lower load blocks must be equipped with close fitting guards. Almost every wire rope installation has one or more sheaves -- ranging from traveling blocks with complicated reeving patterns to equalizing sheaves where only minimum rope movement is noticed. |

| 4.8A -- Inspection Items and-Description | |
|---|---|
| **ITEM** | **DESCRIPTION / PURPOSE** |
| **(13) Main Hoist and Auxiliary Drums System** | Drum crushing is a rope condition sometimes observed which indicates deterioration of the rope. Spooling is that characteristic of a rope which affects how it wraps onto and off a drum. Spoiling is affected by the care and skill with which the first larger of wraps is applied on the drum. Manufacturer's criteria during inspection usually specify:<br><br>C Minimum number of wraps to remain on the drum.<br>C Condition of drum grooves.<br>C Condition of flanges at the end of drum.<br>C Rope end attachment.<br>C Spooling characteristics of rope.<br>C Rope condition. |
| **(14) Main Boorn, Jib Boorn, Boom Extension** | Boom jibs, or extensions, must not be cracked or corroded. Bolts and rivets must be tight. Certification that repaired boom members meet manufacturers original design standard shall be documented. Non-certified repaired members shall not be used until recertified. |
| **(15) Load Hooks and Hook Blocks** | Hooks and blocks must be permanently labeled with rated capacity. Hooks and blocks are counterweighted to the weight of the overhaul line from highest hook position. Hooks must not have cracks or throat openings more than 15% of normal or twisted off center more than 10' from the longitudinal axis. All hooks used to hoist personnel must be equipped with effective positive safety catches -especially on hydraulic cranes. |
| **(16) Hydraulic Hoses Fittings and Tubing** | Flexible hoses must be sound and show no signs of leaking at the surface or its junction with the metal and couplings. Hoses must not show blistering or abnormal deformation to the outer covering and no leaks at threaded or clamped joints that cannot be eliminated by normal tightening or recommended procedures. There should be no evidence of excessive abrasion or scrubbing on the outer surfaces of hoses, rigid tubing, or hydraulic fittings. |
| **(17) Outriggers** | Outrigger number, locations, types and type of control are in accordance with manufacturer's specifications. Outriggers are designed and operated to relieve all weight from wheels or tracks within the boundaries of the outriggers. If not, the manufacturer's specifications and operating procedures must be clearly defined. Outriggers must be visible to the operator or a signal person during extension or setting. |

| Table 4.8A -- Inspection Items and Description | |
|---|---|
| **ITEM** | **DESCRIPTION / PURPOSE** |
| **(18) Load Rating Chart** | A durable rating chart(s) with legible letters and figures must be attached to the crane in a location accessible to the operator while at the controls. The rating charts shall contain the following:<br><br>C A full and complete range of manufacturer's crane loading ratings at all stated operating radii.<br><br>C Optional equipment on the crane such as outriggers and extra counterweight which effect ratings.<br><br>C A work area chart for which capacities are listed in the load rating chart, i.e. over side, over rear, over front.<br><br>C Weights of auxiliary equipment, i.e. load block, jibs, boom extensions.<br><br>C A clearly distinguishable list of ratings based on structural, hydraulic or other factors rather than stability.<br><br>C A list of no-load work areas.<br><br>C A description of hoistline reeving requirements on the chart or in operator's manual. |
| **(19) Wire Rope** | Main hoist and auxiliary wire rope inspection should include examining for:<br>C Broken wires,<br><br>C Excess wear.<br><br>C External damage from crushing, kinking, cutting or corrosion. |
| **(20) Cab** | Contains all crane function controls in addition to mechanical boom angle indicators, electric wipers, dash lights, warning lights and buzzers, fire extinguishers, seat belts, horn, and clear unbroken glass. |

| 4.8A -- Inspection Items and-Description | |
|---|---|
| **ITEM** | **DESCRIPTION / PURPOSE** |
| **(21) Braking Systems** | C Truck cranes and self-propelled cranes mounted on rubber-tired chassis or frames must be equipped with a service brake system, secondary stopping emergency brake system and a parking brake system. Unless the owner/operator can show written evidence that such systems were not required by the standards or regulations in force at the date of manufacture and are not available from the manufacturer. The braking systems must have been inspected and tested and found to be in conformance with applicable requirements.<br><br>C Crawler cranes are provided with brakes or other locking devices that effectively hold the machine stationary on level grade during the working cycle. The braking system must be capable of stopping and holding the machine on the maximum grade recommended for travel. The brakes or locks are arranged to engage or remain engaged in the event of loss of operating pressure or power. |
| **(22) Turntable/Crane Body** | Make sure that the rotation point of a crane gears and rollers are free of damage, wear and properly adjusted and the components are securely locked and free of cracks or damage. The swing locking mechanism must be functional (pawl, pin) and operated in the cab. |
| **(23) Counterweight** | The counterweight must be approved and installed according to manufacturer’s specifications with attachment points secured. |

Table 4.8B shows the items that need to be examined for the Grove Rough Terrain 45 Ton Hydraulic Crane and their corresponding applicable OSHA 1926 and ANSI B30.5 Standards.

| **Table 4.8B -- Rough Terrain 45 Ton Hydraulic Crane** | | |
|---|---|---|
| **STANDARD (1926.550)** | **INSPECTION ITEMS** | **ANSI B30.5** |
| | **Outriggers** | |
| | 1. Lubrication | 5-1.9.9 |
| | 2. Structural Condition | 5-2.1.3 |
| | 3. Pressure hoses/connections | 5-2.1.2 |
| | **Turntable/Crane Body** | |
| | 1. Ensure Level/Stability | 5-1.1 & 5-1.2 |
| | 2. Wear/Gear/Teeth/Rollers | |
| | 3. Cracks | |
| | 4. Bolts/Ensure Securely Attached | |
| | **Counter Weight** | |
| | 1. Proper Size | 5-3.4.2 |
| | 2. Attachment Connection/Bolts | |
| | **Engine Housing** | |
| 550(a)(8) | 1. Cleanliness/No Rags/Trash | |
| 550(a)(13)(ii) &(iii) | 2. Gear/Machinery Guards | 5-1.9.6 |
| -------- | 3. Clear Access/Walkways | 5-1.8.2 & 3 |
| 550(a)(4) | 4. Brakes/Clutch Adjustments | --------- |
| -------- | 5. Hand Signal Illustration | 5-2 (Fig. 16) |
| -------- | 6. Swing Break | 5-1.4 |
| | **Cab** | |
| 550(a)(12) | 1. Glass/Visibility | -------- |
| -------- | 2. Instruments and Controls | 5-5.1.6.1.1 |
| -------- | 3. Functioning Horn (warning signal) | --------- |
| 550(a)(14)(i) | 4. Fire Extinguisher | 5-3.4.9 |
| 550(a)(2) | 5. Appropriate Load Charts and Warning Signs | 5-5.1.1.3 |
| | 6. Proper and Adequate Access (steps/walkway) | |
| 550(a)(13) & 550(a)(13)(iii) | | 5-1.8.2 & 3 |
| | **Drum** | |
| | 1. Proper Size and Spoiling of Hoistlines | 5-1.3.1 & 2 |
| | 2. Drum Sides/Shields for cracks | |
| | 3. Dogs/Pawls/Locking Devices | |
| | 4. Drum Rotation vs. Control Motion | |

| Table 4.8B -- Rough Terrain 45 Ton Hydraulic Crane | | |
|---|---|---|
| **STANDARD (1926.550)** | **INSPECTION ITEMS** | **ANSI B30.5** |
| | **Boom Sections** | |
| | **(Boom sections correspond with crane model)** | |
| -------- | 1. | 5-2.1.3 |
| -------- | 2. | |
| -------- | 3. Boom Stops | |
| -------- | 4. | |
| -------- | 5. Hoist Line Guides/Sheaves | |
| -------- | 6. | |
| -------- | 7. | |
| 550(b) | 8. Jib Attachment/Backstops/Belly Slings | |
| | **Sheave System** | |
| | 1. Ensure hoist line and sheave size match | 5-1.7.4 |
| | 2. Worn | |
| | 3. Lubrication/Move freely | |
| | **Load/Auxiliary Hook and Block System** | |
| | 1. Sheaves Function Smoothly | 5-1.7.1.–6 |
| | 2. Hook Rotates Freely/Lubricated | |
| | 3. Proper Becket | |
| | 4. Properly Reeved | |
| | **Wire Rope/Hoist line** | |
| 550(a)(7) | 1. Overall condition | |
| 550(a)(7)(v) | 2. End Connections | 5-1.7.6 |
| ---------- | 3. Lubrication | ---------- |
| ---------- | 4. Clips | ---------- |
| | **Safety Devices** | |
| -------- | 1. Anti-Two Block Devices | |
| -------- | 2. Boom Backstop Devices | 5-1.1.9 |
| 550(a)(9) | 3. Swing Radius Warning Devices | |
| 550(a)(15) | 4. Job or Site Specific Devices/system (near electric power/personnel hoisting platforms) | 5-2 (Fig. 17) |

Additional references:

550(a)(1) ----- Crane used in accordance with manufactures specification
550(a)(5) ----- Inspection: Competent Person.
550(a)(6) ----- Annual Inspection Record.
550(a)(16) ---- No modifications without written approval of manufacturer

Table 4.8C shows the items that need to be examined for the Manitowoc 4100 150 Ton Lattice Boom Crawler Crane and their corresponding applicable OSHA 1926 and ANSI B30.5 Standards.

<table>
<tr><th colspan="3">Table 4.8C -- 150 Ton Lattice Boom Crawler Crane</th></tr>
<tr><th>STANDARD<br>(1926.550)</th><th>INSPECTION ITEMS</th><th>ANSI B30.5</th></tr>
<tr><td></td><td>Track Crawler System<br>1. Lubrication<br>2. Connection Bolts<br>3. Drive Chain (slack & wear)</td><td><br>5-1.9.9<br>5-2.1.3<br>5-2.1.2</td></tr>
<tr><td></td><td>Turntable/Crane Body (Upper Works)<br>1. Assure level/Stability<br>2. Wear/Gear/Teeth/Rollers<br>3. Cracks<br>4. Bolts/Pins - Assure Securely Attached</td><td><br>5-1.1 & 5-1.2</td></tr>
<tr><td></td><td>Counter Weight<br>1. Proper size<br>2. Attachment Connection/Bolts</td><td><br>5-3.4.2</td></tr>
<tr><td><br>550(a)(8)<br>550(a)(13)(ii) & (iii)<br>---------<br>550(a)(4)<br>---------<br>---------</td><td>Engine Housing<br>1. Cleanliness/No Rags/Trash<br>2. Gear/Machinery Guards<br>3. Clear Access/Walkways<br>4. Brakes/Clutch Adjustments<br>5. Hand Signal Illustration<br>6. Swing Break</td><td><br><br>5-1.9.6<br>5-1.8.2 & 3<br>---------<br>5-2 (Fig.16)<br>5-1.4</td></tr>
<tr><td><br>550(a)(12)<br>---------<br>---------<br>550(a)(14)(i)<br>550(a)(2)<br><br><br><br>550(a)(13) &<br>550(a)(13)(iii)</td><td>Cab<br>1. Glass/Visibility<br>2. Instruments and Controls<br>3. Functioning Horn (warning signal)<br>4. Fire Extinguisher<br>5. Appropriate Load Charts and Warning Signs<br>6. Proper and Adequate Access (steps/walkway)</td><td><br>---------<br>5-5.1.6.1.1<br>---------<br>5-3.4.9<br><br>5-5.1.1.3<br><br><br>5-1.8.2 & 3</td></tr>
<tr><td></td><td>Hoist Drum System<br>1. Proper Size and Spoiling of Hoistlines<br>2. Drum Sides/Shields for Cracks<br>3. Dogs/Pawls/Locking Devices<br>4. Drum Rotation vs. Control Motion<br>5. Clutch and Brakes</td><td>5-1.3.1 & 2</td></tr>
</table>

| Table 4.8C -- 150 Ton Lattice Boom Crawler Crane | | |
|---|---|---|
| **STANDARD (1926.550)** | **INSPECTION ITEMS** | **ANSI B30.5** |
| | **Boom Sections** **(Boom sections correspond with crane model)** | |
| --------- | 1. Base Section Properly Attached | 5-2.1.3 |
| --------- | 2. Pin Clearance | |
| --------- | 3. Boom Lacing/Cord Damage | |
| --------- | 4. Boom Stops | |
| --------- | 5. Gantry System A-Frame | |
| --------- | 6. Hoist Line Guides/Sheaves | |
| --------- | 7. Boom Section Connection Pins/Keys | |
| 550(b) | 8. Boom and Gantry Support System | |
| | 9. Jib Attachment/Backstops/Belly Slings (Jib Security Device) | |
| | **Sheave System** | |
| | 1. Ensure Hoistline and Sheave Size Match | 5-1.7.4 |
| | 2. Worn | |
| | 3. Lubrication/Move freely | |
| | **Load/Auxiliary Hook and Block System** | |
| | 1. Sheaves Function Smoothly | 5-1.7.1-6 |
| | 2. Hook Rotates Freely/Lubricated | |
| | 3. Proper Becket | |
| | 4. Properly Reeved | |
| | **Wire Rope/Hoist Line** | |
| 550(a)(7) | 1. Overall Condition | |
| 550(a)(7)(v) | 2. End Connections | 5-1.7.6 |
| ---------- | 3. Lubrication | ---------- |
| ---------- | 4. Clips | ---------- |
| | **Safety Devices** | |
| ---------- | 1. Anti-Two Block Devices | |
| ---------- | 2. Boom Backstop Devices | 5-1.1.9 |
| 550(a)(9) | 3. Swing Radius Warning Devices | |
| 550(a)(15) | 4. Job or Site Specific Devices/System/Program for work near electric power and use of personnel hoisting platforms | 5-2 (Fig. 17) |

Additional references:

550(a) (1) ---- Crane used in accordance with manufactures specification.
550(a)(5) ---- Inspection: Competent Person.
550(a)(6) ---- Annual Inspection Record.
550(a)(16)---- No modifications without written approval from manufacturers

# APPENDIX A - GENERAL TERMS AND DEFINITIONS

| General Terms and Definitions | |
|---|---|
| Auxiliary Hoist | A supplemental hoisting unit, usually of lower load rating and higher speed than the main hoist. |
| Axis of Rotation | The vertical axis around which the crane's superstructure rotates. |
| Boom | In cranes and derricks usage, an inclined spar, strut, or other long member supporting the hoisting tackle. Also defined as a structural |
| Boom Angle Indicator | An accessory device that measures the angle of the boom base section centerline to horizontal. |
| Boom Stops | A devise used to limit the angle of the boom at its highest position. |
| Brake | A device used for retarding or stopping motion by friction or power means. |
| Block | Sheaves or grooved pulleys in a frame provided with hook, eye, and strap. |
| Crane | A machine consisting of a rotating superstructure for lifting and lowering a load and moving it horizontally on either rubber tires or crawler treads. |
| Counterweight | Weights used for balancing loads and the weight of the crane in providing stability for lifting. |
| Deck | The revolving superstructure or turntable bed. |
| Drum | The spool or cylindrical member around which cables are wound for raising and lowering loads. |
| Gantry | A structural frame work (also known as an A frame) mounted on the revolving superstructure of the crane to which the boom supporting cables are reeved. |
| Headache Ball | A heavy weight attached above the hook on a single line or whip line to provide sufficient weight to lower the hook when loaded. |
| Holding Brake | A brake that automatically sets to prevent motion when power is off. |
| Jib | An extension attached to the boom point to provide added boom length for lifting specified loads. |
| Load | The weight of the object being lifted or lowered, including load block, ropes, slings, shackles, and any other ancillary attachment. |
| Load Block | The assembly of the hook or shackles, swivel, sheaves, pins, and frame suspended from the boom point. |
| Main Hoist | Hoist system or boom used for raising and lowering loads up to maximum rated capacity. |
| Mechanical Load Brake | An automatic type of friction brake used for controlling loads in the lowering direction. This device requires torque from the motor to lower a load but does not impose additional loads on the motor when lifting a load. |
| Outriggers | Support members attached to the crane's carrier frame which are used to level the crane and may be blocked up to increase stability.. |
| Pawl | Also known as "dog". It is a gear locking device for positively holding the gears against movement. |
| Pendants | Stationary cables used to support the boom. |

| General Terms and Conditions | |
|---|---|
| Radius | The horizontal distance from the axis of rotation of the crane's superstructure to the center of the suspended load. |
| Reeving | The path that a rope takes in adapting itself to all sheaves and drums of a piece of equipment. |
| Running Sheave | Sheaves that rotate as the hook is raised or lowered. |
| Superstructure | The rotating frame, gantry, and boom or other operating equipment. |
| Test Load | Any load or force, expressed in pounds, used for testing or certifying the limitations within acceptable tolerances of the anticipated load. |
| Two-Block | The condition in which the lower load lock or hook assembly comes in contact with the upper load block or boom point sheave assembly. |
| Quadrant of Operation | The area of operation that the list is being made in. Usually divided into four quadrants, i.e., front, rear and side(s) - left side and right side. |

## APPENDIX B - GENERAL LOAD CHARTS AND OPERATIONAL CONSIDERATIONS

General Load Chart: Manufacturer's operating notes supplied with the machine contain important information concerning proper set-up, operation and additional points that need to be considered when calculating load handling capacities of cranes. Mistakes in calculating capacity can cause accidents.

Several factors to be considered when calculating a cranes load capacity, including the following:

A. Load Radius: the horizontal distance between the center of the crane rotation to center of the load.

B. Boom length: including the jib, swing away extension or any other attachments that may increase length of the boom.

C. Parts of line:

D. Quadrant of operation: the area of operation that the lift is being made in; note different quadrants usually have lower lifting capacities.

E. Boom angle: the angle formed between the horizontal plane of rotation and center line of the boom.

F. Weight of any attachments: jib, lattice extension or auxiliary boom point.

G. Weight of handling devices: ball, block, and/or any necessary rigging.

Operational Considerations:

A. When working at boom lengths or radii between the figures shown on the load capacity chart, the next lower capacity rating should be used. It is dangerous to guess the capacity for boom lengths or radii between those listed on the rating plate.

B. It is very dangerous to lift a load without knowing whether it is within the rated capacity while expecting the crane to start to tip to warn of an overload. Cranes may suddenly tip over or the boom may collapse if the load is too heavy.

C. Always stay within the rated capacity. Operators must reduce the load capacity under adverse field conditions until, it is determined, the machine can safely handle the lift.

D. Loads shall not be allowed to exceed rated load capacity and working radius.

E. Do not use counterweights heavier than the manufacturer's recommended weight.

F. Even a light wind can blow the load out of control, collapse booms, or tip machines. Winds aloft can be much stronger than at ground level.

G. Proper precautions shall be taken when the velocity of wind exceeds 20-mph.

H. Crane capacity can be adversely effected when the machine set is not level.

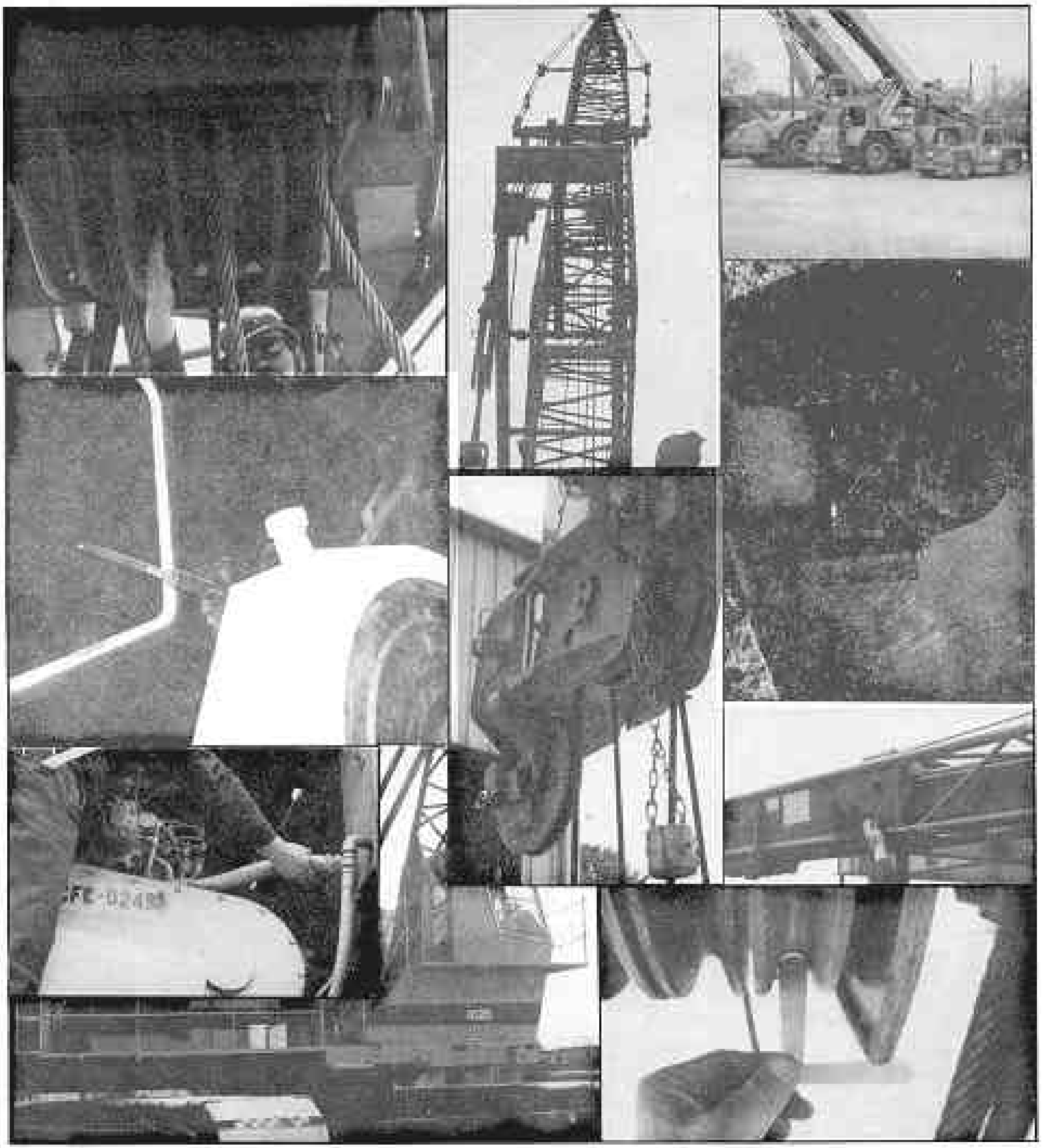
I. Do not lift loads when winds create an unsafe or hazardous condition. Booms should be lowered, if possible, under high wind conditions.

J. Foot pedal brake locks are furnished on some cranes to allow the operator to rest his legs when suspending the load for short periods of time. Operators should keep their feet on the pedals while foot pedal brake locks are in use. Brakes may cool allowing the load to fall.

K. No one, except the oiler, instructor or designated person should be allowed on a crane with the operator when the crane is in operation.

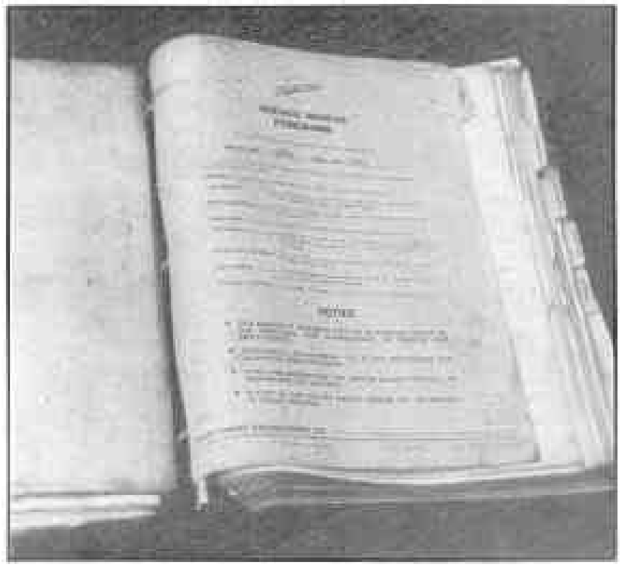
## APPENDIX C - BASIC CRANE COMPONENTS

In addition to reviewing the OSHA and ANSI standards/requirements for mobile construction cranes, it is important that each inspector have a basic knowledge of crane components and their general purpose. The following is a list of basic crane components which should be included in any inspection. In addition to a description or purpose statement photographs are provided to help the inspector recognize each item. The list may not be inclusive, but is intended to be an aid for an inspector who may now be a crane expert.



| 1. Manufacturer's Operating Manual<br><br>2. Machine Guarding | INSPECTION ITEMS |
|---|---|

1. Manufacturer's operating and maintenance manuals shall accompany all mobile hoisting equipment. These manuals set forth inspection, operation, and maintenance criteria for each mobil crane and not generally available from any other source.



2. All exposed moving parts such as gears, chains reciprocating or rotating parts are to be guarded or isolated.

| | |
|---|---|
| 3. Swinging Clearance Protection<br><br>4. High Voltage Warning Signs | INSPECTION ITEMS |

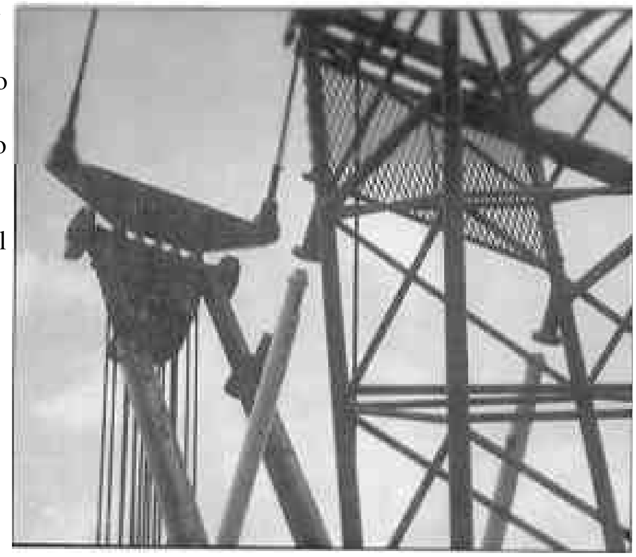
3. The swing radius of the counterweight shall be established and guarded to prevent personnel or other equipment from being struck by the counterweight. Special attention shall be given to guarding of the swing radius when near buildings or other structures. The swing radius guarding is intended to simply be a warning device and not necessarily a barricade guard rail. There are no strength requirements associated with swing radius protection.

4. High voltage warning signs shall be displayed on the exterior of the equipment on each side and on the counterweight of the crane.

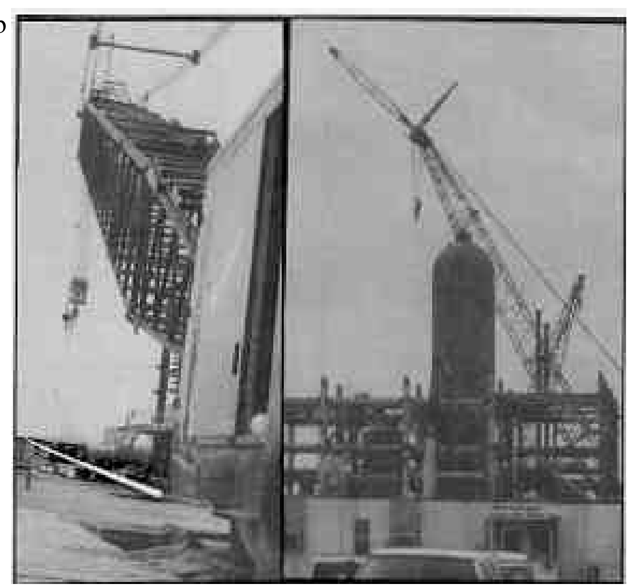
| 5. Boom Stops<br><br>6. Jib Boom Stops | INSPECTION ITEMS |
|---|---|

5. Boom stops are telescoping, shock absorbing, or hydraulic-type safety devices designed and installed in a manner to stop or shut off power to the boom controls. The purpose of the boom stops is to prevent the boom from being raised to a point where the center of gravity is shifted to the rear of the crane causing the boom to fall backwards from lack of resistance and/or control of boom movement.

   Boom stops can be inspected and checked for proper function by raising the boom very slowly until contact is made an power for boom movement is stopped.

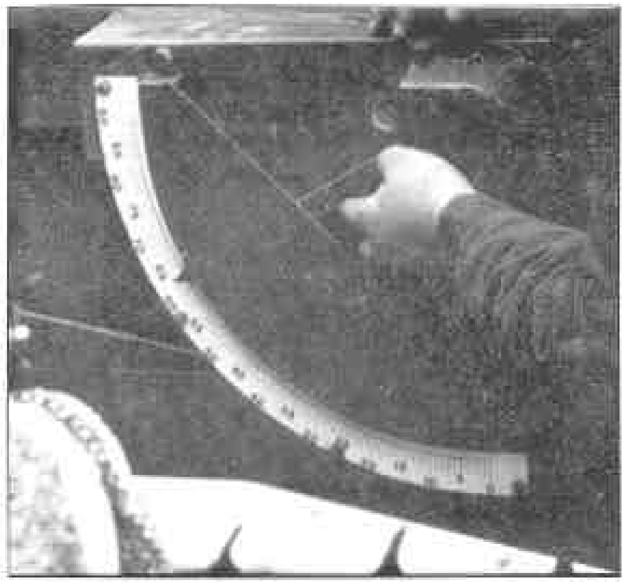


6. Jib stops are restraints designed to prevent the jib from being raised to the point that it overturns onto the boom sections. Jib stops, like boom stops, are telescoping, shock absorbing, hydraulic devices, designed to warn the operator that the jib load block has approached the point at which overtipping/overturning is possible if raising the load line continues.



| 7. Boom Angle Indicator<br><br>8. Boom Hoist Disconnects | INSPECTION ITEMS |
|---|---|

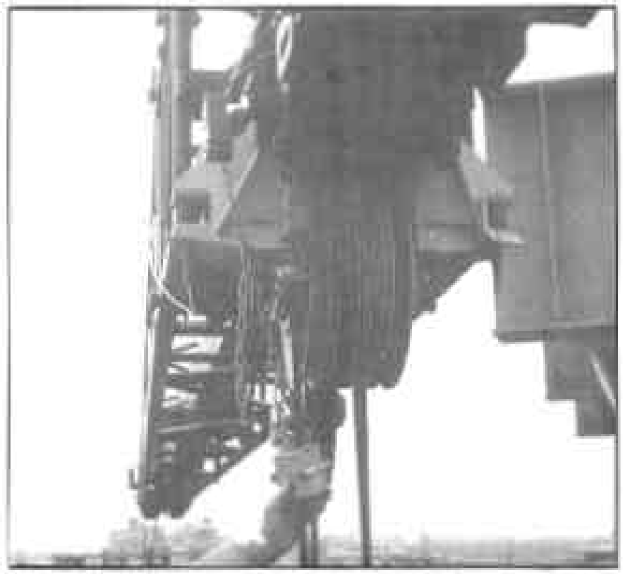
7. Boom Angle Indicators are required to indicate the angle of the boom tip from the base section on a horizontal plane. They may be either mechanical (activated by gravity) or electronic, with a display readout in the cab. Accurate readout of boom angle determines load capacity and working radius.



8. Boom Hoist Disconnects are designed to automatically stop the boom form hoisting when the boom reaches a predetermined high angle.

| 9. Anti-Two Block Devices<br><br>10. Power Controlled lowering | INSPECTION ITEMS |
|---|---|

9. Anti-Two Block Devices are designed to prevent a hoist block and/or load from being hoisted into contact with the boom tip by putting sufficient stress on the wire rope that it is either cut or stressed to the point that the line separates and the load falls onto someone or something. ANSI requires that all hydraulic cranes be equipped with anti-two block devices.



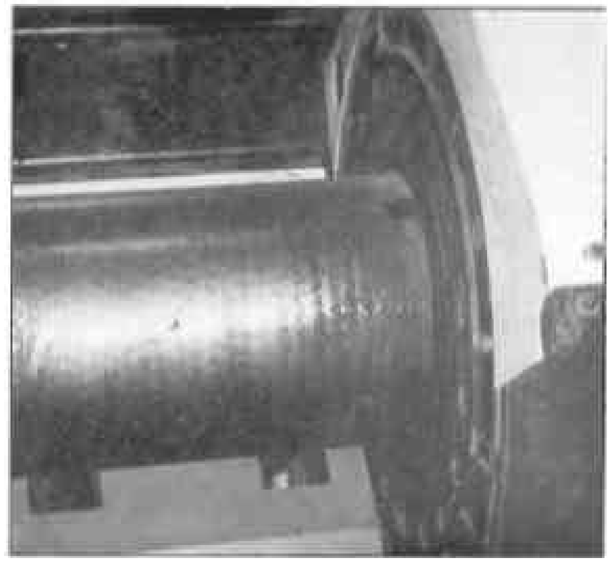
10. All functions of hydraulic cranes feature “power controlled lowering.” Safety devices known as “holding valves” or “counter balance” valves, which prevent uncontrolled decent in the event of hydraulic pressure loss. To test the effectiveness of these safety devices, retract the cylinders or lower the hoist drum with the engine not running. This would apply to the boom lift and extension cylinder as well as the outrigger cylinders and hoist drums. No movement should take place without hydraulic pressure.

11. Leveling of the crane is extremely important. If a crane is out of level more than 1" it exerts a slide load on the crane, and can effect structural capacity. It also can increase the load radius when the crane is rotated to another quadrant of operation.

12. All sheaves should be checked for cracks, grooving, or damage from two-blocking. Undue looseness in the bearing or bushing should be noted. The sheave's groove surface should be smooth and slightly larger than the wire rope being used. It should be checked with a sheave gauge to be sure it is the proper size for the wire rope being used. On most hydraulic cranes, sheave guards which prevent the wire rope form coming off the sheave, are removable pins. Be sure that all of these pins are in place.

| 13. Main hoist and Auxiliary Drums<br><br>14. Main Boom, Jib and Boom Extensions | INSPECTION ITEMS |
|---|---|

13. Drum lagging and flanges should be inspected for cracks or other deficiencies an winch mounting bolts should be checked. Any undue movement of the drum on its bearings should be noted. The wire rope anchoring to the drum should meet the manufacturers specifications and must not be "overspooled." In other words, with the rope fully spooled on the drum, the drum flanges must extend above the top wrap of the rope. Any spoiling devices, such as rollers, or drum rotation indicators, must be functioning properly.



14. All components of the boom assembly should be checked for cracks, bends, or other deformities. On hydraulic cranes, special attention should be given to the topside of the boom where the extension sections exert an upward force. All connecting pins and bolts should be checked. Wear pads should be adjusted properly or replace if necessary.

| 15. Load Hooks and Hook Block<br><br>16. Hydraulic Hoses, Fittings and Tubing | INSPECTION ITEMS |
|---|---|

15. Hooks should be examined to see if they are cracked or distorted beyond allowable tolerances. No welding or heating should be done on hooks. Hooks and blocks should be labeled as to their capacity and weight. Connecting bolts on block cheek plates should be checked. Hook swivels and sheave guards should also be checked.

16. All hydraulic hoses, fittings, swivels, and tubings should be checked for leaking. On flexible hoses, be sure that the working pressure stampled on the hose is more than the working pressure it will be exposed to.

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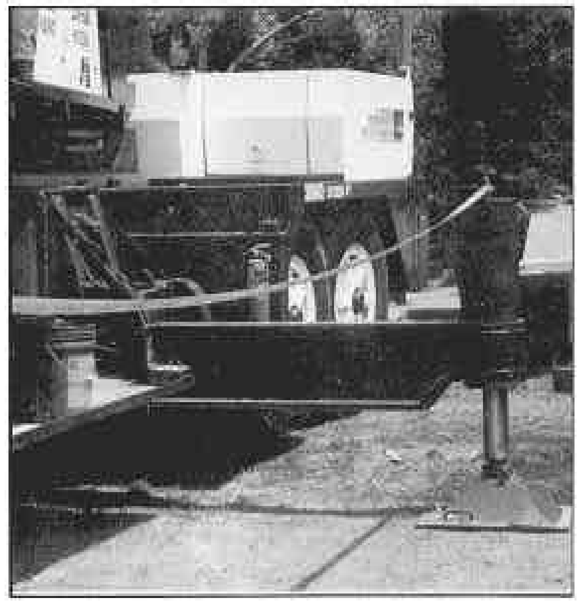
| 17. Outriggers<br><br>18. Load Rating Chart | INSPECTION ITEMS |

17. Outrigger beams and housing should be checked for cracks and distortions. Outrigger floats, or pads, should be checked for damage. The floats must have the capacity to be securely attached to the outriggers. Outrigger beams should be marked to indicate when they are fully extended.



18. A durable load rating chart for the specific model and serial number of the crane shall be accessible to the operator at his operating or work station. All limitations, warnings, specifications and safety data should be displayed.

| 19. Wire rope<br><br>20. Cab | INSTRUCTION ITEMS |
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19. Wire rope should be removed from service when the conditions listed in 29 CFR 1926.550(a)(7) are found. They include outside wire wear, reduction in diameter, broken wires, distortion, corrosion, or heat damage. Special attention should be given to standing rope, such as pendants, at the end fittings. It should be determined that the wire rope is the proper diameter, length, and type of construction for that particular crane and it should be spooled evenly on the hoist drum.

20. The cab should be clean and free from clutter. All controls should be labeled as to their function and free to return to the natural position when released, unless designed to do otherwise. All gauges and warning lights should be operable and a fire extinguisher (at least 5-BC) should be mounted in the cab. The seat should be securely attached and the cab door should open outward and operate smoothly. Electrical and other warning signs should be posted in the cab. All glass must be safety glass with no cracks or distortions.