Chubb Construction Risk Engineering

Crane Management

CHUBB®

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(Updated to include Cranes and Derricks in Construction Subpart CC, Final Rule published August 9, 2010)

Crane Management Fundamentals

Background

[1]Cranes exist in a wide variety of forms - each tailored to a specific use. Sizes range from the smallest jib cranes, used inside workshops, to the tallest tower cranes, used for constructing high buildings, and the largest floating cranes, used to build oilrigs and salvage sunken ships.

Virtually every construction project today relies on cranes in one form or another. They are used to hoist and place structural components and building materials, dredge rivers and lakes and build bridges and dams. It is for these reasons - together with the variations in design, capacity and capability - that cranes are to be revered, respected and fully understood.

According to a revised study from CPWR – The Center for Construction Research and Training in November of 2009: the study identified a total of 632 crane-related construction worker deaths involving 611 crane incidents from 1992-2006 (including 17 multiple deaths incidents causing 38 deaths) compared to a total of 323 deaths in 307 incidents in the previous 2008 study. The revised average is 42 deaths per year. Four main types of cranes have been associated with crane-related fatalities. Of the 611 fatal crane incidents, only 375 were identified from the CFOI record as to type of crane. Of these, 292 (78%) involved mobile or truck cranes. Forty-five of the fatal incidents involved overhead or gantry cranes (12%), 18 involved tower cranes (5%), and 11 involved floating or barge cranes (3%).[2]

The main causes of death were electrocution from overhead power lines, accounting for one-fourth of all crane-related fatalities, the second leading cause was being struck by a crane load, which accounted for 21% of all deaths, struck by cranes or crane parts (20%), crane collapses (14%), falls (9%), and caught in/between crane parts (5%). Seven percent of crane-related fatalities were listed as "other causes."[2]

More construction laborers were killed in crane-related incidents than any other trade, even operating engineers. They experienced 191 crane-related deaths between 1992 and 2006 (30%), followed by 101 deaths of heavy equipment operators (16%) In addition, 86 supervisors/managers/administrators died in crane-related incidents (14%), as did 42 ironworkers (7%), and 41 carpenters (6%). Other trades with fewer numbers of deaths included welders and cutters, electrical workers, mechanics, sheet metal workers, and truck drivers (totaling 27%).[2]

In early 2008, we saw two fatal crane catastrophes, one in New York City and the other less than two weeks later in Orlando, Florida. These two accidents, along with subsequent incidents, resulted in cities across the U.S. immediately shutting down crane operations, mandating new inspections of cranes, reviewing inspection procedures and, in some cases, proposing interim or new crane safety guidelines.

Cranes often are the most valuable single piece of equipment on a construction project, as well as the one piece of equipment that a construction project cannot operate without. It is critical that, if a crane is operating on your job site, you are aware of its fundamental operation, so that it can and will be used properly and safely. It also is critical that qualified professionals be part of the process and that proper training and certification be required. While this guide is a summary of important considerations relating to crane use, no written document is a substitute for proper training, certification and experience. It is essential that education, training and certification be required when cranes are used.

Selection and Use

Experience demonstrates that without review, design and pre-planning of the hoisting operations, together with a qualified crane operator and thorough inspection processes, cranes can be misused and severely abused over the course of a job, a year or lifetime. Unfortunately, the misuse and abuse is not always immediately visible to the operator or even qualified mechanics unless, among other things, routine and thorough inspections occur.

To lessen the potential for misuse and abuse of cranes on your project, selection of the proper type, size and configuration of cranes are essential.

Selection of the Proper Size of Crane: If the crane is too small for the job, not properly configured or within acceptable limits of the appropriate load chart, cranes can become overloaded. In addition, this also creates the possibility for an unstable situation. Unlike cranes of the past, today's cranes are more likely to be unsafe due to overloading and collapsing (catastrophic failure), rather than from tipping (stability failure).

If the crane is oversized for the job, you likely will pay more than necessary to run the larger machine, requirements for transport may be excessive and the risk of transporting a larger crane (on several trucks) over the highway increases risk to the general public. In addition, the location of crane erection and use may be larger and may require

additional resources to prepare and maintain, including an engineer review of adjacent/underground structures to prevent foundation or other damages due to surcharging (placing too great a load on something) of the surrounding area. These issues, if the larger crane was not necessary, are costly, time consuming and require additional coordination and effort, all of which affect safety, liability and production.

Standards, Regulations, Operators Manuals & Manufacturer Recommendations

With any piece of equipment or machinery, there is the potential for personal injury or property damage due in part to improper maintenance or misuse. This is even more relevant when referring to cranes, due to their size, handling capacity and potential for catastrophic loss. Those who are tasked with operating the cranes, rigging the loads and crane oversight must understand the correct way in which these pieces of equipment should be operated and maintained. There are several references that provide guidance in these areas.

OSHA

The Occupational Safety and Health Administration (OSHA) regulation that provides the Federal standard for safe crane operations is, as of August 9, 2010, 29 C.F.R. §1926.1400 (Subpart CC) Cranes and Derricks In Construction. OSHA provides guidance that specifically addresses a number of issues and incorporates certain industry standards by reference into the regulation. The employer is required to follow those standards, practices and references and, if found in violation, can be cited.

To supplement the OSHA standards, other regulations or standards, in whole or in part, are incorporated into the OSHA standard. These include such ASME/ANSI and PCSA standards as: The ASME/ANSI "B30" series of standards which address: "Cranes", "Cableways", "Derricks", "Hoists", "Hooks", "Jacks" and "Slings", ASME/ANSI B30.5, "Mobile and Locomotive Cranes", and the Power Crane Shovel Association (PCSA), Standard No. 2, "Mobile Hydraulic Crane Standards."

ANSI

[3]Founded in 1918, the American National Standards Institute (ANSI) is a private non-profit organization that oversees the development of voluntary consensus standards for products, services, processes, systems and personnel in the United States. The organization also coordinates U.S. standards with international standards so that American products can be used worldwide. The ANSI is one of those organizations whose standards OSHA has “incorporated by reference” in some instances.

Examples of ANSI Standards referenced by OSHA in Subpart CC are:

- ANSI A10.5-1969, Safety Requirements for Material Hoists
- ANSI A10.4-1963, Safety Requirements for Workmen’s Hoists
- ANSI A92.2-1969, Vehicle Mounted Elevating and Rotating Work Platforms
- ANSI A17.1-1965, Elevators, Dumbwaiters, Escalators, and Moving Walks

Manufacturers Recommendations and Equipment Operators Manuals

It is important to comply with the manufacturer’s specifications and limitations for the specific crane operated. Although unlikely to be the case, if manufacturer procedures are unavailable, the employer must:

- Develop and ensure compliance with all procedures necessary for the safe operation of the equipment and attachments
- Develop procedures for the operational controls; these must be developed by a qualified person
- Procedures related to the capacity of the equipment must be developed and signed by a registered professional engineer familiar with the equipment
- Once the engineer has made such determinations, all determinations need to be documented
- All capacities, speeds, warnings and instructions should be posted in view of the operator seated in the cab

If there are no specifications available for the crane to be used, the crane should not be placed into service until the above, at a minimum, are complied with.

Liability Considerations

Self-performing or subcontracting hoisting operations?

Does the contractor subcontract the crane operations in lieu of performing the work itself? If so, the General Contractor (GC) or any other tier contractor who does so needs to ensure the hired contractor is performing those crane operations properly and safely.

Accidents that occur resulting from subcontractor's activity can result in potential third party claims against the hiring and/or General Contractor. In states such as New York, the labor law states that the GC has a duty to supply a safe work place that cannot be delegated. In this case, a subcontractor's employee injured on the job site cannot sue his/her employer since they are covered by workers compensation, but they do have the ability to sue the GC. Accidents resulting from the actions of a subcontractor become general liability claims, which can become quite costly and result in an economic hardship for the GC.

It is important that the hiring contractor take the necessary steps to properly protect itself against this exposure.

Risk Transfer Contract Wording
Risk managers should consult with their legal counsel to adopt proper risk transfer language for inclusion in the contracts that General Contractors exercise with their subcontractors. This form of agreement is known as a "hold harmless" or indemnity agreement. In such an agreement, one party promises to reimburse the other against claims or suits brought by a third party. Properly written hold harmless and indemnity agreements could provide the GC the right to collect from the subcontractor's action.

It is important for contractors to obtain their own legal advice concerning their liability exposure and contracts. It is prudent for a contractor to have a contract reviewed by an attorney before signing it.

From a risk control prospective, prudent contract wording does not prevent an accident, and a contractor may wish to drill down to the root of the claim. Questions that a contractor may wish to address proactively are, "Why did the actions of the subcontractor that resulted in a claim occur in the first place?" "Where was the break down in safety that resulted in the accident and did it occur because the subcontractor's lack of attention to detail or safety?"

Leased or Rented Cranes and Operators?
If the crane is leased, is this done via a signed contract or purchase order? If cranes are leased, is the crane leasing company supplying the crane operator or is the contractor required to hire its own to operate the crane? In certain locations, it is common practice that a crane leasing company leases its cranes bare, meaning no operator is sent along with the crane. To be sure, the risk transfer language used is appropriately, the contractor should use the services of an attorney who specializes in construction contract language to review its contracts on a regular basis.

Use of the Crane by Other Contractors
If the contractor is supplying the cranes on its projects, does the contractor have a company policy that forbids this crane to perform any work/picks for other contractors on that site? Too often, a contractor with a crane is asked to do a favor for another contractor on site who may need to have a piece of equipment or material moved. The contractor may, as a professional courtesy, do the favor. Unfortunately, if an accident results, the contractor now is involved in a possible claim and resulting liability.

If the crane will be utilized to perform work for other contractors, it is important to have proper procedures and protocols to address the potential exposures and safe guard the contractor responsible for the crane from potential liability.

Transporting the Crane
Transportation of the crane and its components needs to be considered when pre-planning crane operations. Depending on the size and type of crane, additional measures to transport the crane safely may be necessary.

Some cranes, such as Rough Terrain and Truck, may be transported to a job site on a highway, which creates risks and which needs to be accomplished with great care to ensure that the general public also utilizing the highway is not placed at risk. Some risks during transport are due to the oversized superstructure, which limits maneuverability of the crane or other vehicles, or to protruding/unsecured components or accessories that can fall loose onto the highway or impact vehicles as the crane, is passing. Risk during transport also can be due to poor maintenance, which causes the crane to operate unsafely, or to error due to using unqualified operators.

Additional concerns when driving cranes on the highway are dirt and debris falling from the crane, operating the crane on unimproved or weight-restricted roadways, damage to private or public property, and impact to overhead structures too low for the crane.

Crawler and Tower Cranes are too large to transport in one piece or on one truck. Therefore, they need to be transported in several pieces to the project using several trucks and trailers. Considerations must be made for appropriate vehicles to transport the crane sections. All the considerations mentioned in the last three paragraphs apply here, as well as ensuring the transportation company (or company owned drivers) has experience, the appropriate permits and proper insurance coverage in place to protect the contractor from any injuries or damages that may occur while the crane is being transported.

Not all highways or rural, suburban and urban streets are the same. Bridges or other culvert type structures may or may not be capable of sustaining the weight of the crane being driven or transported across them. Depending on the location of the project, access into and out of the site may be restricted. To ensure that the general public and property is safeguarded and the crane is safely transported to the sited where and when needed, all routes being used to transport the crane must be pre-planned.

The following are some considerations to keep in mind when pre-planning: determine and use the most direct route and safest access onto the job site to minimize risk to the public; verify that the highways and other roadways to be used are safe and acceptable for the size and type of crane, and check beforehand for active construction zones or other road closures. Depending on the jurisdiction and applicable laws and law enforcement, authorized Vehicle Escort Services and/or warning/safety devices may be required.

Employee and Public Protection

Struck-by and caught between - these accidents continue to be a leading cause of loss for construction workers and can affect the general public who are in close proximity of the crane. Crane operations present specific hazards that can place workers and the general public in harms way.

One way to lessen the potential for struck-by and caught between accidents is to protect the swing radius of the crane. The swing radius of the counterweight needs to be established and guarded to prevent persons or other equipment from being struck by the counterweight. Special attention needs to be given to guarding the swing radius when near buildings or other structures.

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

All employees and the general public need to be kept clear of loads about to be lifted and of suspended loads. Preplanning and coordination of hoisting operations should identify those locations where personnel/public are working and subject to overhead loads. To help remove and protect workers and the public from the suspended loads path, hoisting operations should be coordinated and protocols, warning systems or other means used to protect those affected must be established.

To prevent the load block from contacting the tip of the boom, which in turn can result in the hoist line pulling out and releasing the load (two-blocking), a positive acting device is recommended, which prevents contact between the load block or overhaul ball and the boom tip (anti-two-blocking device), or a system may be used that deactivates the hoisting action before damage occurs in the event of a twoblocking situation (two-block damage prevention feature).

Cranes with telescoping booms should be equipped with a two-blocking damage prevention feature that has been tested on-site in accordance with manufacturer's requirements. All cranes' hydraulic and fixed boom used to hoist personnel need to 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.

Height Concerns and FAA Requirements

A somewhat less obvious but important aspect to consider when pre-planning your crane operations is whether or not the crane when erected will pose a danger to aircraft. Local airports and private runways that operate near by, hospital heliports for emergency victim transport, police, fire, news and corporate aircraft such as helicopters all may fly in and around the project area. If they are not informed of the location of the crane prior to planning and registering their flight plans or the crane is not visible (appropriate lights or markings), these aircraft run the risk of inadvertently striking the crane.

As cranes are erected during the construction operation, they can reach great heights. Just as with tall buildings, communication towers, smoke stacks and power lines, depending on their relative distance to airport runways or other air traffic routes, they may be required to file a "Notice of Proposed Construction or Alteration" with the Federal Aviation Administration (FAA). In addition to the filing, it may be required that the crane be marked with high visibility (specialty) flags and/or lighting or be required to boom down at night. This is true for all types of cranes.

This consideration should be incorporated into the pre-planning process for your crane operations. Some of the information that will be required to complete "Notice of Proposed Construction or Alteration" form is the following: surveyed coordinates of the cranes location(s), dates of the construction, site elevation, total structure height, type of structure (crane, tower, etc.), sponsor/contractor and contact information and description of the proposal.

Engineering and Design

Once the crane is selected and the location of the hoisting area has been determined, a professional engineer's review should be conducted. Some of the things that the engineer may consider are: support base (if applicable), erection and hoisting locations, material lay down locations, underground utilities, overhead power lines, ground soil conditions, excavations (current or future), adjacent structures or any other locations (transportation routes within the project) where the weight and placement of the crane or its components may impact the structural integrity of those locations. New building foundations, for example, are exposed to the weight and vibrations due to un-compacted backfill surrounding them.

This review by a professional engineer is necessary to verify that the locations selected for the crane operations are appropriate and capable of supporting the weight of the crane, of materials to be hoisted and of equipment to transport and erect the crane without surcharging (placing too great a load on something) those locations, causing damage to them.

If there is the potential for such damage, the contractor should reevaluate the selected locations. The contractor may decide to choose new locations or plan for, design and have constructed any necessary support or protection for those locations to prevent damage.

Operators Qualifications

Are the crane operators licensed or certified to operate the specific crane to which they are assigned? What are the criteria used to verify the qualifications of those operators? These two questions are essential to ensure only qualified and properly designated personnel operate the crane.

The newly published Subpart CC, Cranes and Derricks in Construction specifically outlines Operator qualification and training criteria. Compliance for State or local government licensing is effective November 8, 2010 and all other certification and qualification is effective November 10, 2014.

There are (4) basic options in which an Operator can become Qualified:

- **Option 1:** Accredited Testing Organization - There are different tests for different capacity/types of equipment, the Operator Qualification and Certification are portable and valid for (5) years.
- **Option 2:** Employer Qualification Program - The Employer administers the written & practical tests. The Operator Qualification and Certification is valid for (5) years however, it is **NOT** portable.
- **Option 3:** U.S. Military - The US Military issues the operator qualification. Duration of valid Operator Qualification and Certification is set by the issuing entity and is **NOT** portable.
- **Option 4:** State/Local Government License - The State/local licensing office issues the operator's license. Operator qualification and certification is valid only in the entity's jurisdiction and duration is set by the issuing entity, but not to exceed 5 years.

Load Charts

What are they?
Load charts are manufacturer's guidelines and requirements developed for each specific model of crane. Load charts will outline information related to set up, operation, limitations, and provide instructions. Load charts should be used and followed when calculating the rated load handling capacities for a specific crane.

Why are they important?
The operator must be aware of the available capacity of the crane being used. This can vary greatly depending on the configuration of the crane.

Considerations when calculating the crane's load capacity include the following:

- Load radius (center of cranes rotation to the centerline of vertical hoist line)
- Boom length including jib extension
- Levelness of the crane
- Ground stability
- If crane is equipped with outriggers, will they be fully extended or retracted in order to determine if the "on outrigger" or "on rubber" load chart is to be utilized.
- Permissible line pull
- Permissible lifting area diagram (quadrants)
- Proper precautions shall be taken when the velocity of wind exceeds 20-mph
- Weight consideration such as hook blocks, jibs, headache balls and rigging
- Weight of load to be hoisted

Understanding Load Charts:
Manufacturer load charts are divided into two segments, structural strength and stability. Structural strength is defined as the capacity of the individual elements, which together make up a structural system, to withstand the load that is applied to it. Stability means the ability of a crane to resist tipping.

Leveling of the Crane: Cranes are designed to be operated while in a level position. Leveling of the crane is extremely important. If a crane is out of level more than 1 degree, it exerts a side load on the crane and can affect structural capacity. It also can increase the load radius when the crane is rotated to another quadrant of operation. Being "off-level" even a few degrees can significantly reduce a crane's capacity. At minimum, the crane should be checked for level upon initial set up and each time the crane is moved to a new location for hoisting.

Typically, load charts use a bold black line to segregate the structural portion of the chart from the stability portion. This demarcation enables the crane operator to identify which capacities are restricted to structural strength and which ones restricted to stability. Ratings above the bold line are based on structural strength, while ratings below the bold line are based on the stability of the crane.

The importance of understanding this is that if you are in the structural portion of the load chart and you overload the crane, the possibility of a structural or mechanical element of the crane to fail can occur. If you are within the stability portion of the load chart and you overload the crane the possibility of the crane over turning or tipping can occur.

Lifting Area: The working or lifting areas of a crane are defined as over the side, over the rear, over the top and 360 degrees. It is essential that the operator understands - for the particular crane being operated - the crane's rated capacity within those quadrants.

Outriggers: In order to ensure that a crane will operate at its optimum, it is essential that consideration of the ground stability around the area where the crane will be set up and working be established.

Most mobile cranes are equipped with outriggers. Outriggers are provided on mobile cranes to expand the crane's capacity and provide stability. If a crane is equipped with outriggers, manufactures strongly recommend that these outriggers be used on every lift regardless of the weight of the load. The outriggers provide a more stable base then do the tires of the crane. Unfortunately, many mobile crane accidents occur due to lack or improper use of outriggers. In order to achieve the optimum result when outriggers are in use, the outriggers must be fully extended. If they are not fully extended the rated capacity is reduced. Most mobile crane load charts have "on rubber" and "on outrigger" charts. If the outriggers are not fully deployed you must check with the crane manufacture requirements to determine if the "on rubber" chart must be utilized.

The outriggers must be set to remove the equipment weight from the wheels. When outrigger floats are used, they must be attached to the outriggers. When stabilizer floats are used, they must be attached to the stabilizers. Each outrigger or stabilizer must be visible to the operator or to a signal person during extension and setting.

Crane load charts rated load capacity is based on the crane operating under ideal conditions, including the crane being assembled level on a firm supporting surface. The ground bearing pressure generated by a crane on outriggers can be very high, with the possibility that most of the crane's load can be transmitted to one of the outriggers. Considering the ground conditions on many construction sites, this entire load being applied to one outrigger can cause that outrigger to sink into the ground, thus throwing the crane out of level. To displace this load over a greater area, it is strongly recommended that cribbing be placed beneath each of the outrigger pads.

Inspection and Maintenance

Before operations begin and then periodically, inspections need to be conducted to ensure that the machine is in proper working condition. 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.

A Competent Person must be designated to inspect all machinery/equipment prior to and during use. Any deficiency shall be repaired and / or any defective parts replaced before continued use. In addition to the performance of 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. Intervals are:

- **Each Shift:** 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. Taking apart equipment components and booming down is not required as part of this inspection unless the results of the visual inspection or trial operation indicate that further investigation necessitates taking apart equipment components or booming down.
- **Monthly:** Periodic inspections are intended to determine the need for repair or replacement of components to keep the machine in proper operating condition. This includes items listed for daily inspections as well as, but not limited to, structural defects, excessive wear, and hydraulic or air leaks.
- **Annual / Comprehensive:** Completed at least every 12 months and the equipment must be inspected by a qualified person. To complete the annual, disassembly is required as necessary. This inspection includes functional testing to determine that the equipment, as configured in the inspection, is functioning properly. If the qualified person determines that a deficiency is a safety hazard, the equipment must be taken out of service until it has been corrected, except when temporary alternative measures are implemented.
- **Severe Service:** A great deal of hoisting, erection and dismantling, transportation and misuse/abuse can occur to a crane over a period of a year. Relying on only the annual inspection may not be enough. Depending on the date of the last annual inspection and any monthly inspections since, the contractor should consider requiring a more recent inspection be performed before the crane is brought on site and put into service.

- **Inspection records:** The employer shall maintain a record of the dates and results of inspections for each hoisting machine and piece of equipment for future reference. These inspection records should be kept readily available for review. 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. The manufacturer's maintenance and inspection records, forms/checklist, or equivalent should be used.
  - The Monthly Inspection documentation is required to be maintained for at least 3 months
  - The Annual Inspection documentation must be maintained for at least 12 months.

What documentation is required of the crane rental/leasing company or the subcontractor that brings the crane on site for use, to show that the crane is in proper working order and safe for operation? If an annual inspection is all that is required for verification, what is the date of the last annual inspection?

Equipment Modification and/or Repair
Each and every component that makes up a crane is engineered and designed to work in sync with all other components. Each time an individual or group of components is modified, there is the potential for the structural integrity, capacity and/or safety of the crane to be affected, with potentially catastrophic results.

No modifications or additions, which affect the capacity or safe operation of the equipment, shall be made by the employer without the manufacturer's written approval.

Equipment that has had modifications or additions, which affect the safe operation of the equipment, must be inspected by a qualified person after such modifications/ additions have been completed, prior to initial use. Modifications or additions, which affect the capacity or safe operation of the equipment, are prohibited except where:

- The manufacturer approves the modifications/additions in writing, the load charts, procedures, instruction manuals and instruction plates/tags/ decals are modified as necessary to accord with the modification/addition and the original safety factor of the equipment is not reduced.
- The manufacturer is provided a detailed description of the proposed modification/addition, is asked to approve the modification/addition, but declines
- The manufacturer is unavailable
- The manufacturer is provided a detailed description of the proposed modification/addition, is asked to approve the modification/ addition, agrees to review the technical merits of the proposal, but fails to complete the review of the proposal within 120 days of the date it was provided

Signaling and Communication

There are different types of communication that can be used when directing a crane operation: Signal Types are hand, voice, audible or “new”.

A Signal Person is required when the point of operation is not in full view of operator, view of direction of travel is obstructed and / or site-specific safety concerns dictate. The **ONLY** time an operator can use a cell phone while lifting is when the cell phone is used for communication/signaling.

Signal Person qualification requirements:
- They must know and understand the signals
- Be competent in using those signals
- Have a basic understanding of crane operation(s)
- Pass a verbal or written test and practical test

They must be qualified by either a Third Party Qualified Evaluator or Employer Qualified Evaluator. Both must be documented but **ONLY** the qualification by the Third Party Qualified Evaluator is portable.

Considerations: The designated signal person should be visible to the operator at all times. The operator should only respond to signals from the designated signal person, except when being told to stop the crane as when an emergency may have arisen. If more than one person is giving signals to the operator, he/she should halt any further operations until only one designated signal person is determined. The signals given should be clear and crisp. The operator should not have to guess at what the signal is.

There may be times when the load being placed is out of the view of the operator. In these cases, a communication plan and procedures addressing this situation should be written and reviewed with those personnel involved in the operation before it begins.

Training

Employers need to instruct employees in the recognition and avoidance of unsafe conditions in the work environment, and to control exposure to hazards.

Crane operators and personnel working with cranes need to be knowledgeable about basic crane capacities, limitations, specific job site restrictions (such as location of overhead electric power lines, unstable soil, or high wind conditions) and other safety parameters, including all of the issues set out in this guide.

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. Even those workers walking past a crane on their way to lunch need to be aware of and able to avoid being struck by or caught between it and other structures or objects.

Mobile Crane Management

Types

Truck

[1]A crane mounted on a truck carrier provides the mobility for this type of crane. Generally, these cranes are designed to be able to travel on streets and highways, eliminating the need for special equipment to transport a crane to the jobsite. When working on the jobsite, outriggers are extended horizontally from the chassis and then down vertically, to level and stabilize the crane while stationary and hoisting. Factory-calculated charts (or electronic safeguards) are used by the crane operator to determine the maximum safe loads for stationary (outriggers) work as well as (on-rubber) loads and traveling speeds.

Boom Truck

[1]A loader crane (also called a knuckle-boom crane) is an hydraulically powered articulated arm fitted to a truck or trailer, and is used for loading/unloading the vehicle. The numerous jointed sections can be folded into a small space when the crane is not in use. One or more of the sections may be telescopic.

Often the crane will have a degree of automation and be able to unload or stow itself without an operator's instruction. Unlike most cranes, the operator must move around the vehicle to be able to view his load; hence, modern cranes may be fitted with a portable cabled or radio-linked control system to supplement the crane-mounted hydraulic control levers.

Rough Terrain

[1]A crane mounted on an undercarriage with four rubber tires that is designed for pick-and-carry operations and for off-road and "rough terrain" applications. Outriggers that extend horizontally and vertically are used to level and stabilize the crane for hoisting. These telescopic cranes are single-engine machines where the same engine is used both for powering the undercarriage and for powering the crane, similar to a crawler crane. In a rough terrain crane, however, the engine is usually mounted in the undercarriage rather than in the upper, like the crawler crane.

Crawler

[1]A crawler is a crane mounted on an undercarriage with a set of tracks that provide for the stability and mobility of the crane. Crawler cranes have both advantages and disadvantages depending on their intended use. The main advantage of a crawler is that it can move on site and perform lifts with very little set-up, as the crane is stable on its tracks with no outriggers. In addition, a crawler crane is capable of traveling with a load. The main disadvantage of a crawler crane is that it is very heavy, and cannot easily be moved from one job site to the next without significant expense. Typically, a large crawler must be disassembled and transported by trucks, rail cars or ships to its next location.

Coordination, Supervision and Engineering/Calculating Picks

Due to ever-changing job site conditions, changes to lift plans and in locations in which cranes are expected operate, it is necessary that the project staff responsible for crane operations be capable of identifying those times when re-assessing a crane's position, configuration and load calculations is necessary to ensure continued safe operations.

The most critical procedure in any hoisting operation involves determining the weight of the load being hoisted. In addition, the boom length and working radius must be determined, along with the weight of the load, in order to properly utilize the crane's load chart to verify the pick can be safely executed. A note common on many load charts is that the rated loads take into account the weight of the hook blocks, rigging equipment and auxiliary lifting devices and this additional weight must be accounted for when determining the overall weight the crane is being asked to hoist. Always remember to refer to the notes for lifting capacities contained in the manufacturer's load chart prior to making a lift.

The weight of the load must be determined from a source recognized by the industry (such as the load's manufacturer) or by a calculation method recognized by the industry (such as calculating a steel beam from measured dimensions and a known per foot weight). This information must be provided to the operator prior to the lift.

Calculating/configuring the pick should occur:

- Prior to each pick and
- When requested by the operator
- Whenever a "Critical" pick will be made
- If the load will exceed 75 percent of the maximum rated capacity at the longest radius that will be used during the lift operation.
- If two or more cranes will be used to make the pick
- Each time the crane is moved to a new hoisting location or configuration changes
- When the load (material, weight) changes
- If weather conditions such as winds, rain, ice and snow arise, all of which can affect the crane's capacity
- Whenever any other condition arises that may require the operator to recalculate the load, reassess the load chart and/or the configuration.

Site Considerations

Proper Access to Site

With the many types of cranes (crawler, rough-terrain, truck) that may be used on a construction project, which crane is used may determine appropriate access points. Smaller cranes may not have any issues turning into a site access gate off narrow streets or other locations limited in size. Larger machines such as crawlers (which are transported on trailers) and truck cranes may need to have access locations that are designed specifically for them. Take into consideration the need for:

- Larger size gates or access openings
- Access that can be easily maneuvered through (no sharp corners or turns) from street and roads
- Overhead obstructions such as power lines or other structures may need to be relocated
- If accessing from an active roadway, traffic control warnings, devices and flagmen to safeguard the public may be needed

Once in the gate, additional measures should be taken to assure that the route the crane must take to the erection or hoisting area is safe, not only for the machine and operator but for all other site employees as well. The site route should be evaluated and prepared so it can adequately support the weight of the crane, be wide enough, clear any equipment or vehicles that may interfere and safeguard personnel.

Surface Conditions and Stability
The Assembly / Disassembly (A/D) director supervising the assembly/ disassembly operation must address the hazards associated with the operation, such as site and ground bearing conditions. Site and ground conditions must be adequate for safe assembly/ disassembly operations and to support the equipment during assembly/disassembly.

The Controlling Entity must provide adequate conditions, which includes; firm, drained and graded surface that is sufficient to support the crane (in conjunction with blocking, mats, etc.) and must inform the user and equipment operator of known underground hazards (voids, utilities, etc.)

[1]Stability is affected by the magnitude of the load that is permitted to be lifted (rated load). Under U.S. standards for mobile cranes, the stability-limited rated load for a crawler crane is 75 percent of the tipping load. The stability-limited rated load for a mobile crane supported on outriggers is 85 percent of the tipping load. Standards for cranes mounted on ships or offshore platforms are somewhat stricter given the dynamic load on the crane due to vessel motion. Additionally, the stability of the vessel or platform must be considered.

In order for a crane to be stable, the surface in which it sits must be capable of supporting its weight, as well as the forces applied when the crane is moved from one location to another. The crane's capacity cannot be exceeded or there is the potential for the crane to tip over.

A sufficient, level and well-drained support surface must be provided for the crane to operate. In addition, if the outriggers are to be used, additional support (cribbing) will be needed to keep the outriggers from sinking into the ground under the weight of the crane and loads. A rule of thumb for cribbing is to take the cranes capacity in tons divided by five = sq ft for each outrigger pad; this is for typical soil: Less supportive soils such as sand or wet soil may need more surface area. In those cases, an engineer's review of the soil conditions will help determine this requirement.

Remember, as mentioned in the discussion relating to load charts, if the crane is used with the outriggers extended per the manufacturers guidelines, the appropriate load chart must be used. The operator must verify that the position of the outriggers or stabilizers is correct (in accordance with manufacturer procedures) before beginning operations requiring outrigger or stabilizer deployment.

For example, Grove, a leading crane manufacture, has outrigger configurations that range from 0 degrees, 50 degrees and fully extended, with specific load charts for each.

Mobile cranes mounted on barges pose their own safety concerns. When mobile cranes are used on barges, they shall be positively secured. The rated load of the crane shall not exceed the original capacity specified by the manufacturer. When load ratings are reduced to stay within the limits for list of the barge with a crane mounted on it, a new load-rating chart shall be provided.

[1]Many truck cranes possess limited slow-traveling capability (just a few miles per hour) while suspending a load. Great care must be taken not to swing the load sideways from the direction of travel, as most of the anti-tipping stability then lies in the strength and stiffness of the chassis suspension. Most cranes of these types also have moving counterweights for stabilization beyond that of the outriggers. Loads suspended directly over the rear remain more stable, as most of the weight of the truck crane itself then acts as a counterweight to the load.

Overhead Power Lines
Coming into contact with overhead power lines is an all-too-common occurrence with crane operations. Operators or ground crews are not aware of the lines' correct voltages and therefore safe minimal distances, the crane is set up too close to the power lines or, during operations, the crane is maneuvered from a safe distance into an unsafe distance and arching or a direct strike occurs. It is important to know that the new Cranes and Derricks in Construction standard provides additional requirements regarding this exposure.

For Lines Up to 350kV – Before beginning equipment operations, the employer must identify the work zone; this can be accomplished in a number of ways. By demarcating boundaries (such as with flags or a device such as a range limit device or range control-warning device) prohibiting the operator from operating past those boundaries, defining the work zone as the area 360 degrees around the equipment, up to the equipment's maximum working radius or determining if any part of the equipment, load line or load (including rigging and lifting accessories), if operated up to the equipment's maximum working radius in the work zone, could get closer than 20 feet to a power line **(50 feet if over 350kV).**

If the crane could get closer then 20 feet to a power line (50 feet if over 350kV) the employer must comply with one of three options:

- **Option (1)** - De-energize and ground. Confirm from the utility owner/ operator that the power line has been de-energized and visibly grounded at the worksite.
- **Option (2)** - 20 foot clearance (50 feet if over 350kV). Ensure that no part of the equipment, load line or load (including rigging and lifting accessories), gets closer than 20 feet to the power line (50 feet if over 350kV) by implementing specified encroachment/ electrocution measures.
- **Option (3)** - Table A clearance. Determine the line's voltage and the minimum clearance distance permitted under Table A. Determine if any part of the equipment, load line, or load (including rigging and lifting accessories), could get closer than the minimum clearance distance to the power line permitted under Table A and, if so, then you must follow the requirements to ensure that no part of the equipment, load line, or load (including rigging and lifting accessories), gets closer to the line than the minimum clearance distance.

Preventing Encroachment/ Electrocution

Where encroachment precautions are required under Option (2) or Option (3), all of the following requirements must be met:

- Conduct a planning meeting with the operator and the other workers who will be in the area of the equipment or load to review the location of the power line(s), and the steps that will be implemented to prevent encroachment/electrocution.
- If tag lines are used, they must be non-conductive.
- Erect and maintain an elevated warning line, barricade, or line of signs, in view of the operator, equipped with flags or similar high-visibility markings, at 20 feet from the power line (50 feet if over 350kV), (if using Option (2) of this section) or at the minimum approach distance under Table A.
- If the operator is unable to see the elevated warning line, a dedicated spotter must be used as described, in addition to implementing specified measures.
- Implement at least one of the following measures:
- A proximity alarm set to give the operator sufficient warning to prevent encroachment.
- A dedicated spotter who is in continuous contact with the operator. Where this measure isselected, the dedicated spotter must:
  - Be equipped with a visual aid to assist in identifying the minimum clearancedistance.
  - Be positioned to effectively gauge the clearance distance.
  - Where necessary, use equipment that enables the dedicatedspotter to communicate directly with the operator.
  - Give timely information to the operator so that the required clearance distancecan be maintained.
- A device that automatically warns the operator when to stop movement, such as a range control warning device. Such a device must be set to give the operator sufficient warning to prevent encroachment.
- A device that automatically limits range of movement, set to prevent encroachment.
- An insulating link/device, installed at a point between the end of the load line (or below) and the load.

Table A - Minimum Clearance Distances

Voltage (nominal, kV, alternating current)		Minimum clearance distance (feet)
Up to	50 kV	10
Over	50 kV to 200 kV	15
Over	200 kV to 350 kV	20
Over	350 kV to 500 kV	25
Over	500 kV to 750 kV	*35*
Over	750 kV to 1,000 kV	45
Over	1,000 kV	(as established by the utility owner/ operator or registered professional engineer who is a qualified person with respect to electrical power transmission and distribution)

For Lines Over 350kV – The requirements for voltages up to 350kV apply except that:

- For power lines at or below 1000 kV (350kV up to 1000kV), wherever the distance **"20 feet"** is specified, the distance of **"50 feet"** must be substituted **(see Table A above)** and
- For power lines over 1000 kV, the minimum clearance distance must be established by the utility owner/operator or registered professional engineer, who is a qualified person with respect to electrical power transmission and distribution.

It must be assumed that all power lines are energized unless the utility owner/operator confirms that the power line has been and continues to be de-energized and visibly grounded at the worksite.

When it is difficult for the operator to maintain proper clearance by visible means, a dedicated spotter, who is in continuous contact with the operator, shall be assigned to observe the clearance of the crane. This spotter will be in communication with the operator and can give timely warning to halt operation of the crane when it has reached an unsafe working clearance to the overhead power lines.

Fall Protection on Mobile Cranes

For non-assembly/disassembly work, the employer must provide and ensure the use of fall protection equipment for employees who are on a walking/working surface with an unprotected side or edge more than 6 feet above a lower level:

- When moving point-to-point:
- On non-lattice booms (whether horizontal or not horizontal).
- On lattice booms that are not horizontal.
- On horizontal lattice booms where the fall distance is 15 feet or more.
- While at a workstation on any part of the equipment (including the boom, of any type), except when the employee is at or near draw-works (when the equipment is running), in the cab, or on the deck.

For assembly/disassembly work, the employer must provide and ensure the use of fall protection equipment for employees who are on a walking/working surface with an unprotected side or edge more than 15 feet above a lower level, except when the employee is at or near draw-works (when the equipment is running), in the cab, or on the deck.

Assembly and Disassembly

Crane Assembly/disassembly must be directed by a person who meets the criteria for both a competent person and a qualified person, or by a competent person who is assisted by one or more qualified persons ("A/D director").

Where the assembly/disassembly are being performed by only one person, that person must meet the criteria for both a competent person and a qualified person. The A/D director must understand the applicable assembly/disassembly procedures. The A/D director must also review the applicable assembly/disassembly procedures immediately prior to the commencement of assembly/disassembly, unless the A/D director understands the procedures and has applied them to the same type and configuration of equipment (including accessories, if any) and before commencing assembly/disassembly operations. The A/D director must ensure that the crewmembers understand all of the following: their tasks, the hazards associated with their tasks and the hazardous positions/locations that they need to avoid.

Not following recommended procedures for assemble and disassembly of a crane can lead to very serious injuries and damage to the crane or other equipment used to perform the job. When using employer procedures, instead of manufacturer procedures, for assembly/disassembly, the employer must ensure that the procedures: Prevent unintended dangerous movement, and prevent collapse, of any part of the equipment, provide adequate support and stability of all parts of the equipment, position employees involved in the assembly/disassembly operation so that their exposure to unintended movement or collapse of part or all of the equipment is minimized. In addition, employer procedures must be developed by a qualified person.

Assembly/disassembly below power lines is prohibited. No part of a crane/derrick, load line, or load (including rigging and lifting accessories), whether partially or fully assembled, is allowed below a power line unless the employer has confirmed that the utility owner/operator has de-energized and (at the worksite) visibly grounded the power line.

Upon completion of assembly, the equipment must be inspected by a qualified person to assure that it is configured in accordance with manufacturer equipment criteria. Where manufacturer equipment criteria are unavailable, a qualified person must:

- Determine if a registered professional engineer (RPE) familiar with the type of equipment involved is needed to develop criteria for the equipment configuration.
- If an RPE is not needed, the employer must ensure that the criteria are developed by the qualified person.
- If an RPE is needed, the employer must ensure that they are developed by an RPE.
- Equipment must not be used until an inspection demonstrates that the equipment is configured in accordance with the applicable criteria.

Inspection and Maintenance

Manufacturer's operating and maintenance manuals shall accompany all mobile hoisting equipment. These manuals set forth specific inspection, operation and maintenance criteria for each mobile crane and lifting capacity.

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

Tower Crane Management

Types

[1]The Tower crane is a modern form of a balance crane. Fixed to the ground (or "jacked up" and supported by the structure as the structure is being built), tower cranes often give the best combination of height and lifting capacity and are used in the construction of tall buildings. To save space and to provide stability, the vertical part of the crane is often braced onto the completed structure, which is normally the concrete lift shaft in the center of the building. A horizontal boom is balanced asymmetrically across the top of the tower. Its short arm carries a counterweight of concrete blocks, and its long arm carries the lifting gear. The crane operator either sits in a cabin at the top of the tower or controls the crane by radio remote control from the ground, usually standing near the load. In the first case, the operator's cabin is located at the top of the tower just below the horizontal boom. The boom is mounted on a slewing bearing and is rotated by means of a slewing motor. The lifting hook is operated by a system of sheaves.

[1]Hammerhead, or giant cantilever, is a fixed-jib crane consisting of a steel-braced tower on which revolves a large, horizontal, double cantilever; the forward part of this cantilever or jib carries the lifting trolley, the jib is extended backwards in order to form a support for the machinery and counter-balancing weight. In addition to the motions of lifting and revolving, there is provided a so-called "racking" motion, by which the lifting trolley, with the load suspended, can be moved in and out along the jib without altering the level of the load. Such horizontal movement of the load is a marked feature of later crane design. Hammerhead cranes are generally constructed in large sizes, up to 350 tons.

Coordination, Supervision and Engineering/Calculating Picks

Due to the complexity, size and potential for loss, all Tower crane operations need to have a thorough review completed by an engineer, be pre-planned, coordinated and supervised by qualified employees. All parties responsible for crane operations at the site from the Construction Manager, the General Contractor and Subcontractor to the crane leasing/rental company, should be directly involved in the coordination and supervision to assure that all aspects of the Tower cranes selection, arrival, erection, use, dismantling and finally transport off the site are conducted properly and safely.

Site Considerations

Proper Access to Site Due to size, configuration and complexity of Tower cranes they will always need to be transported to the project, on several trailers and in several sections. Unlike mobile cranes that can drive on our highways and streets and easily access the project, the tower crane will always be transported and therefore safe access must be considered and pre-planned for the transport vehicles, the additional cranes or derricks needed to unload and erect the Tower crane and the Tower crane components themselves.

Without pre-planning, access from narrow streets or other locations limited in size can cause traffic congestion, block the project gate for other contractors and may create unsafe conditions as a result. Access locations may need to be designed specifically for the type of crane.

The following should be considered when planning for the Tower crane:

- Larger size gates or access openings and access that can be easily maneuvered through (no sharp corners or turns) from street and roads
- Overhead obstructions such as power lines or other structures may need to be relocated
- If accessing from an active roadway, traffic control warnings, devices and flagmen to safeguard the public.

Once in the gate, additional measures should be taken to assure that the route the crane must take to the erection or hoisting area is safe, not only for the machine and operator but for all other site employees as well. The site route should be evaluated and prepared so it can adequately support the weight of the crane, be wide enough, clear of any equipment or vehicles that may interfere. Personnel must be safeguarded.

Surface Conditions and Adequate Base

[4]The first element of the tower crane's stability is a large concrete pad (base) that must be poured several weeks before the crane arrives. This pad typically measures 30 feet by 30 feet by 4 feet and weighs 400,000 pounds. Large anchor bolts are embedded deep into this pad to provide support for the base of the crane: These cranes are essentially bolted to the ground (base) to ensure their stability.

For the contractor responsible for the Tower crane operations or for providing oversight to a subcontractor who is, it is required that tower crane foundations and structural supports (including both the portions of the structure used for support and the means of attachment) must be designed by the manufacturer or a registered professional engineer. The A/D director must determine that tower crane foundations and structural supports are installed in accordance with their design.

Fall Protection on Tower Cranes

For work other than erecting, climbing, and dismantling, the employer must provide and ensure the use of fall protection equipment for employees who are on a walking/working surface with an unprotected side or edge more than 6 feet above a lower level, except when the employee is at or near draw-works (when the equipment is running), in the cab, or on the deck.

For erecting, climbing, and dismantling work, the employer must provide and ensure the use of fall protection equipment for employees who are on a walking/working surface with an unprotected side or edge more than 15 feet above a lower level.

In addition to providing proper fall protection, there is the potential for the operator or maintenance staff to become injured or trapped on the Tower crane, unable to climb down the mast on their own. The ability to communicate must be ensured, a rescue plan should be created and in place in the event rescue is needed.

Erection, Climbing and Dismantling

[5]Tower cranes can arrive at the construction site on numerous tractor-trailer rigs. The erection crew uses a mobile crane to assemble the jib and the machinery section, and places these horizontal members on a 40-foot mast that consists of two mast sections. The mobile crane then adds the counterweights. The mast rises from this firm foundation. The mast is a large, triangulated lattice structure, typically 10 feet square. The triangulated structure gives the mast the strength to remain upright. To rise during operations and reach its maximum height, the crane is self-erecting and will raise itself one mast section at a time. The crew uses a top climber or climbing frame that fits between the slewing unit and the top of the mast. Once the building is finished and it is time for the crane to come down, the process is reversed; the crane disassembles its own mast and then smaller cranes disassemble the rest. It is important to know who owns and is responsible for Tower cranes on the project, including the erection, climbing and dismantling of the crane. If the contractor leases the tower crane are they responsible for the erection, climbing and dismantling of the crane or is that the responsibility of the leasing company? Regardless, compliance with crane manufacture specifications, procedures and protocols, as well as utilization of a Professional Engineer (PE) or expert in the field of crane safety to ensure erection, climbing, securing and dismantling operations, are executed in compliance with approved engineering drawings. Manufacture's specifications must be implemented and executed.

Employees must not be in or under the tower, jib, or rotating portion of the crane during erecting, climbing and dismantling operations. Not until the crane is secured in a locked position and the competent person in charge indicates, it is safe to enter this area, unless the manufacturer's instructions direct otherwise and only the necessary personnel are permitted in this area.

Prior to, and during, all climbing procedures (including inside climbing and top climbing), the employer must comply with all manufacturer prohibitions and have a registered professional engineer verify that the host structure is strong enough to sustain the forces imposed through the braces, brace anchorages and supporting floors.

Towers must be erected plumb to the manufacturer's tolerance and verified by a qualified person. Where the manufacturer does not specify plumb tolerance, the crane tower must be plumb to a tolerance of at least 1:500 (approximately 1 inch in 40 feet).

Documentation that records the signature of the PE or qualified person attesting to the fact that the work has been reviewed, inspected and performed according to engineered drawings should be maintained.

During the erection, climbing and dismantling operations the personnel used to perform this work must be knowledgeable and qualified. What are the qualifications of the workers performing this work and if they are riggers, what training do they have to verify their knowledge in this area?

Prior to the erecting, climbing and dismantling of the tower crane, pre-work meetings must be held with the crew to discuss and review the procedures and to inspect the rigging equipment. The rigging must be inspected before it is put into use to assure it has the capability to safely perform the work and is in proper working order. All pre-work/safety meetings should be documented and include a list of those who attended.

Inspection and Maintenance

All hammerhead tower cranes in use shall meet the applicable requirements for design, construction, installation, testing, maintenance, inspection, and operation as prescribed by the manufacturer.

Inspection criteria must be in place during the course of the project to inspect the crane, tower mast section and ties (supporting struts attached to the building/structure) to ensure all components are in proper working order and free from damage. As with all other inspections, this inspection should be documented and signed off by the qualified inspector.

Some inspection criteria are: how often is the inspection performed, who is designated to perform the inspection and what are the qualifications and procedures that should be in place to verify the inspector's qualifications to perform the work. There should be documentation requirements and copies of the inspection documentation should be maintained.

Before each crane component is erected, it must be inspected by a qualified person for damage or excessive wear. The qualified person must pay particular attention to components that will be difficult to inspect thoroughly during shift inspections. If the qualified person determines that a component is damaged or worn to the extent that it would create a safety hazard if used on the crane, that component must not be erected on the crane unless it is repaired and, upon re-inspection by the qualified person, found to no longer create a safety hazard.

A post-erection inspection must also be completed. A load test using certified weights, or scaled weights using a certified scale with a current certificate of calibration, must be conducted after each erection. The load test must be conducted in accordance with the manufacturer's instructions when available. Where these instructions are unavailable, the test must be conducted in accordance with written load test procedures developed by a registered professional engineer familiar with the type of equipment involved.

In addition, Monthly and Annual inspections are required. Monthly inspections include: inspection of Tower (mast) bolts and other structural bolts (for loose or dislodged condition) from the base of the tower crane up or, if the crane is tied to or braced by the structure, those above the upper-most brace support and the upper-most tie-in, braces, floor supports and floor wedges where the tower crane is supported by the structure, for loose or dislodged components. Annual inspections require that all turntable and tower bolts must be inspected for proper condition and torque.

Rigging

Basics

Just as the crane must have the capacity to hoist the intended loads with out failure, the rigging used must be just as capable. Several key aspects that need to be taken into consideration to ensure that the hoisting operations go off without a "hitch" are:

When is a qualified rigger required?
According to the new Subpart CC, when:

- The load will be "received" by a worker
- Whenever workers are within the fall zone and hooking, unhooking, or guiding a load, or doing the initial connection of a load to a component or structure and
- Employers must use qualified riggers during hoisting activities for assembly and disassembly work

Who can be a qualified rigger?
A qualified rigger is a rigger who meets the criteria for a qualified person. Employers must determine whether a person is qualified to perform specific rigging tasks. Each qualified rigger may have different credentials or experience. A qualified rigger is a person that:

- Possesses a recognized degree, certificate, or professional standing, or
- Has extensive knowledge, training, and experience, and
- Can successfully demonstrate the ability to solve problems related to rigging loads.

Knowledge of Workers
A qualified rigger must be designated to oversee rigging operations and/or to personally rig the loads to the crane. There are many factors that determine what rigging is used and how it is configured. To determine the proper rigging and configuration, a Qualified Rigger must take into consideration:

- The weight of the load
- The loads "Center of Gravity"
- Sling Angle
- Potential for side or angular loading
- The appropriate hitch for the load
- Is a tag line required and
- Any unusual environmental concerns that can affect the load

When rigging is used for assembly/disassembly, the employer must ensure that:

- The rigging work is done by a qualified rigger.
- Synthetic slings are protected from: abrasive, sharp or acute edges and configurations that could cause a reduction of the sling's rated capacity, such as distortion or localized compression.
- When synthetic slings are used, the synthetic sling manufacturer's instructions, limitations, specifications and recommendations must be followed.

Weight of Load

Knowing the weight of the load is a corner stone element in appropriately choosing the rigging that will be capable of safely supporting the load during the lift. If the weight of the load is not known, neither the rigger nor the crane operator will know whether the rigging, the crane or their configurations will perform the job without failure. The rigging product guides and loads charts are based on, among other factors, knowing the weight of load.

Center of Gravity

The Center of Gravity (CG) is the point at which the load would balance and where the weight is evenly distributed. The rigging used must take into account the center of gravity so that the straps or slings and their attachment devises are not over loaded.

Example: A load is rigged so that each sling attached is receiving an equal share of the load weight. Now, keeping the same rigging in place, we shift the CG further to one side. As the load's CG is moved, the weight of the load is proportionately shifted to the rigging and attachment points closest to the new CG. The rigging closest to the new CG will now see a greater share of the load while the rigging farther away will see less.

In these situations, if the rigger is not aware of or does not rig the load with the center of gravity in mind, or if the incorrect rigging is used a few things will occur:

- The rigging, if not properly sized or configured may no longer be capable of supporting its share of the load and a potential for failure will exist and
- The load itself will see an increased in pressure at the attachment points and can crush under this pressure.

Another concern with not configuring the load with CG in mind is the potential for the load to shift when initially hoisted off the ground. As the crane hoists the load and the load becomes free, it will naturally shift to finds its center of gravity. The load will shift towards the CG and when this happens, workers and equipment can be struck by the load.

- Loads should be rigged level and stable
- Materials hoisted should not be loose and capable of sliding out of the hitch used
- Stand back when the load is initially lifted to see if the load is level

Equipment

Rated Capacity of Rigging Used Each piece of rigging hardware has an established Working Load Limit (WLL) - the maximum amount of load that the rigging hardware is allowed to support - as determined by the manufacturer. If there is no data from the manufacturer, the equipment will need to be load tested to determine it.

When calculating the load and configuring the rigging, the WLL needs to be maintained below the breaking strength of the rigging material and never exceeded. If the load being hoisted is near theestablished WLL, use different rigging that has greater capacity.

Capacity of Attachments
Manufacturer's recommendations must always be followed to determine safe working loads of various types of slings, shackles, hooks and other attachments. Always use compatible slings and related hardware. Every component in the rigging system must be sized properly and compatible so when constructed and used together as a system, they are capable of safely handling the load based on the known weight, material make up, environment, center of gravity and other variables that may effect the hoisting operation.

Rigging should not be loaded in excess of rated capacities:

- Shock loading should be avoided as it can easily cause rigging equipment to exceed the rated capacity.
- Job or shop hooks, links, makeshift fasteners shall not be used.
- Fabricated hooks, grabs, clamps, spreader bars etc. shall be clearly marked with the safe working load and proof tested to 125 percent of the rated load.
- The employer shall maintain and make available records of the proof test.

Sling Angles
When only a single hook is available to attach rigging components, all the slings to be used are placed into this one hook. When this occurs, the Rigging Triangle is created due to angles of the slings and load they are attached to. If not properly balanced, side loading can occur at the load.

Sling length directly affects the sling angles. As the sling angle becomes smaller, slings and attachments see more stress at the load. This in turn can cause a greater crushing force on the load. For optimal performance and safety, horizontal sling angles should be maintained at 60 degrees or greater and never less than 30 degrees.

Slings should not be shortened with bolts, knots or other devices. Slings should be padded or otherwise protected from sharp edges, objects and loads to prevent the equipment from being damaged and failing.

Inspection of Rigging Equipment

Rigging shall be inspected prior to each shift and during use and as conditions warrant. Records need to be maintained and available for the most recent month inspected. Any rigging equipment and hardware found to be defective shall be immediately removed from service.

Each type of rigging equipment and hardware (straps, chain, shackles, hooks etc.) has its own inspection criteria based on its purpose and manufacturer. Those responsible for inspection of the rigging need to know what that criterion is before inspecting the equipment. If during inspection, any of the following conditions are found, the item inspected should be considered for removal from service:

- **Slings:** Abnormal wear, powdered fiber between strands, broken or cut fibers, variations in size or roundness of strands, discoloration or rotting, distortion of hardware in sling, acid or caustic burns, melting or charring of any part of sling surface, snags, punctures, snares or cuts, broken or worn stitches, distortion of fittings, known shock loading (overloading)
- **Hooks:** Wear beyond manufactures recommendations, nicks and gouges, deformation in throat, modifications/ welding (destruction of heat treat), latch functions improperly, known shock loading (overloading), corrosion (reduction of bearing area), altered, reworked, or reshaped hooks
- **Shackles:** Deformations such as bends, twists, and spreading, peening, nicks, and gouges, cracks, corrosion, thread damage, excessive wear in the bow, pin and threads, known heavy use or shock loading, modification/welding, any visible deformations.

Training

As mentioned earlier, the employer is responsible for instructing each employee in the recognition and avoidance of unsafe conditions and the regulations applicable to his work. With rigging it can become complex and in some cases specific training is required, such as in utilizing the “Multiple Lift Rigging Procedure” for steel erection.

Some Practices to Keep in Mind

The following are some considerations that should be kept in mind in crane use:

- Always keep in mind the center of gravity and attach rigging so the load remains level and rigging hardware Working Load Limits (WLL) are not exceeded.
- Check for level by slowly lifting the load to see if it shifts; if it does, set it down and make adjustments for level.
- Protect slings; they can be damaged from sharp edges, rough materials or from being pulled out from under loads.
- To prevent sling damage, and allow the load to be easily accessible for future rigging, slings shall not be pulled from under a load. Dunnage should be used under the loads when landed.
- Always control the hoisted load, tag lines should be used.
- Never hoist loads over personnel or the public, pre-plan to avoid this from occurring.
- In order to select the proper rigging devices, you must know the weight of the load to be picked.
- Inspect the rigging before during and as conditions warrant.
- Always use proper hand signals or approved communication devices.
- Rigging should be stored off the ground to prevent damage.
- If damaged or defective rigging is found, remove it from service immediately.

Conclusion:
As this guide shows, numerous things can go wrong when cranes are used in construction, but there are also many practices that help to increase safety. Involving trained personnel and professional engineers and making sure that safety is part of the culture of the workplace are good practices to help in making the workplace a safer operation.

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