ICSA N007

International Crane Stakeholders Assembly

- Guidance -

"Safe Crane Operation in the Vicinity of Power Lines"

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Legal Note: *This publication is only for guidance and gives an overview regarding the assessment of risks related to lifts when operating cranes in the vicinity of power lines. This document is an industry best practice document that is based on the consensus of member organizations of ICSA. It is not a regulation or standard and should not be treated as such. It neither claims to cover all aspect of the matter, nor does it reflect all legal aspects in detail. It is not meant to, and cannot, replace one's knowledge of the pertaining directives, laws and regulations. Furthermore, the specific characteristics of the individual products and the various possible applications have to be taken into account. This is why, apart from the assessments and procedures addressed in this guide, many other scenarios may apply.*

CONTENT

1. INTRODUCTION

This document has been developed by the international mobile crane industry to provide guidance in relation to operation near energized power lines. It provides information to the industry to assist regulatory authorities when evaluating requirements to prevent power line contact.

Any mandates for crane design requirements need to be evaluated, taking into consideration the limitations and the restrictions during use and also any effects in creating a false sense of security for personnel.

The risk of contact with energized power line is being mitigated during the use of the equipment by individuals involved in the planning and operation. Planning and operations should consider risks to the crane operator, personnel directing the load, crane, and the lifted load.

2. SCOPE

This document provides information and guidance regarding risk mitigation for crane operation near energized power lines with mobile cranes.

This document is not intended to, nor should it be used to replace any documents or guidance provided by the crane manufacturer nor any local or government regulations or codes. All laws, codes and regulations are to be followed.

3. DEFINITIONS

conductor - component of an overhead power line that transmits and distributes power comprised of conductive wire suspended between towers or poles.

ground gradient - the phenomenon that occurs when an energized source of electricity comes into contact with the ground that creates a voltage gradient radiating out from the point of contact.

overhead power line - a structure (including towers, conductors, and insulators, etc.) used in electric power transmission and distribution to transmit electrical energy along large distances.

4. GENERAL

Mobile cranes are designed according to the generally accepted industry standards for the regional market for which they are intended. (e.g., EN13000, ASME B30.5, CSA Z150, etc.). They are high performance equipment capable of carrying high loads (compared to their dead weight) at required radii and height. Typical examples of mobile cranes are shown below.

Figure 1: Telescopic Boom, Wheel Mounted, One Operator Station

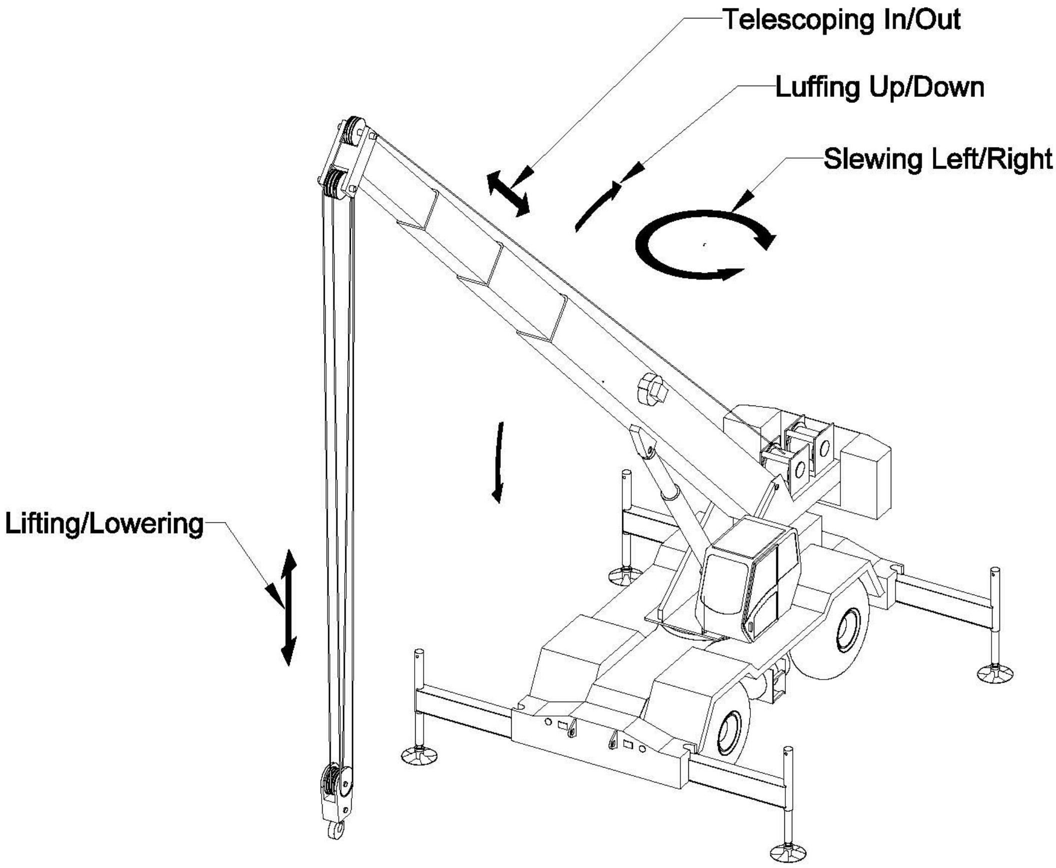


Figure 2: Telescopic Boom, Wheel Mounted, Two Operator Stations

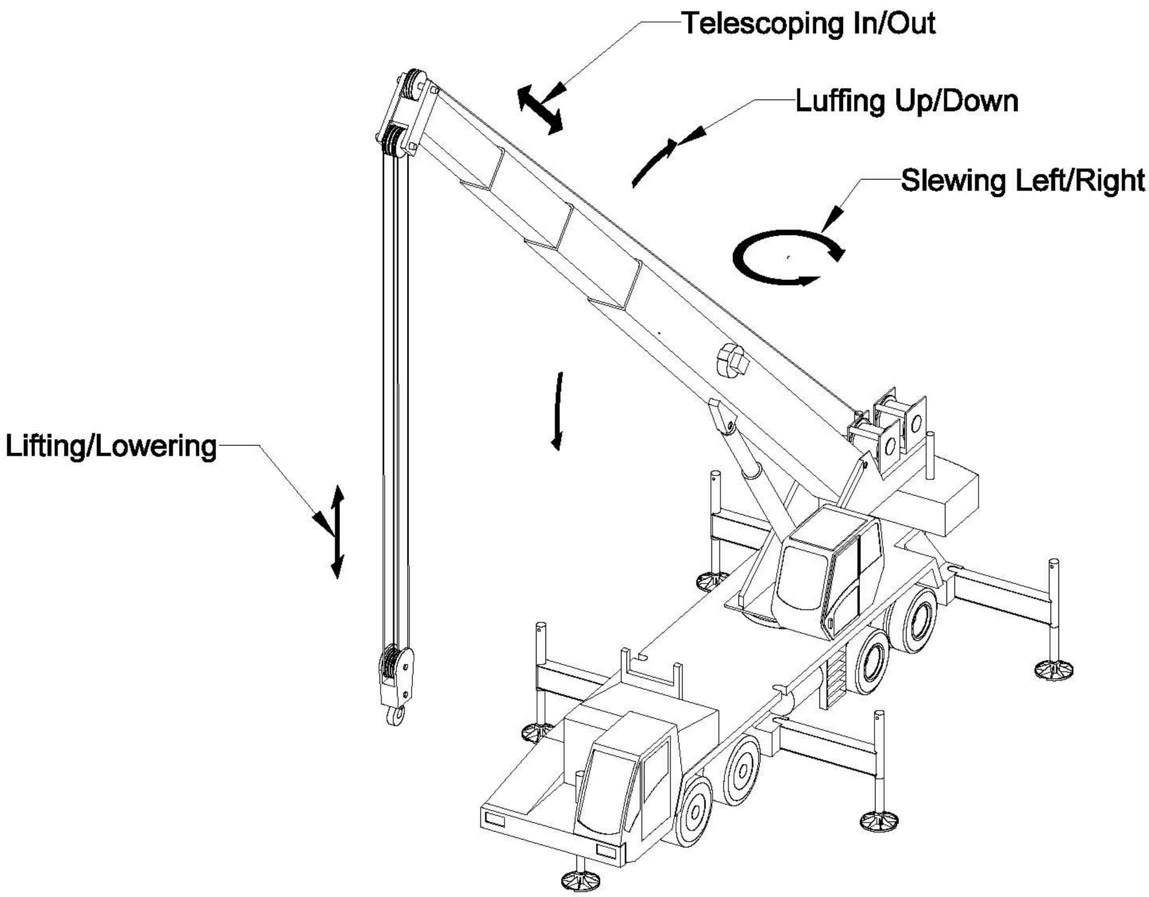
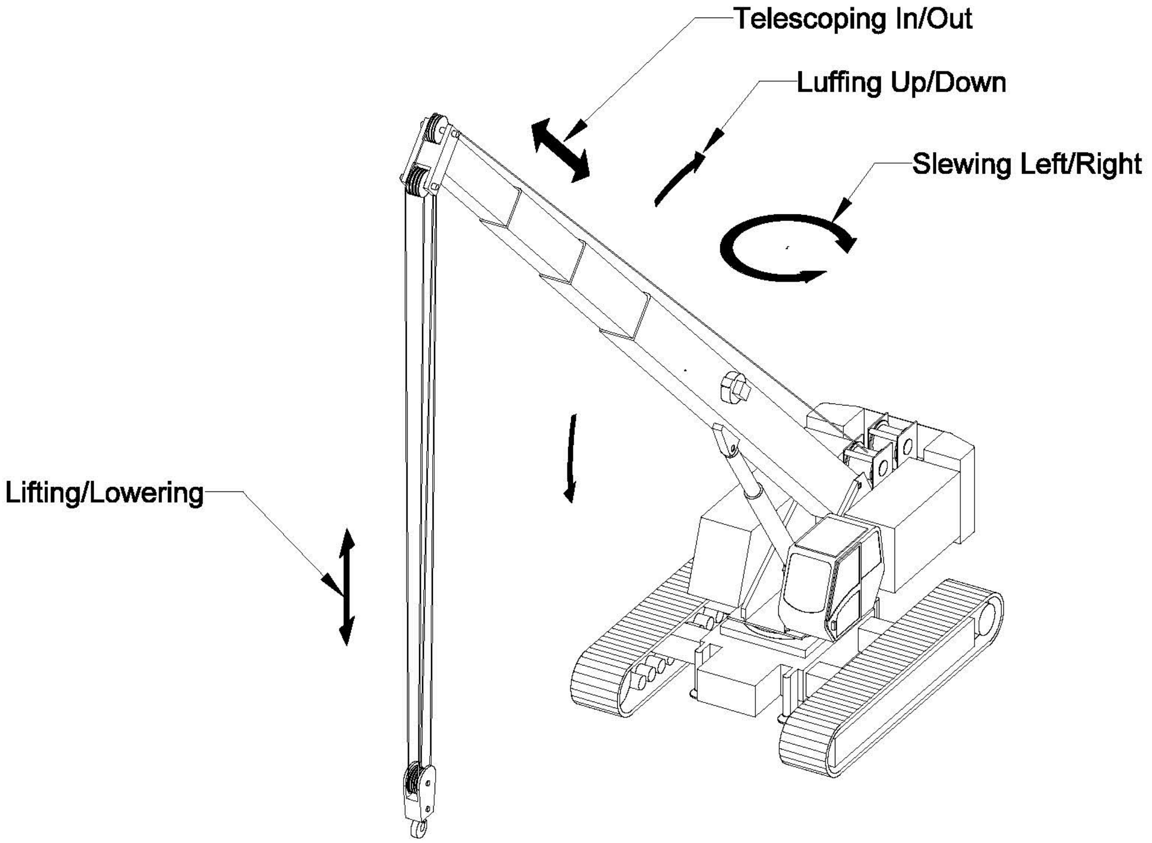
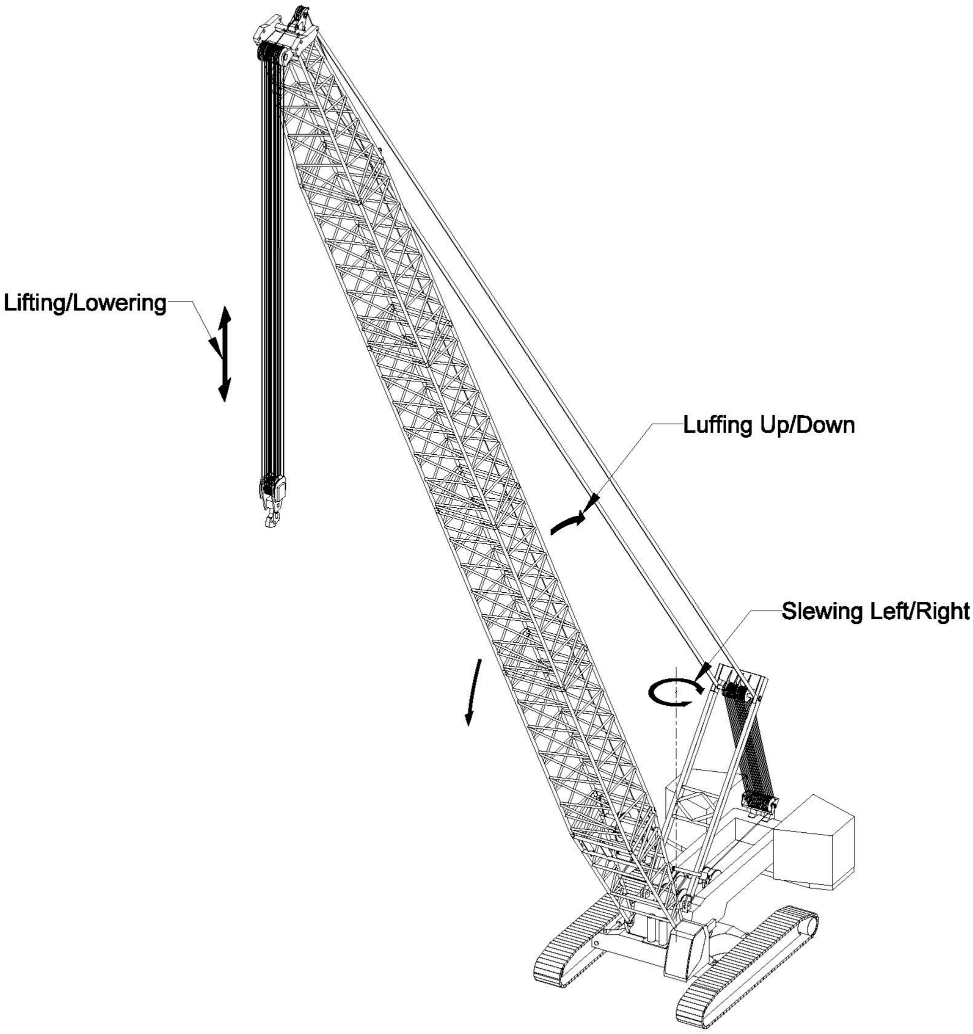


Figure 3: Telescopic Boom, Crawler Mounted



<u>Figure 4: Lattice Boom, Crawler Mounted</u>



Mobile cranes are "non-stationary" cranes as they change location depending on the jobsite. They may be set up in a "quasi-stationary" position on outriggers (Figures 1 and 2) and move the lifted load by combination of movements (i.e., turning (slewing), changing radius (luffing), changing height (lifting). As a result, the lifted load is transported horizontally and vertically. Some mobile cranes are designed to travel with a lifted load, e.g. with crawler cranes without outriggers (Figures 3 and 4).

5. ELECTRICITY

5.1. Electric and Electromagnetic Fields

Where electricity is generated, transported, and used, phenomena such as electric fields occur. When a power line is energized, electric and electromagnetic fields are generated. Many power lines use multiple conductors arranged in specific configurations. Electric and electromagnetic fields radiate from each energized power line conductor and the overall fields will vary based on the current, voltage, and relationship of the conductors to one another and any items in the vicinity. As the voltage or current increases, the field around each conductor will typically be stronger. As the fields from each conductor overlap in space, the effect can be an amplification or nullification of the field strength.

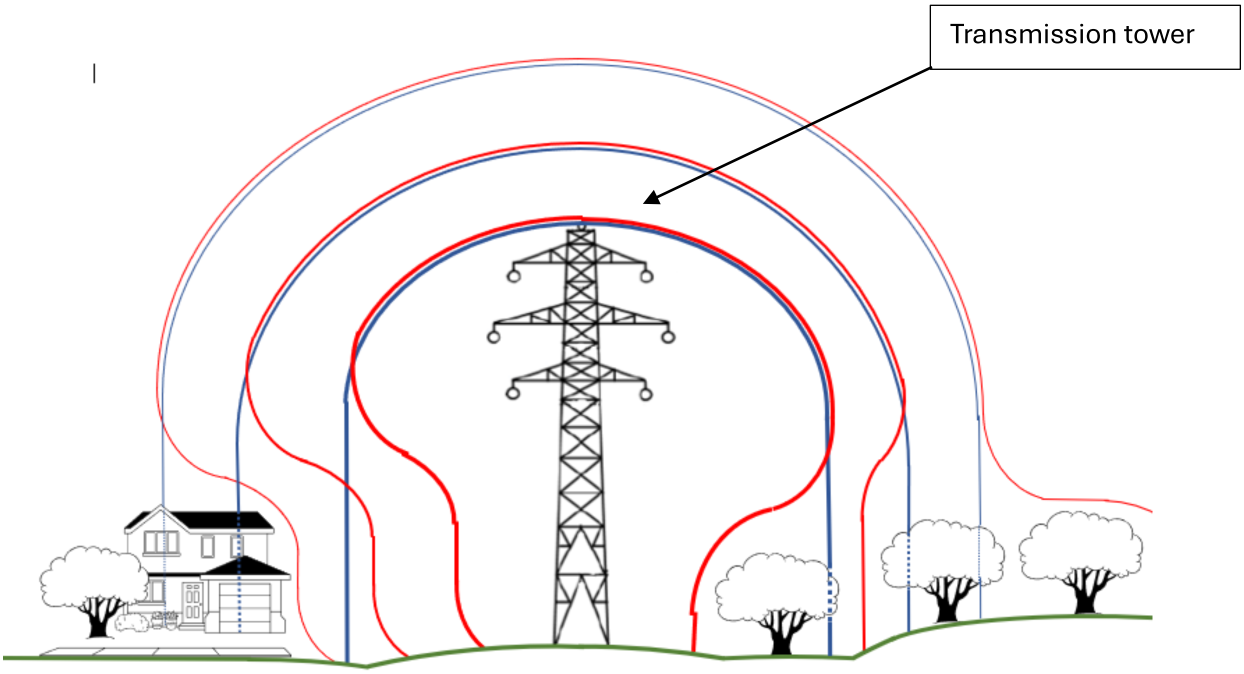
The intensity of an electric field is measured in volts per meter (V/m). It essentially depends on the voltage and the distance from the electrical conductor.

As an example, under a 380 kV high voltage power line, the electric field intensity near the ground can reach 5000 V/m. The lower the voltage, the weaker the field strength. Thus, it can reach up to 3000 V/m under a 220 kV line, a maximum of 700 V/m for 110 kV lines and up to 400 V/m under a 50 kV line.

As shown in the figure below, the electric field intensity decreases with distance from the power line conductors. Note that as shown in the figure, the field intensity will distort as objects are introduced. In this example the field distorts near the house and tree shown in the diagram.

Figure 5 below shows a cross section of the electric field of a 380 kV high voltage power line with two terminals, halfway between two transmission towers, where the power line conductors are lowest and have the minimum permissible distance from the ground.

Figure 5: Electric and Magnetic fields from overhead power lines*



***Electric Field:** created by the electric charges on a powerline and exists even when no electric current is flowing.
***Electromagnetic Field**: generated when electric current flows through a powerline.

Note: The strength of both fields decreases significantly with increasing distance from the power line as denoted in the figure by the decreasing size of the red and blue lines.

Figure 6 below is an example of how electric and magnetic fields around a power line change over time. As can be seen, there are zones of higher and lower field around the power lines that are constantly changing. Additionally, the introduction of metallic objects (e.g., crane booms, load being lifted, other equipment in the vicinity of the work zone) will alter the field. The alteration is difficult to predict as it is affected by the size, location, movement, and orientation of the metallic object.

When a conductive crane boom, load line, and/or load is positioned within the electric field generated by the power line, the electric field will be distorted, and the distortion will fluctuate as the crane moves.

The movement of a crane can be complex and include the following:

- extension/retraction of the crane's boom
- raising/lowering of the crane's boom
- rotation of the crane's upper structure (which includes the boom),
- raising/lowering of the crane's load line and load
- rotation of the load
- traveling the crane

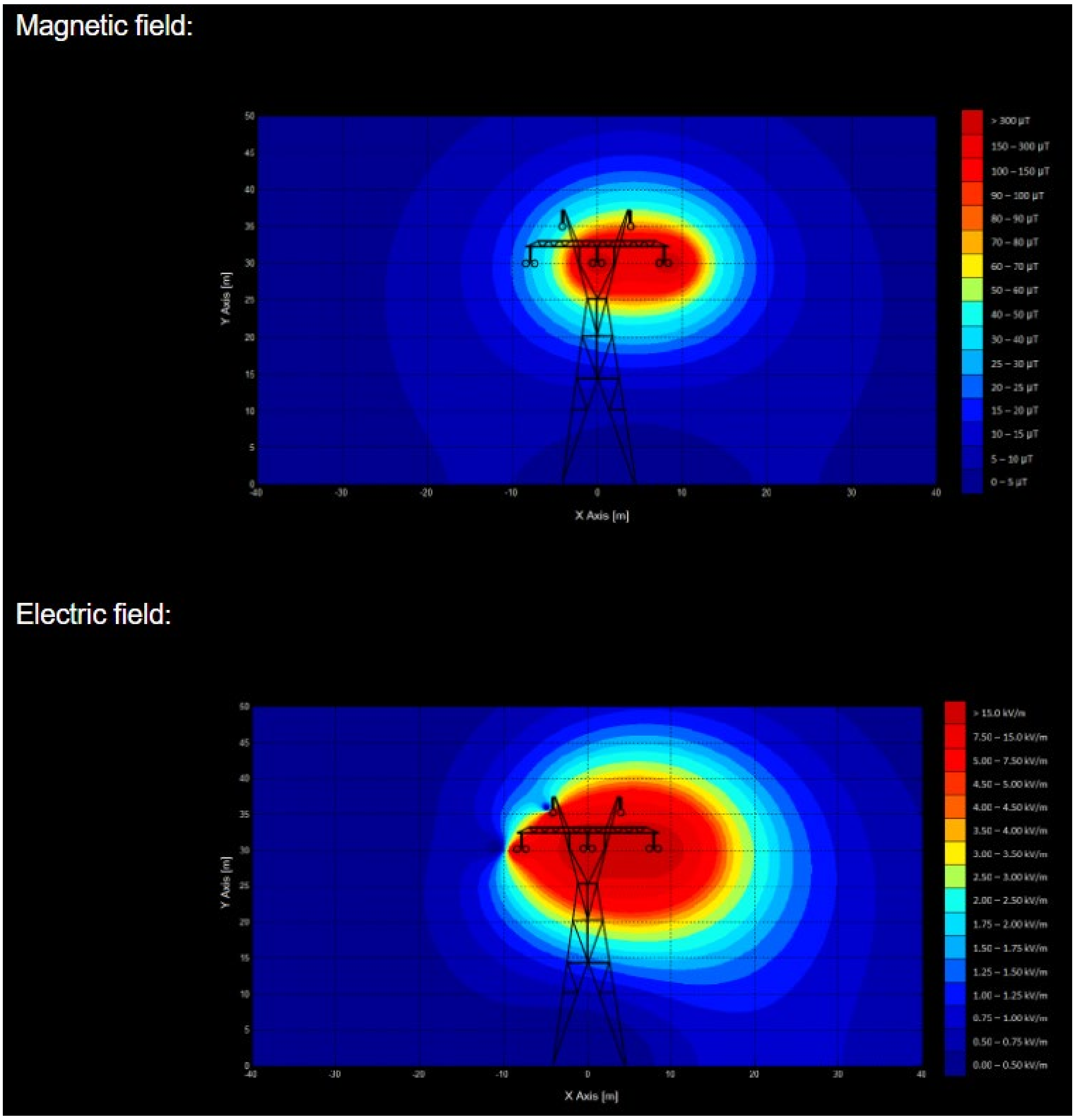
Multiple movements of the crane can occur simultaneously.

Other equipment present on the job site can also cause distortion of the electric field as the equipment operates and moves.

<u>Figure 6: Magnetic and electric fields around a power line changing over time</u>

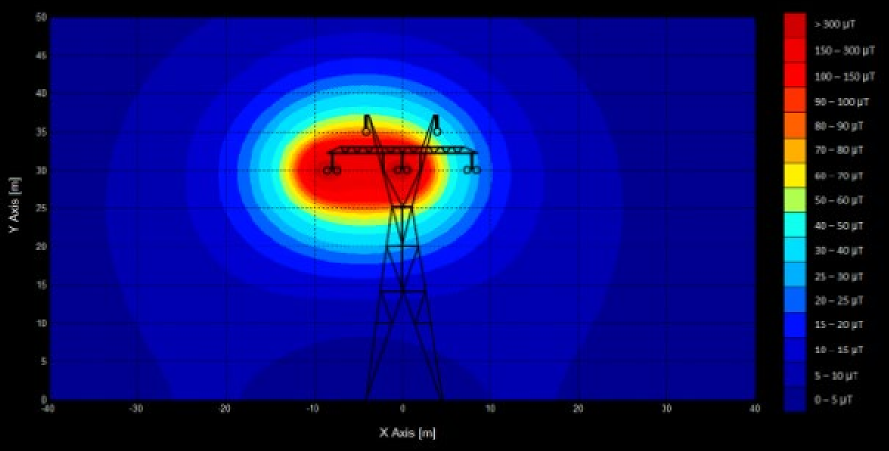
Source: The Fragmentation Paradox blog

For t = 0ms

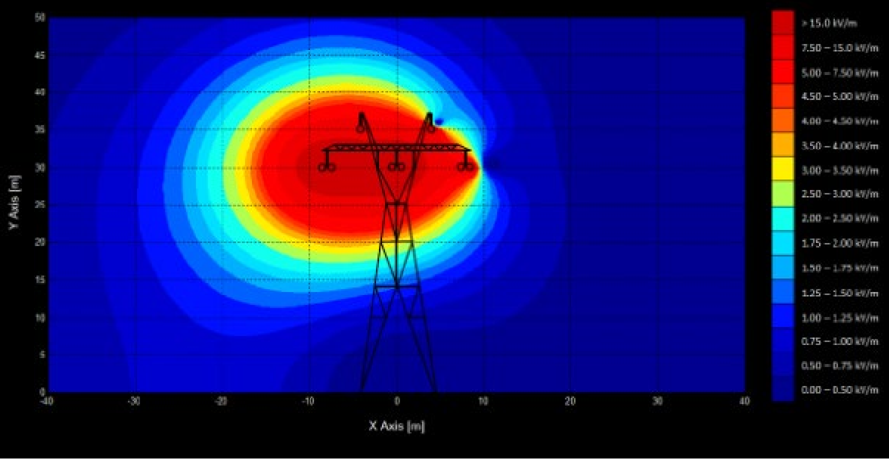


For t = 3ms

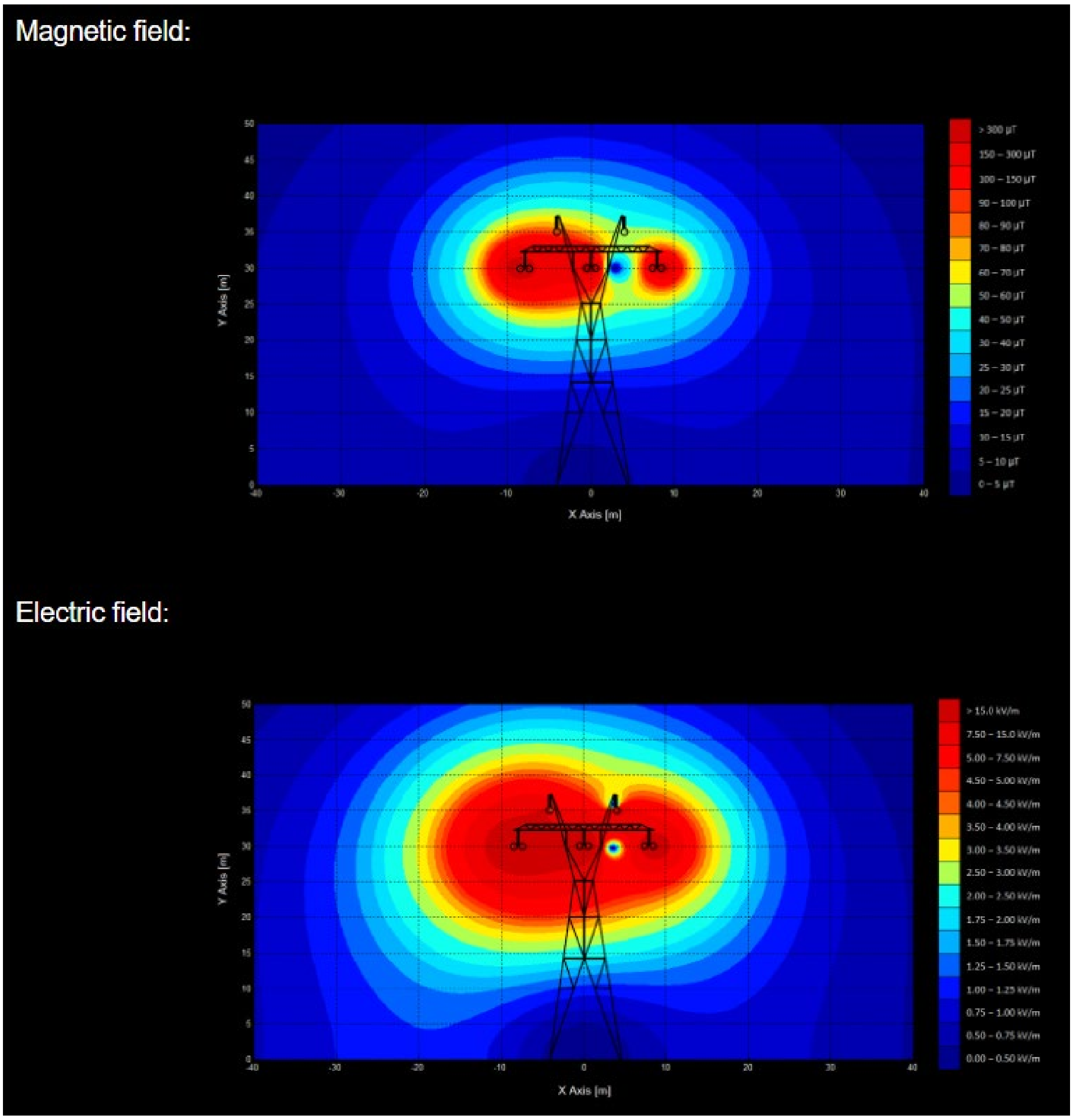
Magnetic field:



Electric field:



For t = 5ms



5.2. Induced Voltage

Induced voltage refers to the electric potential created by an electric field. When a metallic object such as a crane boom is operated within an electric field (e.g., near conductors, radio towers or other transmitters), induced voltage on the crane can occur and produce an electric potential in the crane. The stored electrical potential can travel to the ground if the crane comes in contact with an object or person to complete the electric path to the ground. If the crane becomes grounded (e.g., touched by someone on a jobsite) the built-up potential will discharge through the person to the ground.

Induced voltages can occur on a crane near high voltage transmission power lines, even though the equipment is in full compliance with nationally recognized requirements for clearance and far from touching the power lines.

5.3. Arcing in Air

Arcing is the conduction of electricity through air. For an arc to start, an object connected to ground potential, e.g. crane, must get close enough, within the sparking distance, to a power line to cause the air between them to break down and become conductive. This breakdown is a spark that immediately becomes an arc continuing to carry current until either the power is turned off or the crane is moved far enough from the line (several times the initial sparking distance) to extinguish it. Sparking distance is roughly proportional to voltage, and with the most adverse conditions, the sparking distance is less than 2.5 cm for each 8 kV. While temperature, humidity and barometric pressure all influence sparking distance, their effects are only a few percent, and none would cause the spark distance to exceed 2.5 cm for each 8 kV.

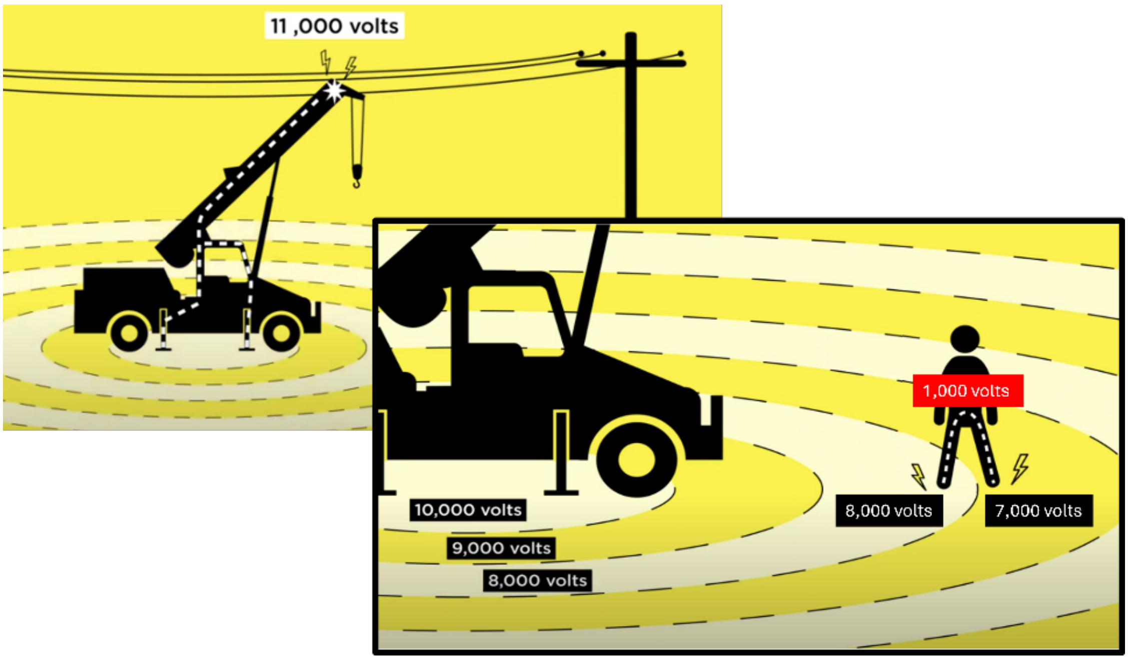
When a machine contacts a bare, overhead power line conductor or becomes energized by arcing through the air, the crane becomes energized to approximately line-to-ground voltage, often ranging from several thousand to more than 750,000 volts. Several possible scenarios can lead to injury under this circumstance. In one, workers guiding a suspended load, or otherwise in direct contact with both the machine and ground, immediately become a path for electric current. In another, equipment operators are not aware of the line contact or may perceive themselves to be in immediate danger and attempt to dismount the equipment, simultaneously bridging the high voltage between the equipment and ground. Finally, nearby workers who may not realize a serious electrical hazard exists, try to help those involved in the incident, and in doing so contact energized equipment or victims.

5.4. Electrical Hazards

Utility companies equip power lines with breakers that will disconnect power flowing through a line when a fault is detected. However, when a crane contacts a power line, there may not be sufficient current draw to trip the breaker. Additionally, many breakers are equipped with reclosure devices that attempt to reconnect the power multiple times before it is fully disconnected. The power line may become re-energized multiple times, exposing workers to repeated events.

As a crane is inadvertently brought into contact with an energized power line, the crane, its load line, and suspended load become energized to the same voltage as the power line. When a crane is in contact with an energized power line conductor, the high voltage difference between it and ground will almost certainly severely burn or kill anyone touching the crane and ground simultaneously. In addition to this energization of the crane, the ground around the outriggers and around crane wheels or tread becomes dangerously energized. There is a rippling effect that can be likened to dropping a pebble into calm water. In the pool of water, the wave created at the point of contact gets smaller as it rings out. Similarly, in this "pool" of electricity, the energy is at full system voltage as the point of ground contact, but as you move away from the contact point, the voltage drops progressively. This effect is known as "ground gradient." When a person steps across the ground gradient, the voltage difference travels through the person.

Figure 7: Ground gradient

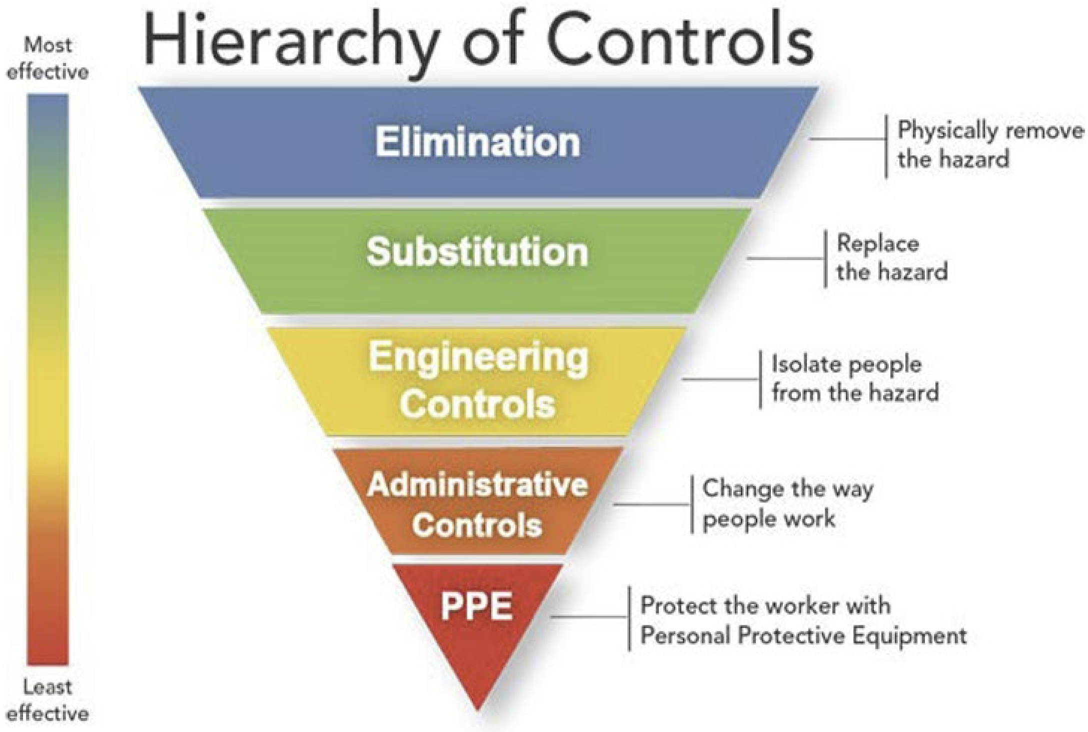


6. ASSESSMENT OF RISK

6.1. Overview

Power line contact has been a major contributor to injuries and fatalities for individuals in the construction industry. When operating cranes near energized power lines, electrical hazards exist that can cause injury to personnel operating the equipment as well as those in the general vicinity. Not only does direct contact with power lines create a hazard for personnel but working in close proximity to power lines may also result in arcing. Any personnel working on or around the crane could be exposed to electrical hazards by coming in contact with the energized crane, load or ground gradient. As shown below, the preferred method for elimination of the risk entirely is to avoid crane operation near energized power lines.

Figure 8: Hierarchy of Controls



Source: NIOSH.

Studying the comprehensive description in [1] reveals that currently there are no other means available to minimize the electrical contact hazard, in particular no engineering controls, other than administrative controls through procedures when preparing and doing the work.

6.2. Elimination of the Hazard

During the lift planning stage elimination of the electrical hazard should be evaluated for feasibility before using other controls. Can the job be planned in such a way that the power lines can be de- energized and grounded while the work is performed? De-energizing the power lines removes any risk of electrical hazards while working near power lines. Confirmation that the power lines have been de-energized and grounded should be completed before operation commences.

6.3. Substitution to Mitigate the Hazard

If elimination of the hazard through de-energization of the power line is not feasible then using the method of substitution should be reviewed for feasibility. Substitution includes crane selection, position, and configuration. Some possible questions to consider include:

- Can the job be performed without the use of a crane?
- Can a different crane configuration or lifting device that is not capable of encroaching on the restricted proximity of power lines be used?
- Can the crane be placed in a position where the lift handling activities do not require the crane to move towards power lines, e.g., work zones, crane orientation for picking and placing loads?

When operating the crane remotely, use of a **non-tethered** remote device would assist in mitigating this hazard. See section 6.4.2.2 Remote Operation.

6.4. Engineering Controls

6.4.1. Crane Design

Mobile crane manufacturers design cranes so they can be safely used during lifting operations. However, due to environmental and specific conditions, accounting for all jobsite hazards is impossible.

In order to maximize the usefulness of a mobile crane, they are designed to safely lift and place loads over a broad area, and many can travel extended distances with a load. Due to size and weight restrictions when traveling on public roadways, many will also require assembly once arriving at a jobsite and then moved to the final location where the loads need to be lifted. When power lines are present, additional hazards are introduced during the transportation, assembly, positioning, and actual lifting operations that are beyond the control of the crane manufacturer and can only be addressed at each jobsite.

The potential risks brought about by movement of a mobile crane and its lifted load in the vicinity of power lines necessitate advanced planning including a comprehensive review of all movement and lifting operations. This needs to be done by competent personnel familiar with the equipment, jobsite/environment and the loads to be moved. A plan that includes a risk assessment identifying potential hazards, establishes measures to mitigate the risks. The risk assessment may be a formalized process, or it can be quite informal based on the complexity of the job and local hazards.

6.4.2. Protective Measures

Cranes are designed to reach the same heights or higher than power lines. To provide the capacities necessary to accomplish the lifting activities, cranes are made of strong but lightweight metallic materials that are conductive. Therefore, it is not possible to eliminate the hazard of becoming energized when it is operated too close to an energized power line.

The only way to prevent the crane from becoming energized is to isolate the crane from the energy flowing through the power lines. The only method to completely isolate the crane from the energy is to have the power line supplier de-energize and ground the power lines. Once this occurs and de-energization is confirmed, the hazard is eliminated, and crane operations can commence.

If the power line cannot be de-energized, other measures to ensure that the crane remains an appropriate distance away from the power lines need to be implemented. This is done through planning and operational controls.

6.4.2.1. Power Line Detection

Currently, there are no safety devices available that can accurately detect the fluctuating electric fields required by various standards (e.g., EN/ISO 13849 Level C).

There are proximity warning devices that can detect electric fields emitted by power lines and alert the operator of their presence. One type of device uses a fixed field sensor (calibrated to a single reading). The other type uses an adjustable field sensor. The adjustable field sensor requires input by the operator to set the limit of crane movement to stay outside the minimum clearance distance. Testing of these devices has indicated that they have limitations and require restrictions for their use.

The main limitation is due to the nature of the electric field which is constantly changing. Additionally, as previously discussed in section 5.1., when the crane, load, or other equipment moves in the vicinity of the power line, the electric field fluctuates. Therefore, it is impossible for the device's sensor to reliably detect the field and maintain the set distance. As the crane moves, the load moves, etc. and even returning to the same exact location may result in a difference in the strength detection of the electric field. If the field strength decreases, the sensor may not detect if the crane moves closer than permitted to the power line.

Additional limitations to be considered are environmental and include temperature, humidity, power line configurations, and other equipment in the vicinity.

There have been several studies performed related to the reliability of proximity warning devices. Two recent studies include:

a) Manufacturers of concrete pumps organized in the German VDMA organized a study which was carried out at the University of Dresden in 2006 [7]. The study involved representatives of the German HSE. Four different devices sold as detectors for high voltage were tested with regard to their ability of reliably detecting power lines when used on mobile machinery, with the focus on mobile concrete pumps. These pumps comprise knuckle booms and are as such of same design as many loader cranes and similar to mobile cranes. The test results did not qualify these systems as reliable detectors for high voltage.

b) The U.S. Center for Disease Control, National Institute for Occupational Safety and Health (NIOSH) published a study entitled: “A Performance Evaluation of Two Overhead Power Line Proximity Warning Devices”. (IC9510/2008) As was stated in the study, NIOSH identified two specific areas that warrant more study (1) crane operation near multiple independent overhead power line circuits, and (2) anomalies associated with power line circuit phase sequence reversal. A conclusion published stated that “Both of these factors can have an adverse and, from the operator’s perspective, unpredictable effect on PWD performance.”

During the development of the most recent OSHA regulations regarding operation of cranes near power lines, NIOSH provided a public comment during the review period. They referenced the published study and provided the following comment, “Proximity alarm performance was the subject of a study conducted by the National Institute for Occupational Safety and Health (NIOSH) published in January 2009 and submitted as an exhibit to this rulemaking. (ID–0141.2.) This study tested the efficacy of two proximity alarm models under various simulated construction conditions. The study indicated that the accuracy of the proximity alarms could be adversely affected by such factors as: (1) Operating the equipment with a boom angle and length significantly different than that used for the device’s last sensitivity adjustment; and (2) operating the equipment on sites with multiple overhead power lines, especially where those power lines had differing voltages or involved intersecting installations.” OSHA responded by stating, “OSHA shares the concerns expressed by NIOSH and other commenters over the accuracy of currently available proximity alarms.[49] However, such concerns are addressed by the definition of ‘‘proximity alarm’’ in § 1926.1401, which states that the term refers to a device ‘‘that has been listed, labeled, or accepted by a Nationally Recognized Testing Laboratory in accordance with § 1910.7.’’ To be so listed, labeled, or accepted, the Nationally Recognized Testing Laboratory (NRTL) must determine that the device works properly by concluding that it conforms to an appropriate test standard. Accordingly, no proximity alarm can be listed, labeled, or accepted by a Nationally Recognized Testing Laboratory (NRTL) in accordance with § 1910.7 until the problems identified by the commenters have been rectified. OSHA concludes that retaining this option in the final rule will provide an incentive for proximity alarm manufacturers to improve these devices to the point where they will meet the definition’s criteria.”

Since the time these studies were published, neither the physics of the electric fields nor the technology of the proximity warning devices has changed. Therefore, avoidance of contact of energized power lines by detection is (at least today) not a reliable solution and if proximity warning devices are relied upon for hazard mitigation, the crane users will have to identify and evaluate all limitations and restrictions of the devices prior to use.

6.4.2.2. Remote Operation

Remote operation allows an operator to function the crane from a position independent of the crane’s operation cabin. Therefore, one benefit of a remote device is that the operator can be positioned to view the entire lift area (from the crane to the load to the landing area for the load). When operating remotely though, additional hazards exist and should be evaluated which include:

- If the crane contacts a power line, the operator, and any other workers near the crane, may still be exposed to electrical hazards through any contact with the crane, load, load line, or through ground gradient (see section 5.4.).

- When using a tethered remote device physically connected to the crane and power line contact occurs, electrical energy will flow through the tether to the remote device, exposing the operator to an electrical hazard.

6.4.2.3. Non-Conductive Materials & Design

There are materials with insulating properties that exist but due to their strength and weight limitations, are not viable options to be used in the design of the crane's lifting structure. In addition, use of this material would not insulate the entirety of crane, the load line, or the load. Therefore, it is impossible to effectively use insulating material and protect all portions of the crane to prevent electrical hazards if power line contact occurs.

Insulated links are devices made of non-conductive material that claim to provide insulating properties that prevent the flow of electricity to the lifted load if the boom or load line contacts a power line. Insulated tag lines are another type of non-conductive devices that claim to provide insulating properties that prevent the flow of electricity to workers controlling the load if the load contacts a power line. However, limitations associated with these devices can make them ineffective, creating additional hazards to be evaluated which include:

- An insulated link inserted between the hook of the crane and the load's rigging requires a structural rating sufficient to support the load being lifted. At the same time, the insulated link requires an electrical rating sufficient for the possible voltage of the power line. Overhead power lines are broken into categories that range in voltage from a few thousand volts (e.g., 7kV or less) to hundreds of thousands of volts (e.g., 500kV or greater). At this time, there is limited availability of insulated links that can cover the full range of lifting capacities of cranes in combination with electrical voltages of the power lines. Tag lines have the same limited availability with regard to the electrical voltages of power lines.

- The weight of an insulated link is considered as part of the lifted load, therefore reducing the available capacity of the crane and will limit the available height to lift the load due to the size of the link

- The non-conductive insulating properties of both insulated links and tag lines are reduced and sometimes completely eliminated if they are exposed to environmental conditions such as dust, dirt, or moisture. When they are contaminated by moisture and/or dirt, a path is created across the outside of the device that allows arcing, often referred to as flashover. This is totally independent of the insulating properties of the device. Testing has shown that flashover is a major concern with any insulating link or tag line.

6.4.2.4. Grounding the Entire Equipment

Grounding equipment working in the vicinity of power lines is required by regulation and by many utility companies around the world. Grounding equipment will reduce the resistance to the flow of electricity to the ground by ensuring a better path through the ground. However, if contact with an energized power line occurs, the amount of energy that would need to be dissipated may exceed the capability of the grounding system.

When a crane is energized by contact with power lines, electricity will flow through the machine towards the ground. While a properly installed grounding system will dissipate some energy, it will not and cannot control the flow of electricity through other paths to ground. Therefore, it does not provide protection to those working around the crane or load.

When grounding is required, a qualified person will specify the size and location of the grounding system taking into consideration many factors such as:

- the rating of the power lines
- the environmental conditions (e.g., soil type and consistency)
- The location of the grounding connection on the crane

In addition to the concerns regarding safety that are not mitigated by grounding, grounding of mobile cranes can also create issues related to mobility. Grounding a crane involves placing a conductive rod into the ground. The crane is then connected to this rod by means of a conductive cable that is affixed to the crane at a designated location. Therefore, travel of the crane is limited, if not eliminated, when connected to the grounding system. Furthermore, many recommendations for grounding cranes include placing the grounding connection to the crane above the rotation bearing. If this is done, then the rotational movement of the upper structure is also limited, if not eliminated, to prevent snagging or disconnection of the grounding system. Regardless of where grounding is connected, the functionality of the crane is greatly diminished.

6.5. Administrative Controls

If engineering control of the hazard is not practical, then administrative controls should be reviewed for feasibility. Lift procedures are completed for a variety of lift handling activities. When the lifting activity involves operating around power lines, specific procedures should be applied. In the onsite pre-start meeting, review these procedures before beginning work. Include in the procedure:

- Whether a spotter is to be used as a safety countermeasure or as required by regulations in the lift procedure.
- The path of travel for the load or crane in the lift procedures to ensure that adequate clearances to the power lines are maintained.
- Markers or barricade lines to define the allowable load path corridor to assist the operator in maintaining the required power line clearance.
- Where long spans of power line conductors can sway laterally, additional clearance between the crane and the power line is required.
- Use of appropriate personal protective equipment (PPE) specific to the task when working around power lines.

Regulations for operating near power lines will vary from country to country. Local jurisdiction requirements specify how work zones and encroachment are defined, as well as mitigation requirements when operating near power lines. Local jurisdiction requirements must be followed.

Following the administrative controls outlined in local regulations have been deemed sufficient in minimizing risk. Specific training on the local regulations has been shown to improve safe operations around power lines. Review of local regulations is a key element of the pre-start meeting on site.

Examples of distances for lift handling activities is shown below (in Australia and USA). The examples have different distances based on the voltage carried in the power line.

Figure 8: Australia Safe Operating Distances

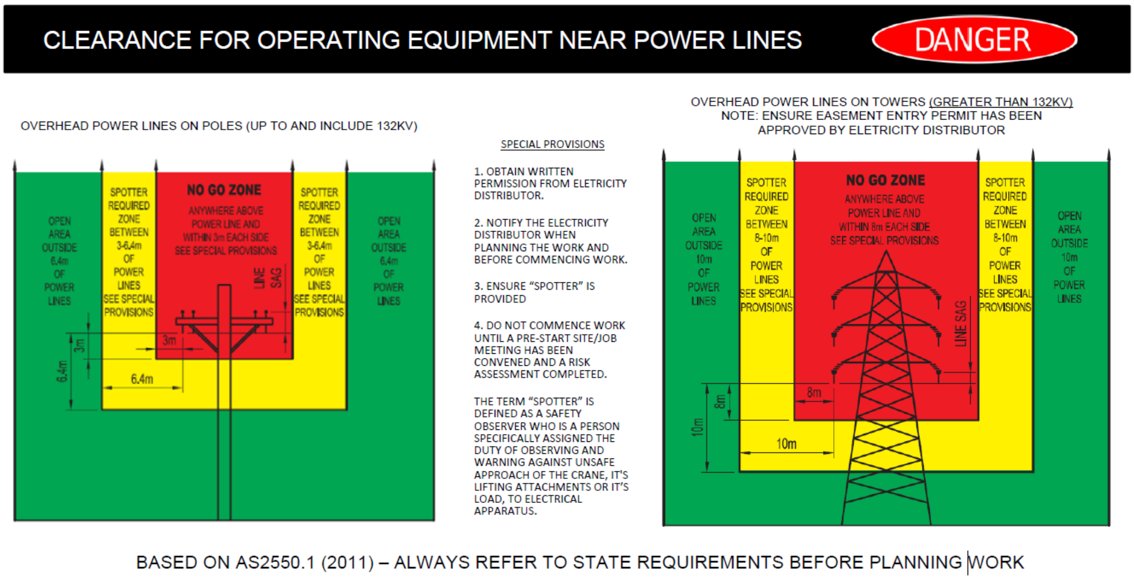
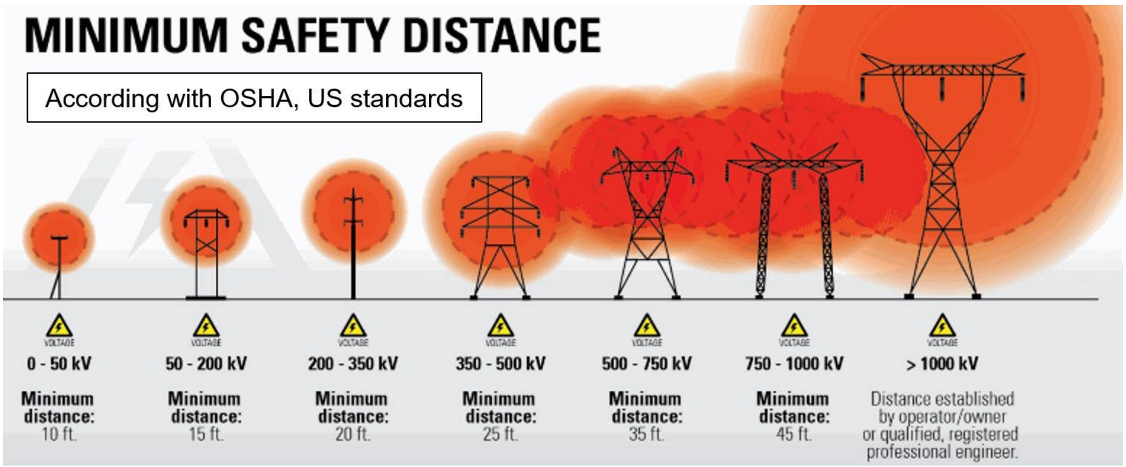


Figure 9: USA Safe Operating Distances



7. CONCLUSION

As demonstrated, it is not possible to completely eliminate the risk of contact between a crane and a power line, the only method to completely eliminate hazards associated with crane operation near electric power lines is to de-energize and ground the power lines prior to crane operation. Therefore, it is necessary to implement a risk management system based on a risk assessment to develop a safe system of work for the operation/jobsite. Any changes to the operation or jobsite conditions may require a review and modification of the safe system of work.

ANNEX

European Machinery Regulation (2023), Annex III clause 3.5.4

The following text is copied from REGULATION (EU) 2023/1230 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 June 2023 on machinery and repealing Directive 2006/42/EC of the European Parliament and of the Council and Council Directive 73/361/EEC.

[...]

3. SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS TO OFFSET RISKS DUE TO THE MOBILITY OF MACHINERY

[...]

3.5. PROTECTION AGAINST OTHER RISKS

[...]

3.5.4. Risk of contact with live overhead power lines

Depending on their height, mobile machinery or related products shall, where relevant, be designed, constructed and equipped, so as to prevent the risk of contact with an energised overhead power line or the risk of creating an electric arc between any part of the machinery or an operator driving the machinery and an energised overhead power line.

When the risk to the persons operating machinery incurred by the contact with an energised overhead power line cannot be fully avoided, mobile machinery or related products shall be designed, constructed and equipped so as to prevent any electrical hazards.

[...]“

BIBLIOGRAPHY

There are various standards, regulations and guidance documents from different countries and organizations that address avoiding contact to energized power lines and provide guidance for such operations:

- Cranes and Derricks in Construction, Final Rule, Department of Labor, OSHA Federal Law 29 CFR part 1926 Subpart CC 1926.1407 thru 1926.1411ff, published 2010.08.09.

- Mobile and Locomotive Cranes, ANSI B30.5, published 2021.17.12 (next revision is scheduled for 2024).

- Preventing Electrocutions of Crane Operators and Crew Members working near Overhead Power Lines, NIOSH Publication 95-108, published May 1995, last reviewed 2014.06.06 (still refers to NIOSH Safety Alert from 1995, see [4] below).

- Preventing Electrocutions of Crane Operators and Crew Members working near Overhead Power Lines, NIOSH Alert – Worker/employer Summary Sheet, published 1995.05.

- Information Circular 9510 – A performance Evaluation of Two Overhead Power Line Proximity Warning Devices – NIOSH Dated: November 2008.

- Electromagnetic Fields (EMF) in High Voltage Power Lines, The Fragmentation Paradox, see https://thefragmentationparadox.blogspot.com/2014/03/electromagnetic-fields-emf-in-high_16.html.

- Deadly Power Line Contact with Cranes, DOSH Hazard Alert, published 2012.07 ESV urges caution after crane hits power lines, Media Release Energy Safe Victoria, published 2021.04.13.

- Examples for specialized equipment with isolated work baskets to perform work on energized power lines, aka utilities, see: https://www.terex.com/utilities/en/products/overview.

- Bericht über messtechnische Untersuchungen an Hochspannungswarneinrichtungen im Einsatz an mobilen Arbeitsmaschinen, insbesondere an Betonpumpen – Technische Universität Dresden, 2006 („Report, Measurements of High Voltage Detection Devices used on mobile Machinery, in particular Concrete Pumps“).

There may be other publications to consider depending on location (e.g., local, state, country regulations).

ICSA MEMBERS

This document has been reviewed and jointly adopted by the following member associations of the ICSA:

- **Association of Equipment Manufacturers [AEM]**
- **Canadian Crane Rental Association [CCRA]**
- **The Crane Industry Council of Australia [CICA]**
- **The European Association of abnormal road transport and mobile cranes [ESTA]**
- **European Materials Handling Federation [FEM]**
- **Japanese Crane Association [JCA]**
- **Specialized Carriers & Rigging Association [SC&RA]**

This document is maintained by the Specialized Carriers & Rigging Association (SC&RA).

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