Data Sheet 743
Rev. April 2016

Mobile cranes and power lines

Injuries and fatalities resulting from crane booms and cables contacting live power lines account for a significant percentage of construction site incidents. According to OSHA, hundreds of construction workers die every year in the U.S. while on the job. In 2011 alone, there were over 700 fatalities. The third leading cause of these deaths is electrocution. Electrocutions cause one of every ten construction worker deaths, with nearly 70 deaths in 2011. (https://www.osha.gov/dts/vtools/construction/crane_powerline_fnl_eng_web_transcript.html).

1. This data sheet deals only with the operation of mobile cranes near energized power lines and not with general operating practices for mobile cranes. The purpose of this sheet is to help reduce injuries by giving owners and operators information and guidelines on how contacts occur and how they can be avoided. The goal is to eliminate power line contacts through informed and responsible crane operation.

Hazards of operation near power lines

2. The safe operation of a mobile crane in ordinary lifting and carrying operations requires skill and training on the part of the operator and the undivided attention of all crew members. Operation of a crane near (within two boom lengths) a power line is dangerous and must be recognized as a hazardous operation that requires extra precautions, including the designation of a person whose only duty is to observe clearance of the equipment and give timely warning.

3. Factors frequently associated with incidents when operating mobile cranes near overhead power lines are:

- **a.** Movement of loads to and from storage areas located under a power line
- **b.** Highway construction and maintenance, including placing and removing concrete traffic barriers or guard rails on highways with adjacent and crossing power lines
- **c.** Highway bridge construction near energized lines
- **d.** Picking up and carrying a light load across a field on an “off road” accessory path or along a highway

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e. Core or post hole drilling or pile driving near energized lines

f. Moving crane near energized lines

g. Operating parallel to power line and swinging in the wrong direction

h. Booming out or swinging into an energized wire that appears further away because of the difficulty in judging distance

i. While erecting or replacing outdoor advertisements along roadways (i.e., billboards).

Applicable regulations

4. OSHA provides regulations applicable within the United Stated for safe operation of cranes near power lines in 29 *CFR*, 1926.550(a)(15)-Cranes and Derricks.[1] This subsection covers non-energized power lines; mandates minimum clearance between power lines and crane or load, in operation and in transit; requires the designation of a signal person or spotter to observe clearance and give timely warning; mentions the use of cage boom type guards, insulating links and proximity warning devices; and lists precautions to be taken near a transmitter tower. Because many states, municipalities and other countries may have other regulations, the owner and operator should know the rules and standards applicable to the location where the crane is being operated.

Preoperation safety measures

5. Long before the start of any major construction project, the problems of power lines near work areas need to be recognized, studied and resolved. It is done by prudent and conscientious contractors during the prebid stage of the contract. The important thing is to call the electric utility company early during the prebid planning stage. At that stage, you will know if the power line can be de-energized or if other precautions will be needed during the job.

6. When construction is to start, there should be a meeting of property owners, general contractors, subcontractors, the supervisor of crane operations and any other responsible entities and the electric utility. They need to discuss possible hazards and to agree on measures necessary to ensure that equipment will not be exposed to accidental contact with energized power lines. When any crane lift or other operation is to be done near energized power lines, the crane operator or job supervisor should advise the electric utility and should take whatever steps necessary to ensure safety throughout the project. Storage under power lines of any equipment or material that might be lifted by a crane should be prohibited. A job safety analysis can be conducted for the anticipated crane operations.

7. To reduce the potential for crane power line contact, safeguards can include:

a. Temporarily de-energizing and visibly grounding the wires

b. Relocation or burial of power lines to minimize the hazard

c. Placing flagged warning ropes at appropriate distances below and to the sides of the power lines

d. Erecting fences 15 feet horizontally from the parallel to the outside conductors on each side of the power line, with signs mandating that nothing requiring crane handling shall be stored within the fenced area

e. Erecting structures of non-conducting material (not attached to the crane) to put a physical barrier between power lines and the crane

f. At site entrances where equipment must be moved frequently under the power line:

- Install special warning signs.
- Put orange balls on the lowest outside wires to call attention to them.
- Raise or bury the wires.
- Erect goal posts (rider poles) on both sides of the line with cross bars at least 4 feet lower than the lowest wire (Figure 1).

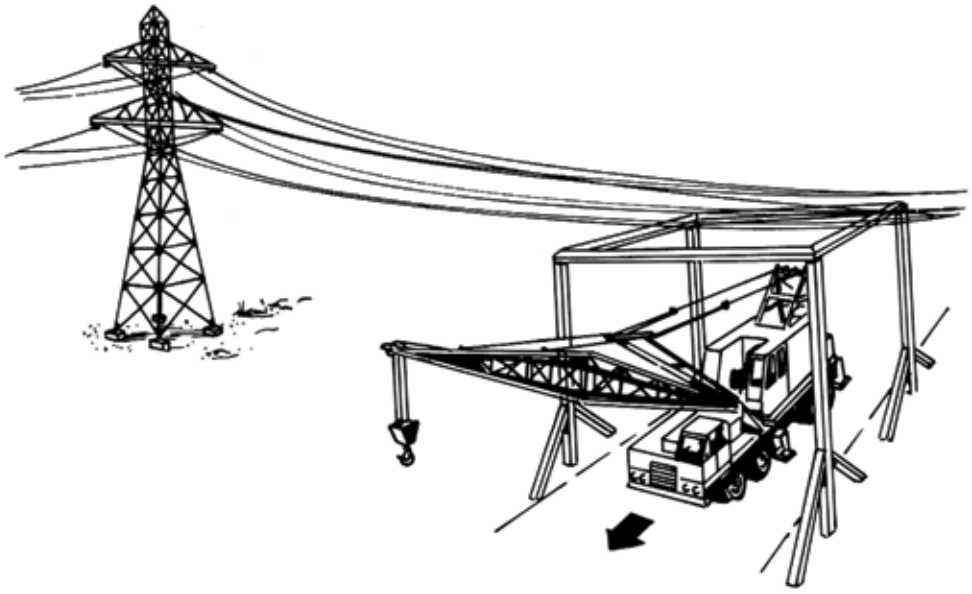

Figure 1. Ensure that whenever cranes must repeatedly travel beneath power ines, a route is plainly marked and "rider poles" are erected on each side of the crossing approach to ensure that the crane structure is lowered to a safe height. *(Figures 1 and 5 are redrawn from Mobile Crane Manual with permission from Construction Safety Association of Ontario)*

g. Temporarily covering wires with insulating sleeves if the voltage is not too high determined by the utility.

Note: None of these safeguards should be taken in any way as altering the regulations or decreasing the minimum clearances established by OSHA[1]. Note also remedies a, b, c and g can be implemented only by the proper utility personnel. Finally OSHA[1] cautions: "Any overhead wire shall be considered to be an energized line unless and until the person owning such line or the electrical utility authorities indicate that it is not an energized line and it has been visibly grounded."

8. When a crane is to be operated near a power line, OSHA[1] requires "A person be designated to observe clearance between the equipment and power lines and give timely warning for all operations where it is difficult for the operator to maintain the desired clearance by visual means." Steps must be taken to ensure reliable communication (i.e., a clear radio channel) between the spotter and operator, especially at night and in inclement weather.

Safety measures for operating near energized power lines

9. Operating a crane very near a power line places a burden of responsibility on the crane operator and crew beyond the demands of an ordinary operation. (Very near in this circumstance means closer than two boom lengths). Since the full and undivided attention of the operator and other members of the crew is already needed to operate the crane and guide the load, OSHA[1] requires (except where electrical distribution and transmission lines have been de-energized and visibly grounded at point of work, or where insulating barriers, not a part of or an attachment to the equipment or machinery, have been erected to prevent physical contact with the lines) that minimum clearances for any part of crane or load be maintained as follows:

a. For lines rated 50 kV or below: 10 feet.

b. For lines rated over 50 kV: 10 feet plus 0.4 inch for each 1 kV over 50 kV; never less than 10 feet.

c. In transit with no load and boom lowered: 4 feet for voltages lower than 50 kV, 10 feet up to 345 kV and 16 feet up to 750 kV.

For altitude over 3,300 feet, increase all distances by 3 percent for each additional 1,000 feet, per National Electrical Safety Code, ANSI C2-1990, section 234F4.[2]

10. The operator may be unable to maintain the required clearance by visual means because the human eye is not capable of judging with any degree of accuracy the distance to a smooth horizontal wire in space.[3] It is, therefore, essential that a qualified spotter be provided.[4] While the operator knows quite accurately where the boom tip, the load line and the load are, he/she cannot tell by looking from his/her place at the controls how far they are from the nearest power wire.

Crane operation near radio, radar or television transmitting towers

11. As required by OSHA,[1] prior to work near transmitter towers where an electrical charge can be induced in the equipment or materials being handled even when the tower is at a considerable distance, the transmitter shall be de-energized unless tests have been made that demonstrate no significant electrical charge is being induced into the crane.

12. As required by OSHSA,[1] the following precautions must be taken when it is necessary to dissipate induced voltage:

- **a.** The equipment shall be provided with an electrical ground directly to the upper rotating structure supporting the boom.
- **b.** Ground jumper cables shall be attached to materials being handled by the crane when an electrical charge is induced while working near energized transmitters.
- **c.** Crews shall be provided with non-conductive poles having large alligator clips or other similar apparatus that can be used to safely attach the ground cable to the load.
- **d.** Combustible and flammable materials shall be removed from the immediate area prior to operations.

Auxiliary equipment

13. Three devices designed to provide added protection (especially for ground crews) are described by the National Safety Council's *Accident Prevention Manual for Business and Industrial Engineering Technology*, 14th Edition. This equipment is no substitute for an alert, well-trained operator. Sole reliance should not be placed on these devices because, if they fail, the results could be deadly.

- **a.** A proximity warning device can be installed on the crane, which sounds an alarm to warn the operator and ground crew when the crane boom is brought near any electrically charged equipment or line. A PWD, set for maximum sensitivity, will sound early warning when the crane is 100 feet or more from typical power lines and can be adjusted to warn of lesser distances.
- **b.** Another device is a cage-like insulating guard that can be attached to the top side of the boom. It is intended to prevent contact with the wire.
- **c.** An insulated safety link that can be installed between the load hook and load attachment cables, or the line hook and sling is also available to provide protection for the hook-up person.

If cage-type boom guards, insulating links or proximity warning devices are used on cranes, such devices must not be a substitute for the requirement of a specifically assigned signal person, even if such devices are required by state or local regulations.

14. The use of tag lines should be avoided except where it is possible for the load to spin into the power line. The use of non-conducting tag lines reduces the likelihood of injury. The line must be dry and such materials as polypropylene rope are the best.

15. As stated by OSHA,[1] compliance with practices recommended in paragraphs 4 and 10 and not

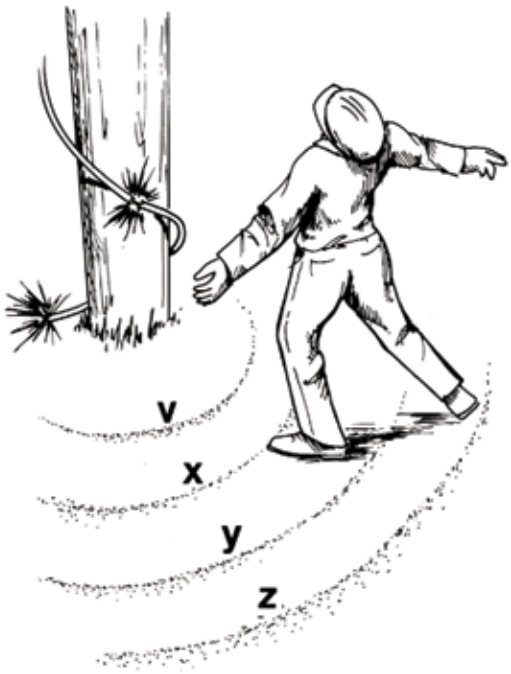

Figure 2. The ground becomes electrified around the point of electrical contact in a rippling pattern known as "ground gradient." As you move away from the point of contact, the voltage drops progressively. Thus, if one foot is at y voltage and the other is at z voltage, the difference in voltage will cause a flow of electricity through the body. Run, (don't walk,) or hop away from the point of contact with feet together.

reliance on the devices described in paragraph 13, shall be followed in determining proximity of the crane and its protuberances, including load to electric power lines.

Electrical shock—cause and effect

16. Electrical shock occurs when two parts of the human body (a hand and a foot, for example) simultaneously contact two objects of differing voltages, usually one energized and one grounded. If the voltage difference is high enough to produce electric current in the human body of more than a few thousandths of an ampere, that current will be felt, and this occurs at voltages lower than 100 volts. Symptoms of current in the human body range from mild discomfort to severe pain and death. The most severe effects include: loss of ability to control muscles and involuntary muscular action, fibrillation of the heart (stops beating effectively) causing death unless cardiopulmonary resuscitation is administered promptly, and severe burns that may or may not be fatal.

Shock avoidance while crane is in contact with power line

17. When a crane is inadvertently brought into contact with an energized power line, the crane and its cable and suspended load become electrified to the same voltage as the line. In addition to this electrifying of the crane, the ground around the outriggers and around crane wheels or tread becomes dangerously electrified.

18. 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 (Figure 2). This effect is known as "ground gradient."

19. Workers near the electrified crane should avoid touching the crane,* and should run** (or hop with feet together***) away from it, not stopping until they are well away. Workers should not stop under the power line because it could melt and fall, putting energized wires on the ground.

20. The operator within the crane is usually in no danger of shock. The operator is contacting only the crane (not the power line or ground), which is at only one potential (that of the power line). Like a bird sitting on a power wire, the operator is not being shocked. The operator should act promptly to maneuver the boom out of and away from the power line, proceeding in the manner least likely to cause the power line to break. If the line is in danger of breaking, for example, if the crane is welded to it, the operator should wait until the line is de-energized.

21. In any event, the operator should remain in the cab until the crane is well clear of the power line, or it is de-energized and grounded. If threat of fire or other serious danger necessitates leaving the crane, the operator should jump off the crane, being careful not to touch the crane and ground simultaneously,* and then run** (or hop***) away from the crane as described above.

22. If a worker should become electrically entangled at or near the crane, no one should attempt to rescue or aid the victim until the crane is altogether out of and away from the power line, or the power line has been de-energized and grounded— lest the would-be rescuer also becomes a victim.

23. One should also be aware that power line protective relays and circuit breakers may de-energize the line when crane contact occurs, and then automatically re-energize it in a few seconds or a few minutes; and this sequence can occur more than once. No power line should be assumed de-energized and safe to approach until it has been de-energized by the utility and visibly grounded.

24. Before using the crane after a power line contact, it should be thoroughly checked for any electrical, electronic or mechanical damage and especially damage to the load line. It should be given a complete function test.

*With the crane in contact with an energized power line wire, the high voltage difference between it and ground will almost certainly severely burn or kill anyone touching the crane and ground simultaneously. **With the crane in contact with an energized power line wire, and with the accompanying electrification of the ground around the crane, a worker standing with feet apart can be subjected, feet and legs, to electric current causing loss of muscular control. The worker would fall, making the situation much worse. Attempting to walk has the same negative effect because with each step, both feet are on the ground in different "rings" and a potential voltage difference is likely. In running, however, a person lifts one foot before setting the other down, and the problem is avoided. The best advice is, "Run, don't walk!" or hop (feet together).

***Hopping with both feet together provides the same protection as running, in that both feet together are touching only one small area of ground, at any one time. Hopping or running, one must be extremely careful not to fall, as one would then be touching the ground at points several feet apart with potentially disastrous results.

Operator training

25. To improve safety in the operation of cranes near power lines and lower the high incidence of injuries and fatalities, crane operators, crews and their supervisors, must be trained and aware of the dangers and avoidance techniques, when operating a crane around any electric power lines (Ref. OSHA 1926. Safety and Health Regulations for Construction Cranes & Derricks in Construction Power Line Safety (up to 350 kV) Equipment Operations)

Arcing in air

26. Inaccurate information is sometimes quoted concerning arcing and therefore, the following information is included for the reader's information. Its inclusion is not intended in any way to suggest operating closer to power lines that the distances mandated by OSHA[1] or by any applicable local or state regulations.

27. Arcing is the conduction of electricity through air, as between a power line and a crane. For the arc to start, the crane must get close enough to the 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 1

inch for each 8 kV.[5] 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 1 inch for each 8 kV.[5]

28. Induced voltages can occur on rubber-tired equipment near high voltage transmission lines, even though the equipment is in full compliance with OSHA-mandated clearance (see paragraph 9 above), and far from touching the lines. This is the same condition that occurs around transmitting towers (see paragraphs 11 and 12), and the same precautions should be followed.

29. It is sometimes suggested that between a crane boom and a nearby power line wire there exists a force of attraction pulling each toward the other. This is true, but such forces are so small as to be completely insignificant. As an example, a crane boom oriented parallel to and 10 feet from an 8 kV wire is subject to an attractive force of approximately one one-thousandth (1/1000) of one ounce.

Sources of information

[1]OSHA Standards, *29 Code of Federal Regulations (CFR)* 1926.550-Cranes and Derricks.

[2]*National Electrical Safety Code*, ANSI C2-1990, section 234F4.

[3]Construction Safety Association of Ontario, Mobile Crane Manual, 1985.

[4]Accident Prevention Manual for Business & Industry Engineering Technology, 14th Edition.

[5]IEEE Recommended Practice For Grounding of Industrial and Commercial Power Systems, ANSI C114.I-1982/IEEE Std. 142-1982, p.73.