State of California
Department of Industrial Relations
Memorandum

To: Marley Hart, Executive Officer
Occupational Safety and Health Standards Board
2520 Venture Oaks Way, Suite 350
Sacramento, CA 95833

Date: November 19, 2015

From: Juliann Sum, Chief

Division of Occupational Safety and Health
Department of Industrial Relations

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OCCUPATIONAL SAFETY AND HEALTH
STANDARDS BOARD

Re: Petition No. 551 to amend Title 8 Safety Orders

1.0 INTRODUCTION AND BACKGROUND

On September 3, 2015, the Division of Occupational Safety and Health (Cal/OSHA) received a petition, filed by Ronald Rudolph (petitioner), to amend Title 8 California Code of Regulations. The petitioner is an Adjunct Industrial Technology Instructor at the Institute of Technology in Clovis California, but has submitted the petition on his behalf only.

The petition requests new regulatory language in Title 8 Section 3423. This section contains requirements to protect employees from electrical hazards during tree work. The following is an evaluation of the petition.

2.0 PETITIONER'S REQUEST

The petitioner is requesting a new regulatory requirement in Title 8 Section 3423 that aerial devices used in tree work be equipped with a proximity-warning device for high-voltage power lines. The warning devices would alert employees if an aerial device moves within a preselected minimum distance of a high-voltage power line. Specifically, the petitioner is requesting the proximity alarm to be equipped with an alternating current (AC) Gauss meter that would detect the magnetic field created by the current running through the power line. No specific regulatory language was suggested by the petitioner for the requested change.

3.0 HAZARDS TO EMPLOYEES OPERATING AERIAL DEVICES NEAR ENERGIZED POWER LINES

Hazards to employees operating aerial devices near high-voltage electrical power lines are well documented in Cal/OSHA's inspection records. Injuries commonly occur when an employee encroaches too closely while distracted or attempting to perform an operation that is in close proximity to the line. With voltages in range of 12kV and higher, serious or fatal injuries are likely in the event that an employee comes into contact with a high-voltage electrical power line. Common injuries resulting from such incidents include:

1. Electrocution
2. Electric shock
3. Arc flash burns
4. Fractures
5. Contusions

4.0 EXISTING TITLE 8 REGULATIONS – Required clearances from power lines are a function of the voltage (electric potential energy per unit charge) in the power line

Current Title 8 regulations specify that an employee's body, conductive tools or equipment being used, or parts of trees being worked upon, cannot come or be within a certain distance of high voltage power lines while performing power line clearance tree trimming operations. The distance is dependent on the voltage of the power lines.

Qualified line clearance tree trimmers or supervised trainees must maintain a distance of 2.1 to 15 feet from high voltage power lines (section 2940.2) while other workers must maintain a distance from 10 to 35 feet from high voltage power lines (section 2950) during tree trimming work. Boom-type lifting or hoisting equipment must be 10 to 42 feet from high voltage energized power lines and can never be used directly above the power lines regardless of distance (section 2946). The employer is responsible for ensuring that employees do not violate the distance requirements.

Title 8 regulations do not specify how to measure distances from high voltage power lines or how to ensure that employees or uninsulated equipment do not come within the minimum distances. However, Title 8 requires the employer to train tree trimming employees to recognize electrical hazards (section 3423). Employers are also required to locate and identify all electrical conductors and equipment within the work area prior to beginning tree work (section 3427) and determine a safe method of performing the work (section 2951). In addition, a qualified line clearance tree trimmer must have a minimum of 18 months-related training and on-the-job experience and be familiar with the special techniques and hazards involved in line clearance tree trimming operations (section 2700).

The minimum safe distances can be maintained by using specialized insulated tools of known length to work on or near high voltage equipment, by use of non-contact distance measuring devices (such as a laser distance meter) or through a conservative visual estimation of the distance.

4.1 High Voltage Safety Orders (Sections 2700 - 2989.1)

The High-Voltage Electrical Safety Orders Article 38 sections 2950 and 2951 are specific to preventing unsafe proximity and contact with high voltage overhead power lines during tree trimming operations. Article 38 incorporates the distance requirements of section 2940.2 (in Article 36 of the High-Voltage Safety Orders) for qualified line clearance tree trimmers.

The High-Voltage Safety Orders Article 37 of the high voltage safety orders contains requirements for preventing accidental contact with overhead power lines. The general requirements of this article are superseded by the vertical requirements of preventing contact with high voltage lines during tree trimming in Article 38 (Line Clearance Tree Trimming Operations). However, Article 37 section 2940.2 contains specific requirements for boom-type hoisting equipment not addressed in Article 38.

The relevant regulations in the High-Voltage Safety Orders are the following:

High-Voltage Electrical Safety Orders
Article 36. Work Procedures and Operating Procedures
§2940.2. Clearances.

(a) No employee shall be permitted to approach or take any conductive object without an approved insulating handle closer to exposed energized parts than shown in Table 2940.2-1 through Table 2940.2-3 unless:

(1) The employee is insulated or guarded from the energized part (gloves or gloves with sleeves rated for the voltage involved shall be considered insulation of the employee from the energized part), or

(2) The energized part is insulated or guarded from the employee and any other conductive object at a different potential.

(b) When performing work with live line tools, minimum clear distances in Table 2940.2-1 through Table 2940.2-3 shall be maintained. Conductor support tools, such as link sticks, strain carriers, and insulator cradles, shall be permitted to be used provided that the clear insulation is at least as long as the insulator string or the minimum distance specified in Table 2940.2-1 through Table 2940.2-3 for the operating voltage.

TABLE 2940.2-1 ALTERNATING CURRENT - MINIMUM APPROACH DISTANCE	
Nominal Voltage in Kilovolts Phase to Phase	*Distance Ft-in*
0.6 to 15	*2-1*
15.1 to 36.0	*2-4*
36.1-46.0	*2-7*
46.1-72.5	*3-0*
72.6-121	*3-4*

121.1-145	*3-7*
145.1-169	*4-0*
169.1-242	*5-3*
242.1-362	*8-6*
362.1-552	*11-3*
552.1-765	*15-0*

NOTE 1: These distances take into consideration the highest switching surge an employee will be exposed to on any system with air as the insulating medium and the maximum voltages shown.

NOTE 2: The clear live-line tool distance shall equal or exceed the values for the indicated voltage ranges.

(f) With the exception of emergency restoration procedures, line clearance tree trimming work shall not be performed when adverse weather conditions such as thunderstorms in the immediate vicinity, high winds, snow storms or ice storms, make the work hazardous in spite of the work practices required by this section.

* * * * *

High-Voltage Electrical Safety Orders
Article 37. Provisions for Preventing Accidents Due to Proximity to Overhead Lines
§2946. Provisions for Preventing Accidents Due to Proximity to Overhead Lines.

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TABLE 2	
Boom-type lifting or hoisting equipment clearances required from energized overhead high-voltage lines.	
Nominal voltage (Phase to Phase)	Minimum Required Clearance (Feet)
600.....50,000	10
over 50,000.....75,000	11
over 75,000.....125,000	13
over 125,000....175,000	15
over 175,000....250,000	17
over 250,000....370,000	21
over 370,000....550,000	27
over 550,000....1,000,000	42

High-Voltage Electrical Safety Orders
Article 38. Line Clearance Tree Trimming Operations
2950. Application.

(a) This article shall apply to all line clearance tree trimming operations performed in the vicinity of exposed energized overhead conductors and equipment where any part of the employee's body, tools or equipment being used, or parts of trees being worked upon, is likely to come within the distances specified in Table 1 of this section.

(b) Minimum approach distances to energized conductors for persons other than qualified line clearance tree trimmers and trainees shall be maintained in accordance with Table 1.

EXCEPTION NO. 1: A qualified tree worker as defined in the General Industry Safety Orders (GISO), Section 3420(b) may perform tree trimming activities within 10 feet, but no closer than 1 foot, of energized low voltage (600 volts or less) power lines and conductors, provided the provisions in GISO Section 3423 related to such work are met.

EXCEPTION NO. 2: A qualified telecommunication worker as defined in Section 8601 of the Telecommunication Safety Orders when performing restoration work or other emergency work, provided the employee is trained and experienced in the special techniques and work procedures required to avoid the hazards of line clearance tree trimming operations.

EXCEPTION NO. 3: A qualified electrical worker as defined in Section 2700 of the High Voltage Electrical Safety Orders when performing restoration work or other emergency work, provided the employee is trained and experienced in the special techniques and work procedures required to avoid the hazards of line clearance tree trimming operations.

Table 1

Minimum approach distances to energized conductors for persons other than qualified line-clearance tree trimmers and trainees

Nominal voltage in kilovolts (kV) phase to phase*	*Distance*	
	Ft-in	Meters
0.0 to 1.0	10-00	3.05
1.1 to 15.0	10-00	3.05
15.1 to 36.0	10-00	3.05
36.1 to 50.0	10-00	3.05
50.1 to 72.5	10-09	3.28
72.6 to 121.0	12-04	3.76
138.0 to 145.0	13-02	4
161.0 to 169.0	14-00	4.24
230.0 to 242.0	16-05	4.97
345.0 to 362.0	20-05	6.17
500.0 to 550.0	26-08	8.05
785.0 to 800.0	35-00	10.55

**Exceeds phase to ground minimum approach distances per the federal standard, 29 CFR 1910.333.*

High-Voltage Electrical Safety Orders
Article 38. Line Clearance Tree Trimming Operations
§2951. Line Clearance Operations.

(a) Prior to commencing line clearance tree trimming operations, the employer shall ensure that an inspection of the work locations is made in order to identify potential hazards and a tail gate briefing is conducted to discuss the work procedures to be followed.

(b) Only qualified line clearance tree trimmers, or trainees under the direct supervision and instruction of qualified line clearance tree trimmers, shall be permitted to perform line clearance tree trimming operations as described in Section 2950. Under no circumstances shall the minimum distance specified in Section 2940.2(b) Table 2940.2, be violated.

(c) The employee in charge of each independent crew shall coordinate the de-energizing and re-energizing of high-voltage lines with the operator of the high-voltage line(s).

(d) During all tree trimming operations performed in accordance with the requirements of subsection (b) above, there shall be another qualified line clearance tree trimmer or trainee at each work location to render immediate assistance.

NOTE: A qualified high-voltage electrical worker shall be permitted to be the second employee, provided the employee doing the line clearance tree trimming is a qualified line clearance tree trimmer.

(e) Branches contacting energized conductors or equipment shall be removed only by using nonconductive equipment.

4.2 General Industry Safety Orders (Sections 3200-6184)

In addition to the High-Voltage Safety Orders, Article 12 of the General Industry Safety Orders also contains regulations specific to tree trimming near high-voltage lines. These regulations require employers to evaluate electrical power line hazards at a worksite, provide employees with information on the hazard of overhead power lines and establish safe work practices for employees when working near overhead power lines.

The relevant General Industry regulations are the following:

General Industry Safety Orders
Group 3. General Plant Equipment and Special Operations
Article 12. Tree Work, Maintenance or Removal
§3423. Electrical Hazards, General.

(a) Employees engaged in tree work operations such as, but not limited to, tree trimming, maintenance and removal in proximity to electrical equipment and conductors, shall be instructed regarding the following:

(1) To consider all such equipment to be energized with potentially fatal voltages, never to be touched (contacted) either directly or indirectly.

(2) Electrical shock will occur when a person, by either direct contact or indirect contact with an energized electrical conductor, energized tree limb, tool, equipment, or other object, provides a path for the flow of electricity to a grounded object or to the ground itself. Simultaneous contact with two energized conductors phase to phase will also cause electric shock that may result in serious or fatal injury.

(3) Electrical shock may occur as a result of ground fault when a person stands near a grounded object. For example, if an uninsulated aerial device with its outriggers down comes into contact with a conductor.

(4) In the event of a downed energized electrical conductor or energized grounded object, there exists the hazard of step potential.

(b)(1) Employees shall not perform tree trimming activities within 10 feet of high voltage energized power lines and conductors unless the employee meets the requirements of subsection (c).

(2) A qualified tree worker shall be permitted to perform tree trimming activities within 10 feet, but no closer than 1 foot, of energized low voltage (600 volts or less) power lines and conductors, provided that the qualified tree worker is trained and competent in the following:

(A) The skills and techniques necessary to identify components of an electrical system, including the ability to distinguish exposed live parts from other parts of electric equipment;

(B) The skills and techniques necessary to determine the difference between low and high voltage energized conductors and equipment;

(C) The minimum approach distances that must be maintained as specified in this section corresponding to the voltages to which an employee will be exposed, and

(D) The skills and work practices necessary to avoid contact with electrical lines and conductors, including the use of personal protective equipment and insulating or non-conductive tools.

(c) Line clearance tree trimming operations as defined in Section 2700 of the High-Voltage Electrical Safety Orders (related to electrical equipment and conductors in excess of 600 volts) shall be conducted in accordance with Article 38 of the High-Voltage Electrical Safety Orders. Only qualified line clearance tree trimmers, or trainees, as defined in Section 2700 of the High-Voltage Electrical Safety Orders shall be permitted to perform such line clearance tree trimming work.

NOTE: Sections 2940.2 and 2951 of the High-Voltage Electrical Safety Orders provide minimum approach distances and requirements for line clearance operations.

(d) Metal core rope used in a climbing system shall not be used in proximity to energized electrical equipment and conductors.

General Industry Safety Orders
Group 3. General Plant Equipment and Special Operations
Article 12. Tree Work, Maintenance or Removal
§3427. Safe Work Procedures.

(a) Climbing and Access.

(1) Prior to climbing the tree, the employer shall ensure that the tree, including the root collar, is visually inspected by a qualified tree worker who shall determine and ensure a safe method of entry into the tree. The location of all electrical conductors and equipment within the work area shall be identified in relation to the work being performed. Climbing lines, ropes, lanyards, and other climbing equipment shall be inspected in accordance with the provisions of Section 3422(j) of this Article 12.

(A) Only when a tree cannot be safely accessed by climbing or the use of aerial devices, a qualified tree worker may be hoisted into position by using an approved tree worker's saddle secured to a crane's hook that shall be closed with a positive locking device. The tree worker's saddle shall also be secured to an independent line attached above the crane hook, and the following criteria shall be met:

* * * * *

(B) Special Training Requirements. The employer shall ensure that every qualified tree worker involved in tree work utilizing a crane to position personnel into a tree under the provisions of Section 3427(a)(1)(A), receives instruction and training on such work and is competent in the following areas:

* * * * *

5. Instructions regarding electrical hazards as described in Section 3423.

* * * * *

(4) The tie-in point shall be established on or around the main leader or a major upright branch of the tree as high as necessary using branches with a wide crotch to prevent any binding of the climbing line. The crotch selected for tying-in shall be over the work area as nearly as possible, but located in such a way that a slip or fall would not permit the employee to come in contact with any electrical conductor, equipment or other hazard.

* * * * *

(c) Felling.

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(5) Prior to the start of any tree felling or removal operations, the hazards and relevant factors pertaining to the tree and the site are to be considered by undertaking actions that include, but are not limited to, the following:

5.0 APPLICABLE FEDERAL OSHA REGULATIONS

Federal OSHA regulations do not specifically address electrical hazards of employees conducting tree maintenance and removal that are not line-clearance activities. Electrical hazards of line-clearance activities are addressed in the Code of Federal Regulations, Section 1910.269(r):

1910.269(r)(1)

Electrical hazards. This paragraph does not apply to qualified employees.

1910.269(r)(1)(i)

Before an employee climbs, enters, or works around any tree, a determination shall be made of the nominal voltage of electric power lines posing a hazard to employees. However, a determination of the maximum nominal voltage to which an employee will be exposed may be made instead, if all lines are considered as energized at this maximum voltage.

1910.269(r)(1)(ii)

There shall be a second line-clearance tree trimmer within normal (that is, unassisted) voice communication under any of the following conditions:

1910.269(r)(1)(ii)(A)

If a line-clearance tree trimmer is to approach more closely than 3.05 meters (10 feet) to any conductor or electric apparatus energized at more than 750 volts or

1910.269(r)(1)(ii)(B)

If branches or limbs being removed are closer to lines energized at more than 750 volts than the distances listed in Table R-5, Table R-6, Table R-7, and Table R-8 or

1910.269(r)(1)(ii)(C)

If roping is necessary to remove branches or limbs from such conductors or apparatus.

1910.269(r)(1)(iii)

Line-clearance tree trimmers shall maintain the minimum approach distances from energized conductors given in Table R-5, Table R-6, Table R-7, and Table R-8.

1910.269(r)(1)(iv)

Branches that are contacting exposed energized conductors or equipment or that are within the distances specified in Table R-5, Table R-6, Table R-7, and Table R-8 may be removed only through the use of insulating equipment.
***Note to paragraph (r)(1)(iv)**: A tool constructed of a material that the employer can demonstrate has insulating qualities meeting paragraph (j)(1) of this section is considered as insulated under paragraph (r)(1)(iv) of this section if the tool is clean and dry.*

1910.269(r)(1)(v)

Ladders, platforms, and aerial devices may not be brought closer to an energized part than the distances listed in Table R-5, Table R-6, Table R-7, and Table R-8.

1910.269(r)(1)(vi)

Line-clearance tree-trimming work may not be performed when adverse weather conditions make the work hazardous in spite of the work practices required by this section. Each employee performing line-clearance tree trimming work in the aftermath of a storm or under similar emergency conditions shall be trained in the special hazards related to this type of work.
***Note to paragraph (r)(1)(vi)**: Thunderstorms in the immediate vicinity, high winds, snow storms, and ice storms are examples of adverse weather conditions that are presumed to make line-clearance tree trimming work too hazardous to perform safely.*

General electrical hazard requirements for mobile equipment are addressed in Section 1910.333(c)(iii).

1910.333(c)(3)(iii)
"Vehicular and mechanical equipment."

1910.333(c)(3)(iii)(A)
Any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines shall be operated so that a clearance of 10 ft. (305 cm) is maintained. If the voltage is higher than 50kV, the clearance shall be increased 4 in. (10 cm) for every 10kV over that voltage. However, under any of the following conditions, the clearance may be reduced:

1910.333(c)(3)(iii)(A)(1)
If the vehicle is in transit with its structure lowered, the clearance may be reduced to 4 ft. (122 cm). If the voltage is higher than 50kV, the clearance shall be increased 4 in. (10 cm) for every 10 kV over that voltage.

1910.333(c)(3)(iii)(A)(2)
If insulating barriers are installed to prevent contact with the lines, and if the barriers are rated for the voltage of the line being guarded and are not a part of or an attachment to the vehicle or its raised structure, the clearance may be reduced to a distance within the designed working dimensions of the insulating barrier.

1910.333(c)(3)(iii)(A)(3)
If the equipment is an aerial lift insulated for the voltage involved, and if the work is performed by a qualified person, the clearance (between the uninsulated portion of the aerial lift and the power line) may be reduced to the distance given in Table S-5.

1910.333(c)(3)(iii)(B)
Employees standing on the ground may not contact the vehicle or mechanical equipment or any of its attachments, unless:

1910.333(c)(3)(iii)(B)(1)
The employee is using protective equipment rated for the voltage; or

1910.333(c)(3)(iii)(B)(2)
The equipment is located so that no uninsulated part of its structure (that portion of the structure that provides a conductive path to employees on the ground) can come closer to the line than permitted in paragraph (c)(3)(iii) of this section.

1910.333(c)(3)(iii)(C)
If any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines is intentionally grounded, employees working on the ground near the point of grounding may not stand at the grounding location whenever there is a possibility of overhead line contact. Additional precautions, such as the use of barricades or insulation, shall be taken to protect employees from hazardous ground potentials, depending on earth resistivity and fault currents, which can develop within the first few feet or more outward from the grounding point.

6.0 APPLICABLE CONSENSUS STANDARDS

5.1 ANSI A300 Standard

Tree maintenance (pruning) is addressed in Part 1 of the American National Standards Institute (ANSI) A300 – Pruning standard.

5.2 ANSI A92.2 Standard

The design, manufacture and safe operation of aerial devices is covered in ANSI A92.2. The design and manufacturing portions of ANSI A92.2 are incorporated by reference in Title 8 Section 3638.

Neither ANSI A300 nor ANSI A92.2 requires a high-voltage electrical detection and warning device for aerial devices.

7.0 Possible Warning Devices

7.1 Gauss meter would measure magnetic fields, which are created when electrical current flows through a power line

Energized power lines produce both magnetic and electric fields. Therefore, the presence of energized power lines may be detected by measuring either the magnetic field or the electric field surrounding them. The petitioner proposes to require that Gauss meters be used to warn of the proximity of high voltage power lines to aerial devices.

The magnetic fields of power lines flow in an orbital path around the line. The magnitude of the magnetic field depends on and is directly proportional to the magnitude of the current flowing through the line, which can vary significantly along the line.

7.2 Currently available proximity warning devices detect electrical fields created by the presence of voltage in a power line

Currently available proximity warning devices detect the electric fields around high voltage power lines instead of the magnetic fields.[1]

The electric fields flow radially out from power lines, and the strength of an electric field is a function of voltage in the line and remains constant irrespective of current flow. Thus, sensing of the electric field may be more reliable and produce more consistent results than attempting to detect the magnetic fields

Several high-voltage electrical proximity warning devices are currently available to employers, and at least two have patents pending. All proximity warning devices identified during the course of this evaluation operate with electric field strength meters. As discussed previously, no high voltage warning devices on the market use magnetic field detection.

The electric field detection devices provide an audible and/or visible warning for the operator of boom-type equipment when encroaching upon live high-voltage systems. Meters currently available come in both hard-wired and wireless models and can be adapted to function on most boom-type equipment. However, only two devices were identified that could be utilized on aerial devices. Those devices are equipped with antennas or probes used to detect the strength of a high-voltage power line electric field based on the voltage and proximity to the line. Most meters are equipped with

[1] Although the petitioner specifically requested the use of a Gauss meter to detect magnetic fields, the technology is not used and would not be reliable to warn employees of the proximity of high voltage lines. Because the petitioner seeks to provide a warning to employees operating aerial devices near high voltage lines, this evaluation also considers the use of electric field detection technology.

sensitivity adjustments that allow the operator to set a certain proximity distance at which the alarm will sound. Available devices have maximum detection ranges from 50 to 200 feet.

8.0 PETITIONER'S BASIS FOR NEW REGULATION

The petitioner asserts that many potentially serious and fatal injuries could be prevented by requiring the installation and use of a high voltage proximity alarm on aerial devices. In support of his assertion, the petitioner references an article taken from the Electrical Construction and Maintenance (http://ecmweb.com) periodical website. Based on this research, contact with electrical current was the seventh leading cause of workplace fatalities in the nation between 2003 and 2007 with a total of 1,213 deaths. An additional 13,150 workers suffered injuries from electrical incidents that resulted in lost work time. The petitioner did not identify how many of these incidents related to the use of aerial devices during tree trimming operations, although the petitioner did relay the hardship of one of his students who lost two relatives within six years when they were electrocuted while trimming trees from an aerial device.

9.0 ANALYSIS

9.1 Gauss meters would not be effective because the magnitude of magnetic fields is directly proportional to the magnitude of the current flowing through a power line, which can vary

As discussed in Section 7.0 of this evaluation, the magnetic field of energized high-voltage power lines depends on the current flowing through the line. This current, however, varies greatly within power lines at different locations, thereby creating magnetic fields of varying strengths[2]. Since Gauss meters measure magnetic fields, proximity warning devices using this technology would not be effective at determining distance from high-voltage power lines and protecting workers.[3]

9.2 Currently available proximity warning devices are not reliable because their performance is affected by the configuration and length of the equipment as well as the configuration of the power lines, even though the electrical fields they measure are proportional to the voltage in a power line.

9.2.1 NIOSH proximity warning device evaluation

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[2] Homce, Crawley and Hencheck. "A Performance Evaluation of Two Overhead Power Line Proximity Devices."CDC Workplace Safety and Health, Information Circular 9510. 2008. Print.

[3] David Andres, D; Stevick, G. Overhead Powerline Early Warning Devices for Cranes, Lifts and other Aerial Mobile Equipment. Berkeley Engineering And Research, Inc. May 15, 2014 (http://www.bearinc.com/papers/PowerlineWarningSystems.pdf)

In 2008, the National Institute of Occupational Safety and Health (NIOSH) conducted a performance evaluation of two hard wired electric field high-voltage proximity warning devices manufactured by SIGALARM and Allied Safety Engineering, respectively[3]. These two systems include spooled probes that must be installed along the entire length of the boom of boom-type equipment. The devices were installed on a mobile hydraulic boom crane operated in a controlled environment while encroaching upon live 13kV and 25kV high-voltage power lines. Representatives of both warning device manufacturers were present during the evaluation to oversee installation and sensitivity adjustment of the equipment. Tests were conducted with crane boom lengths of 28, 48.7, and 69.4 feet encroaching upon single and multiple line installations at differing voltages, orientations and phases. This evaluation identified four major factors that significantly affected the performance of the tested devices:

1. Equipment boom length
2. Equipment boom angle
3. Orientation of power lines
4. Phases of power lines

Both devices exhibited significant inconsistencies in performance at different boom lengths and angles of the test crane. The devices performed most poorly at the minimum boom length and 61 degree boom angle. Performance results indicated that the devices failed to alarm at the desired proximity during 89% to 94% of the tests at the minimum boom extension and 33% to 46% of the tests at a 61 degree boom angle. Accuracy of the systems during the tests in which an alarm did sound was shown to be poorest at the maximum boom length and 0 degree boom angle. These tests indicated averaged deviations in alarm distances of 160% and 145% to 205% for boom length and angle respectively.

The orientation of power lines was also shown to significantly affect the performance of these warning devices. Testing was conducted with lines of both 13kV and 25kV oriented parallel and intersecting at 90 degrees to each other. Results of testing indicated poorest accuracy of the systems encroaching upon intersecting lines. Average deviations of alarm proximities during these tests were from 90% to 215% with the worst accuracy exhibited with intersecting power lines of differing voltages.

Finally, reversal of current phase[4] within one of two parallel or intersecting power lines also significantly affected performance of the two tested devices. Reversal of the line phase during testing resulted in the lines with current of the same phase. Results of these indicated the greatest effect in the accuracy of parallel power lines of the same and different voltages. The 13kV/25kV line tests of the SIGALARM and ASE systems resulted in a 41% and 63% decrease in warning proximity respectively. Accuracy of the devices with intersecting lines of differing voltages, however, was shown to be most degraded with current of opposite phase.

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[4] Sinusoidal wave pattern of electrical current that is generated at a certain frequency e.g. 60Hz in the U.S.

9.2.2 Effectiveness of electric field proximity warning devices

Like Gauss meters, the use of electrical field proximity warning devices would not effectively protect employees from high-voltage hazards while working from aerial devices. Currently available devices that detect electric fields do not provide consistent warning and have operational limitations as indicated in the evaluation described in subsection 9.2.1. Additionally, these devices require sensitivity adjustments to be made at each approach to a power line due to the effect of differing voltages, phases, installation and boom lengths of equipment. This places a great deal of responsibility on the operator of an aerial device in order for these proximity devices to function effectively.

10.0 Conclusion

This evaluation included a review of statistical and personal information provided by the petitioner as well as materials from the manufacturers of proximity warning devices. Manufacturers' information included installation and operating procedures of several different proximity systems. Performance evaluations of these systems were also reviewed to assess the effectiveness of these systems in protecting employees from the hazards of high-voltage electrical power lines.

Cal/OSHA believes that the petitioner's request for an amendment of Title 8 Section 3423 should be denied. Gauss meters measure only magnetic fields, which are not directly correlated with voltage, and the performance characteristics of electrical field proximity warning devices are not of sufficient consistency and rely on too many variables to effectively protect employees from the hazards of contact with power lines.