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Evaluation of Two Proximity Warning Devices on a Mobile Elevating Work Platform

By Scott Raszeja, PE (NAFE 906A)

Abstract

Contact between a mobile elevating work platform (MEWP) and an energized overhead powerline (OHPL) is a warned-against event that is associated with damage to property as well as injury or death. The objective of this project was to evaluate the effectiveness of two different proximity warning devices (PWDs) installed on an MEWP operated near OHPLs. The general procedure used was to rotate the MEWP work platform horizontally away from, then toward, the OHPL from each side of the MEWP (at various platform heights), noting the distance between the MEWP and the OHPL when an alarm occurred. PWD2 allowed violation of the simulated OSHA boundary on 74.3% of the total rotations without initiating a warning alarm and was too sensitive to be practical as a startup alarm system. PWD1 did not allow operation of the MEWP within 20 feet of the actual OSHA minimum approach distance. The results of the startup test for PWD1 were nowhere near consistent.

Keywords

Proximity, warning, device, overhead, powerline, contact, mobile elevating work platform, lift, OSHA, safety

Introduction and Background

Hazards[1] are presented when working with cranes, mobile elevating work platforms (MEWPs), telescopic handlers, or similar equipment that operate with articulating/telescopic portions of the equipment above ground level. One hazard is contact with energized overhead power lines (OHPLs). Contact between an MEWP and an OHPL is a warned-against event associated with damage to (or loss of) property as well as personal injury or death.

To account for this hazard, the Occupational Safety and Health Administration (OSHA) dictated the minimum approach distance between equipment and an OHPL[2]. OSHA required a distance of at least 10 feet between equipment and any OHPL energized with a voltage of 50,000V (50kV) or less.

Multiple vendors have marketed proximity warning devices (PWDs) as an effective tool to warn equipment operators when approaching OHPLs. A PWD can be defined as a safety device that provides a warning of proximity to a power line. OSHA defines a proximity alarm as a device that provides a warning of proximity to a power line and has been listed, labeled, or accepted by a Nationally Recognized Testing Laboratory in accordance with 29 CFR 1910.7[3]. OSHA allows the use of PWDs, but not as primary protection from contact with OHPLs. For such a device to be an effective tool in preventing accidental contact with an OHPL, the PWD must consistently and reliably alert the operator when any portion of the equipment has encroached upon a specified distance from an OHPL. As with any warning device, inconsistent or unreliable operation of the alarm will reduce or eliminate the utility of the device, which, in turn, increases the risk of personal injury or death to users or ground personnel.

A great deal of effort has been expended to evaluate PWDs installed on aerial/telescopic cranes. Most PWDs are designed to detect the electric field that surrounds an OHPL. A review of the literature has revealed various issues and complexities inherent in electrical field sensing for OHPL detection. The literature has also revealed various issues with available PWDs. The goal of this project was to evaluate the effectiveness of two different PWDs installed on an MEWP operated in close proximity to OHPLs.

Purpose

The objective of the evaluation was to equip a telescopic boom MEWP with two PWDs. While using the MEWP (as it would typically be used and operated under reasonably foreseeable conditions proximate to overhead

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power lines), the author observed and documented performance of the PWDs in consideration of the OSHA-defined boundaries, and identified/documented factors during the above evaluation that influenced the PWDs' operation, accuracy, repeatability, practical utility, and reliability.

Operation of the MEWP occurred at a test site located in a secluded pasture. The PWDs were evaluated as an operational warning device, in which the PWDs warned the MEWP operator when approaching a preset boundary from the OHPLs. The PWDs were also evaluated as a startup device in which the PWDs (on startup) checked the environment for the presence of electromagnetic fields associated with OHPLs and warned the MEWP operator.

Electromagnetic Fields

OHPLs create an electromagnetic field surrounding the conductor. An electromagnetic field consists of both an electric field and a magnetic field.

The magnetic field strength surrounding OHPLs is primarily based upon the electric current moving through the conductors. The electric current can vary over time according to user demand, thus changing the strength of the magnetic field. The variable magnetic field strength becomes problematic for PWD manufacturers and the users of these devices who rely on the detection and quantification of the magnetic field as a method to determine proximity to an OHPL.

The electric field strength surrounding OHPLs is primarily based upon the voltage at which they operate. Power generation companies have become adept at maintaining consistent voltage levels throughout their distribution system. Consistent voltage levels allow PWD manufacturers to design equipment to sense electric field strength and make assumptions that the electric field strength surrounding an OHPL will remain consistent at a point in space over time. However, factors other than voltage can influence the electric field surrounding an OHPL, some of which include grounded objects in the area, phase orientation of the OHPLs, vertical and horizontal orientation of the OHPLs, and proximity to other OHPLs in the area.

Literature Review

The reviewed literature[4,5,6,7,8,9,10] provided an account of PWD evaluations and investigations from 1977 through 2014. The literature was reviewed to get a sense of the prior evaluations with regard to the reliability, repeatability, and general performance of the PWDs. The literature was also reviewed to gain an understanding of the methods used to test the PWDs and lessons learned from such tests. The overall intent of the review was to learn as much as possible from prior evaluations in order to construct the best possible test procedure for the current evaluation. Investigations also highlighted the difficulty inherent with using electric field sensing to accurately and repeatedly warn equipment operators when the equipment was in the vicinity of an OHPL.

PWD Descriptions and Implementation

Two PWDs were evaluated in this study. The first PWD is herein referred to as "PWD1".

PWD1, which was designed to sense magnetic as well as electric field strength surrounding an OHPL, had one sensor unit hardwired to the control module. The sensor unit had both the magnetic field sensor as well as the electric field sensor built into one enclosure. An audible alarm horn was connected to the control module to warn users when OHPLs were detected. PWD1 did not have the capability to create a setpoint.

The second PWD evaluated is herein referred to as "PWD2". Designed to sense the electric field strength surrounding OHPLs, PWD2 allowed for the connection of up to 12 wireless sensors, which communicated wirelessly (via Zigbee radio communication) to the control module. The extent of the effect, if any, of the Zigbee radio on the ability of the wireless sensors to accurately sense the electromagnetic field produced by the OHPLs was unknown and untested. The control module activated a two-tone audible alarm horn based upon the condition sensed. One tone indicated a "warning" condition, while the other indicated a "danger" condition. According to the PWD2 manual, *a warning status means the equipment is getting closer, but has not yet reached the danger zone. A danger status means the equipment has crossed into the danger zone.*

The PWD2 manual describes two modes of operation. As a startup device, the manual states: *Powering up: When power is first applied, the control module will search for sensors. No data will appear while connectivity is in progress (approximately 2 seconds). Once sensors are connected, the control module will go into a maximum setting. If any power lines are in the vicinity, the alarms will sound. The operator must select the reset button to revert the system to the last displayed setpoint.*

PWD2 was also used as an operational device. As an operational device, the manual states: *The operator must*

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decide what setpoint is appropriate for each and every job site. To adjust the setpoint, position the equipment at the desired location where an operator would like an alarm state, then depress the "one touch" button. This will change the setpoint to the greatest numerical sensor reading +5 at that position. When adjusting the setpoint, always position the equipment far enough away from the power line to give the operator time to react.

From that point, during normal use, PWD2 should have sounded an audible warning alarm when one or more sensors were within 80% of the setpoint and an audible danger alarm when one of the sensors matched the setpoint.

Test Boundaries and Parameters

The OHPLs present at the test site were energized with less than 50kV. Equipment used in the evaluation was required to maintain a 10-foot minimum approach distance from site OHPLs per OSHA regulations. The PWD2 setpoint was set at a distance of approximately 22 feet from the OHPLs for all tests. This allowed the PWD2 response to be tested at the simulated OSHA boundary (22 feet from the OHPL) as well as up to 10 feet closer to the OHPL (12 feet from the OHPL) while remaining beyond the actual 10-foot minimum approach distance required by OSHA. Once a setpoint location had been created, movement past the setpoint location, without an alarm, was considered a violation of the OSHA boundary.

Given that the actual OSHA minimum approach distance for the OHPLs at the test site was 10 feet from the OHPL, movement of the MEWP 10 feet past the simulated OSHA boundary (setpoint location), without an alarm, constituted simulated contact with the OHPL. The boundaries were selected to allow movement of the MEWP to simulate violation of the minimum approach distance and contact with an OHPL without actually violating the minimum approach distance or contacting an OHPL.

Instrumentation

Two outdoor laser distance meters were used to measure the distance between the MEWP and the OHPL. To verify the accuracy and calibration of the meters, test measurements were verified on two separate occasions prior to the site test by a professional surveying company. Backup measurements during the site test (where appropriate) were performed using a laser scanner with post-processing. A weather station was used to monitor and record ambient temperatures throughout the evaluation.

OSHA Minimum Approach Distance

The sub-transmission voltage present at the test site was approximately 44kV (**Figure 1**, shown in green) and the distribution voltage was approximately 12kV (**Figure 1**, shown in blue). Thus, according to OSHA 1926.1408 Table A, the mandated minimum approach distance was 10 feet. A ground based test boundary was set up 22 feet from the OHPLs. Movement of the MEWPs was allowed beyond the 22-foot barrier, but at no time were the MEWPs or personnel intentionally allowed to come closer than 10 feet to the OHPLs.

Test Site Layout

The test site selected was in a pasture. Four unique station locations were selected for the evaluation (as shown in **Figure 1**) based on availability of level ground as well as proximity to OHPLs. The location of the MEWP at each station is accurate as shown and based upon embedded GPS data with laser scanning. The lateral ground-based distance from directly below the center of the MEWP chassis to directly below the OHPLs is shown for each station.

Test Site Preparation

A site survey was performed. The purpose of the survey was to accurately determine ground-based boundaries from the OHPLs at the site, and to place wooden stakes every 25 feet along those determined boundaries. Colored surveying tape was attached to the stakes for easy visual reference of the boundaries.

Two ground-based danger boundaries were created and marked with red surveying tape. One boundary was placed at 8.7 horizontal feet from the OHPL. This boundary served as the ground-based boundary that denoted the 10-foot minimum approach distance between the MEWP platform and the OHPL when the platform was rotated from a position 5 feet above or below the height of the OHPL.

The second ground-based danger boundary was placed at 10 horizontal feet from the OHPL. It served as the ground-based boundary that denoted the 10-foot minimum approach distance between the MEWP platform and the OHPL when the platform was rotated from a position at the same height as the OHPL. Both ground-based danger boundaries represented actual (opposed to simulated) OSHA boundaries (minimum approach distance). No boundary was required for testing with the MEWP platform 10 feet above or below the OHPL because the platform could not get closer than 10 feet to the OHPL.

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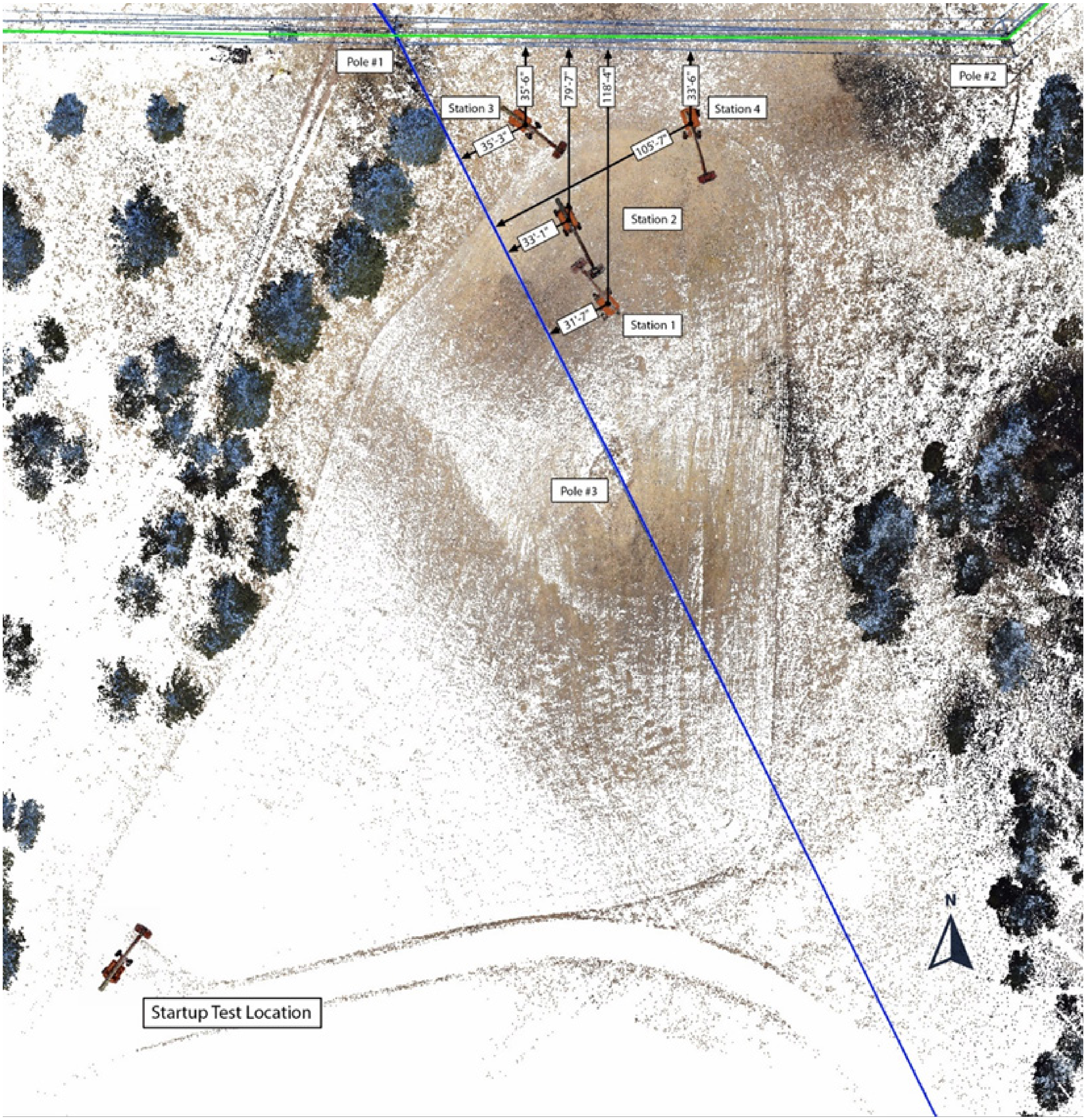

Figure 1
Laser scan point cloud representation of test site with OHPLs, poles, and station locations.

A ground-based test boundary, marked with yellow surveying tape, was created at 22 horizontal feet from the OHPL. It served as the ground-based boundary that denoted the 22-foot limit between the MEWP platform and the OHPL when the platform was rotated from a position at the same height as the OHPL. The 22-foot boundary served as the simulated OSHA boundary (simulated minimum approach distance), as shown in **Figure 2**.

Data Collection and Procedure

For the purposes of this evaluation, the right and left sides of the subject MEWP were defined according to the layout shown in **Figure 2**. Two MEWPs were used to perform the test. The PWD sensors were installed on the subject MEWP. The second MEWP was used to control the movement of the subject MEWP. The subject MEWP was remotely controlled by a qualified operator.

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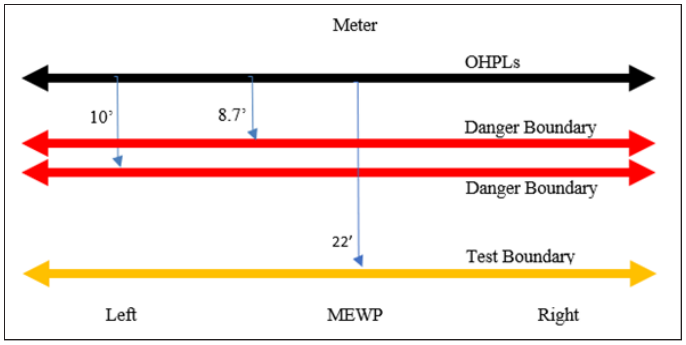

Figure 2
For the purposes of this evaluation, ground-based boundary layout. Location of MEWP and measuring device (meter) relative to the OHPLs.

The purpose of the remote control was to give the operator greater control of the subject MEWP. The subject MEWP was controlled as if the operator was located within the platform of the subject MEWP, while being located safely in the platform of the second MEWP. The setup allowed the operator to rotate the subject MEWP platform toward the OHPLs with greater control and at slower speeds than could be provided with ground-based control of the subject MEWP. The second MEWP was located away from the subject MEWP.

A series of MEWP movements occurred at each of the four stations. A laser scan was performed at each station such that the exact location of the MEWP within the test site was documented. The general procedure used to test PWD2 was to raise the subject MEWP platform to the same height as the OHPL, create a setpoint at the simulated OSHA boundary (22 foot boundary), and then rotate the platform horizontally away from (then back toward) the OHPL from each side of the MEWP, noting the distance between the MEWP and the OHPL when the PWD2 warning/danger alarm sounded.

If a warning alarm sounded, the movement was halted, and a distance measurement was taken. The movement then continued toward the OHPL until a danger alarm sounded, at which point another distance measurement was taken. The horizontal rotation of the MEWP toward the OHPL ceased with the danger alarm or the appropriate (according to platform height) OSHA ground-based danger boundary (actual OSHA minimum approach distance). Spotters were used to halt movement at the appropriate boundary. The procedure was repeated at platform heights relative to OHPL height of +10 feet, +5 feet, -10 feet, and 5 feet.

The procedure was also repeated with the subject MEWP platform at the same height as the OHPL with the second MEWP inserted into the area near the station. The procedure was performed immediately after the rotations with the platform at the same height as the OHPL, and the setpoint was not changed. The purpose of inserting an additional MEWP into the field was to observe the effect, if any, that an additional MEWP near the station would have on the operation of the PWD. For this set of rotations, the subject MEWP was no longer operated by the second MEWP but was instead operated using the ground controls of the subject MEWP.

This general procedure — raising the platform to a specific height and then rotating horizontally away from and back toward the OHPLs from both sides of the subject MEWP — was selected to produce repeatable movements. The subject MEWP had many articulation points, which made it problematic to create repeatable movements at other approach angles. The procedure generally aligns with the procedure developed by NIOSH for PWD testing[9]. Setpoints were created at every height for every station. Setpoints were created on both the right and left sides of the MEWP as noted in the test results. PWD1 did not have the capability to create a setpoint. Thus, PWD1 was merely rotated horizontally away from and then back toward the OHPLs until an alarm sounded.

Measurements between the subject MEWP and the OHPL were always taken between the two closest points. They were obtained with an outdoor laser distance meter, and the MEWP platform/OHPLs were scanned with a laser scanner as often as deemed necessary.

At the time of testing, it was not known how quickly the PWDs could respond to movement of the MEWP and the associated electric field changes. The maximum horizontal swing speed of the subject MEWP was changed to a slower setting to give the PWDs more time to respond to changing electromagnetic fields. The subject MEWP was configured for a maximum horizontal swing speed of 64% of the maximum speed set at the factory.

Both PWDs were also evaluated as a startup device. The goal of the startup device evaluation was to drive the subject MEWP away from the OHPLs in order to deactivate any alarms — then drive the subject MEWP toward the OHPL until an alarm sounded. The distance between the subject MEWP and the OHPL at the time that the alarm sounded was measured. PWD2 automatically starts in the most sensitive detector setting. PWD1 did not have adjustable settings. The PWD1 sensor and the 12 PWD2 wireless sensors were attached to the subject MEWP (as

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shown in **Figure 3**).

General Analysis and Discussion

For PWD2, warning rotations were defined as the initial rotations toward the OHPL, in which no alarm had yet sounded. The warning alarm should have occurred when one or more of the sensors were within 80% of the setpoint. Danger rotations were defined as rotations in which the warning alarm had already sounded, measurements were taken, and rotation of the subject MEWP resumed toward the OHPL. The danger alarm should have occurred when one of the sensor readings matched the setpoint.

PWD1 did not allow the operator to select or create a setpoint. PWD1 showed substantial variability in alarm distance from the OHPLs. PWD1 also alarmed far away from the simulated OSHA boundary of 22 feet. Since it did not provide the capability to adjust the sensitivity of the device, PWD1 could not be operated near the simulated OSHA boundary without an alarm. PWD1 did not allow operation of the subject MEWP within 20 feet of the actual OSHA minimum approach distance as it alarmed constantly at even greater distances from the OHPLs. These facts, discovered at Station1, limited PWD1's practicality as a PWD for use with MEWPs. Due to these limitations, it was decided that no further testing of PWD1 would be performed after Station1. However, PWD1 was later evaluated at Station4 to determine how it would respond to the more complex OHPL configuration as opposed to the simple configuration present at Station1.

Graphs

The alarm distance (PWD1 **Figures 4** and **9**) and setpoint deviation (PWD2, **Figures 5** through **8**) graphs produced in the analysis section can be evaluated as follows:

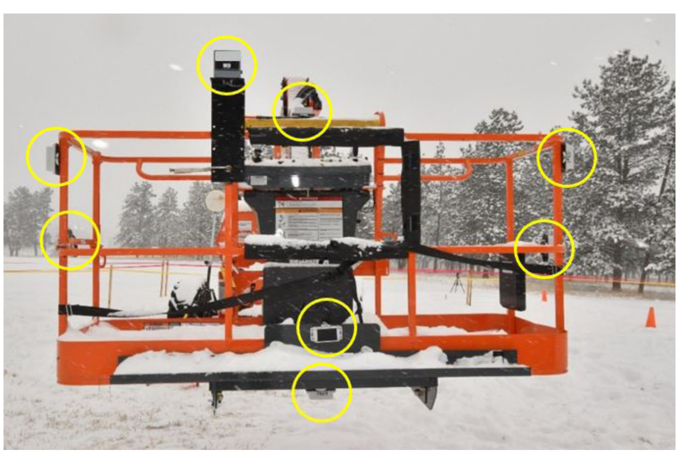

Figure 3
PWD1 and PWD2 sensor locations on MEWP platform and boom. Five PWD2 sensors not shown.

For the PWD1 deviation graphs, the blue line represented the location of the OHPL. Points below the line represented the distance (in feet) that the alarm condition occurred prior to the OHPL. For the PWD2 deviation graphs, the yellow line represented the setpoint (simulated OSHA boundary). Points above the line represented the distance (in feet) that the warning alarm condition occurred past the simulated OSHA boundary. Points below the line represented the distance (in feet) that the warning alarm condition occurred prior to the simulated OSHA boundary. The vertical scales should be noted when each graph is examined.

Station1: Analysis and Discussion

PWD1 alarmed at distances between 30 to 40 feet from the OHPL at the various platform heights. The closest (to the OHPL) alarm occurred at 30.3 feet, and the farthest (from the OHPL) alarm occurred at 39.3 feet. Only the electric field sensor alarmed. No alarms from the magnetic field sensor occurred during any of the rotations. The alarm distances with respect to the OHPL can be seen in **Figure 4**.

Station1A: Analysis and Discussion

The PWD2 setpoints for Station1A were all set on the right side of the subject MEWP. The subject MEWP chassis position for Station1A was the same position that was used for Station1. It should be noted that the "A" in Station1A merely denoted that the test occurred on a different day from the Station1 PWD2 test, which was shut down due to low ambient temperatures.

The subject MEWP was able to operate in ambient conditions below the lowest operating temperature

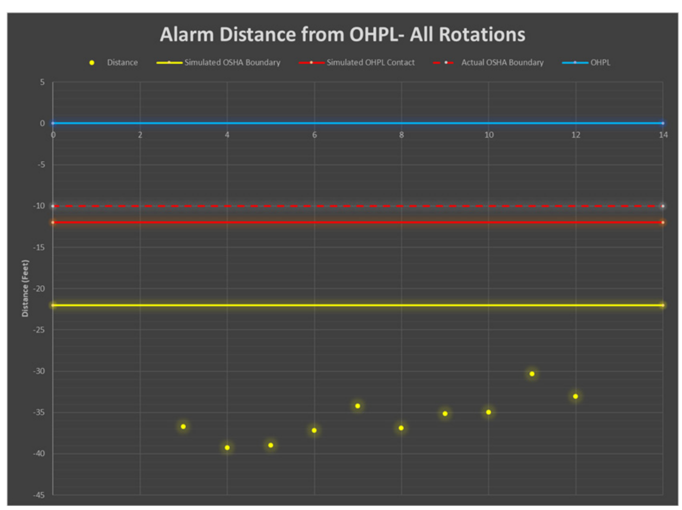

Figure 4
PWD1 alarm distance from OHPL at Station1.

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specified in the PWD2 manual, and PWD2 operated erratically at ambient temperatures below its specified range. Operation of PWD2 on an MEWP that was utilized in ambient temperatures below the minimum specified operating temperature of PWD2 would create a dangerous condition in which the operator of the lift may rely on PWD2 to warn of a dangerous condition when the device may not, in fact, be operable. Low ambient temperatures could be experienced at many locations worldwide.

The deviation from the setpoint (simulated OSHA boundary) for all the warning rotations can be seen in **Figure 5**. The warning rotation alarm farthest from the setpoint, prior to the setpoint location, occurred at 4.8 feet. The warning rotation alarm farthest from the setpoint (past the setpoint location) occurred at 12 feet. There was substantial variation in PWD2 responses for the warning rotations. The variation was also substantial for the danger rotations (not shown).

Station2: Analysis and Discussion

The PWD2 setpoints for Station2 were all set on the right side of the subject MEWP. The deviation from the setpoint (simulated OSHA boundary) for all the warning rotations can be seen in **Figure 6**. The PWD2 warning rotation alarm farthest from the setpoint, prior to the setpoint location, occurred at 10.6 feet. The warning rotation alarm farthest from the setpoint, past the setpoint location, occurred at 12.7 feet. There was substantial variation in the PWD2 responses for the warning rotations. The variation was also substantial for the danger rotations (not shown).

Station3 Analysis and Discussion

PWD2 setpoints for Station3 were all set on the right side of the subject MEWP. The deviation from the setpoint (simulated OSHA boundary) for all the warning rotations can be seen in **Figure 7**. The PWD2 warning rotation alarm farthest from the setpoint, prior to the setpoint location, occurred at 5.1 feet. The warning rotation alarm farthest from the setpoint, past the setpoint location, occurred at 13.4 feet. There was substantial variation in the PWD2 responses for the warning rotations. The variation was also substantial for the danger rotations (not shown).

Station4: Analysis and Discussion

Half of the PWD2 setpoints for Station4 were set on the right side of the subject MEWP; the other half were set on the left side of the subject MEWP. PWD2 deviation from the setpoint (simulated OSHA boundary) for all the warning rotations can be seen in **Figure 8**. The PWD2 warning rotation alarm farthest from the setpoint, prior to

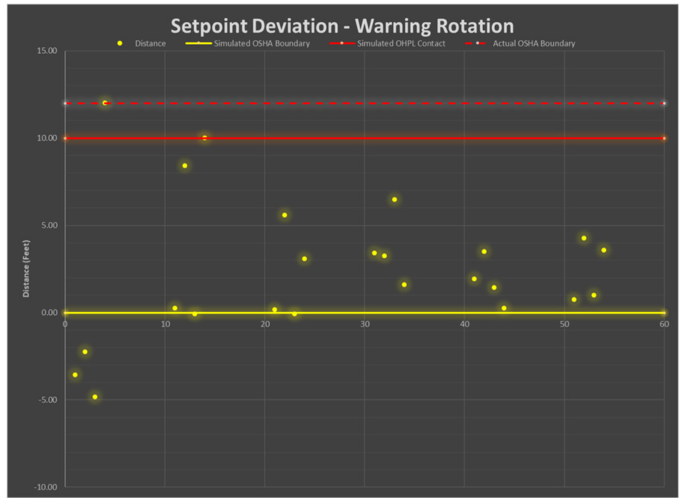

Figure 5
PWD2 deviation from setpoint (warning rotations at Station1A).

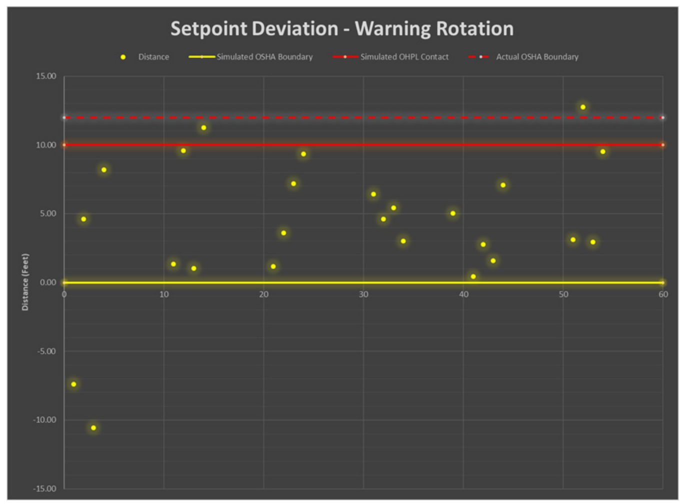

Figure 6
PWD2 deviation from setpoint (warning rotations at Station2).

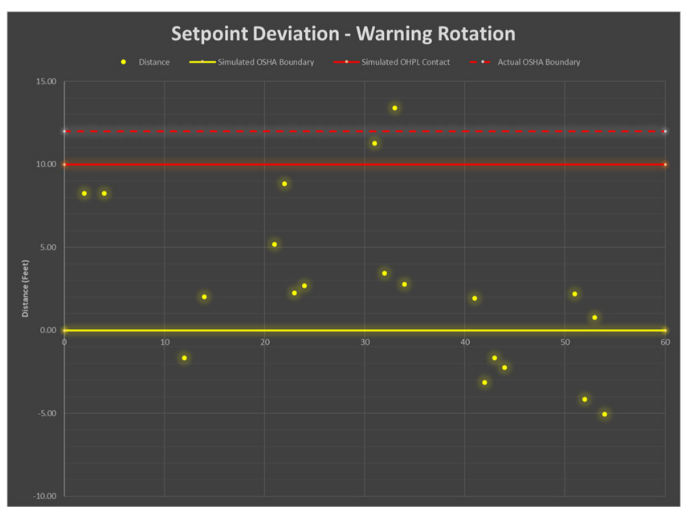

Figure 7
PWD2 deviation from setpoint (warning rotations at Station3).

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the setpoint location, occurred at 23.2 feet. The warning rotation alarm farthest from the setpoint (past the setpoint location) occurred at 15 feet. There was substantial variation in the PWD2 responses for the warning rotations. The variation was also substantial for the danger rotations (not shown).

The location (right or left side) of a setpoint at a given height negatively affected the response of PWD2. With a right side setpoint, the warning alarm would often sound at a great distance from the simulated OSHA boundary. With a left side setpoint, at the same height, the warning alarm might not occur at all while the subject MEWP achieved simulated OHPL contact. For example, with the platform at OHPL elevation with a right side setpoint on the first left rotation, the PWD2 warning alarm sounded with the platform located 21.7 feet prior to the simulated OSHA boundary. With the platform at OHPL elevation, with a left side setpoint on the first right rotation, the PWD2 warning alarm never sounded even though the MEWP achieved simulated OHPL contact.

PWD1 alarmed at distances between 27 to 66 feet from the OHPL at the various platform heights. The closest (to the OHPL) alarm occurred at 27.3 feet and the farthest (from the OHPL) at 65.6 feet. Only the electric field sensor alarmed. No alarms from the magnetic field sensor occurred during any of the rotations. The alarm distances with respect to the OHPLs can be seen in **Figure 9**.

Other notable issues occurred at every station. For the sake of brevity, only the notable issues at Station2 are listed below:

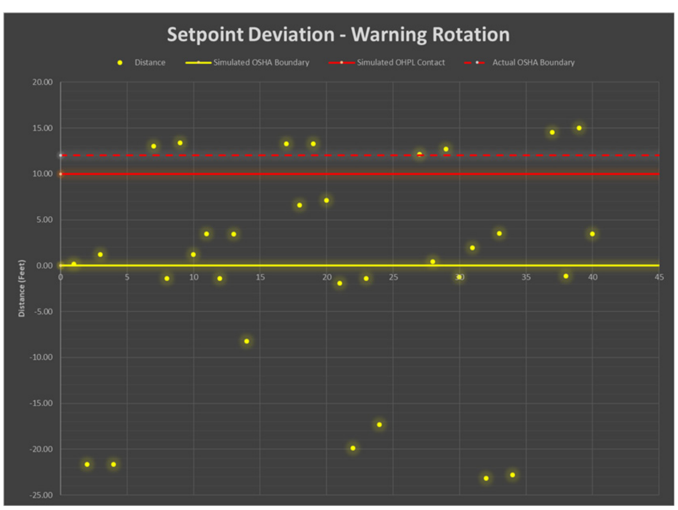

Figure 8
PWD2 deviation from setpoint (warning rotations on Station4).

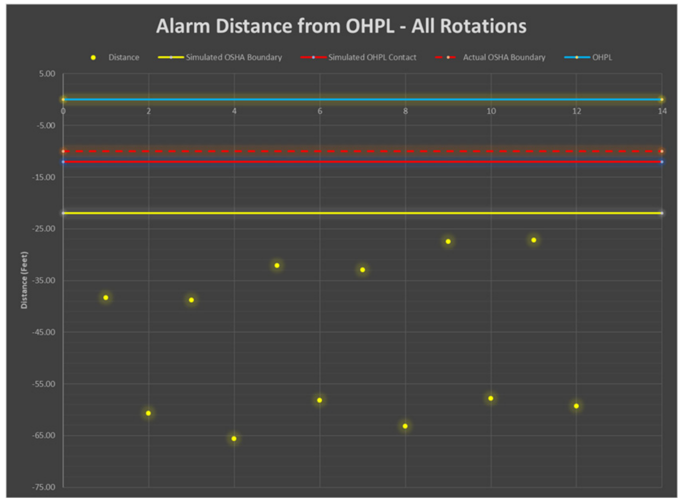

Figure 9
PWD1 alarm distance from OHPLs at Station4.

- There was one danger rotation in which the rotation was stopped by the spotters without the occurrence of a danger alarm, but the danger alarm later activated approximately five minutes into the measurement process with the subject MEWP stationary.
- There was one warning rotation in which the alarmed sensor changed from warning to danger while distance measurements were performed with the subject MEWP stationary.
- There was one rotation in which the warning alarm never sounded. The first alarm to sound was the danger alarm.
- There was one warning rotation in which the warning alarm stopped sounding between the simulated OSHA boundary and the OHPL before sounding again. The control module did not lose communication with the sensors.
- There was one rotation in which the warning alarm toggled on/off as communication between the activated sensor and control module was gained/lost.
- There was one rotation in which the danger alarm toggled on/off as communication between the activated sensor and control module was gained/lost.

Boundary Violations

Boundary violations occurred when the subject MEWP

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moved past a boundary without a PWD alarm. For the purposes of this testing, the PWD2 setpoint location functioned as the simulated OSHA boundary (simulated minimum approach distance). Once a setpoint location had been created, movement past that setpoint location (toward the OHPL) was considered a violation of the simulated OSHA boundary. The simulated OSHA boundary was set to approximately 22 feet from the OHPL for all tests.

Given that the actual OSHA mandated boundary (actual minimum approach distance) for the OHPLs at the test site was 10 feet from the OHPL, movement of the MEWP 10 feet past the simulated OSHA boundary constituted simulated contact with the OHPL. Simulated OHPL contact occurred at 10 feet past the setpoint location. Additionally, if a PWD alarm condition had still not occurred — and the spotters did not stop movement of the MEWP precisely at the actual OSHA boundary (10 feet from the OHPL) — an actual OSHA boundary violation occurred. PWD2 boundary violations are shown in **Figure 10**. Only boundary violations that occurred for warning rotations are shown. Boundary violations for danger rotations were more numerous.

Rotation Deviations

A rotation deviation was defined as the difference (in feet) between the alarm distance on one MEWP rotation and the alarm distance on another MEWP rotation. To better understand the nature of the variability of alarm distance experienced during the test, several PWD2 rotation deviations were examined. The comparison was not exhaustive, and other rotation comparisons could be made. Rotation deviations for PWD2 are shown in **Figure 11**.

The following rotations were examined at Station1A, 2, 3, and 4, at each height (for both warning and danger rotations):

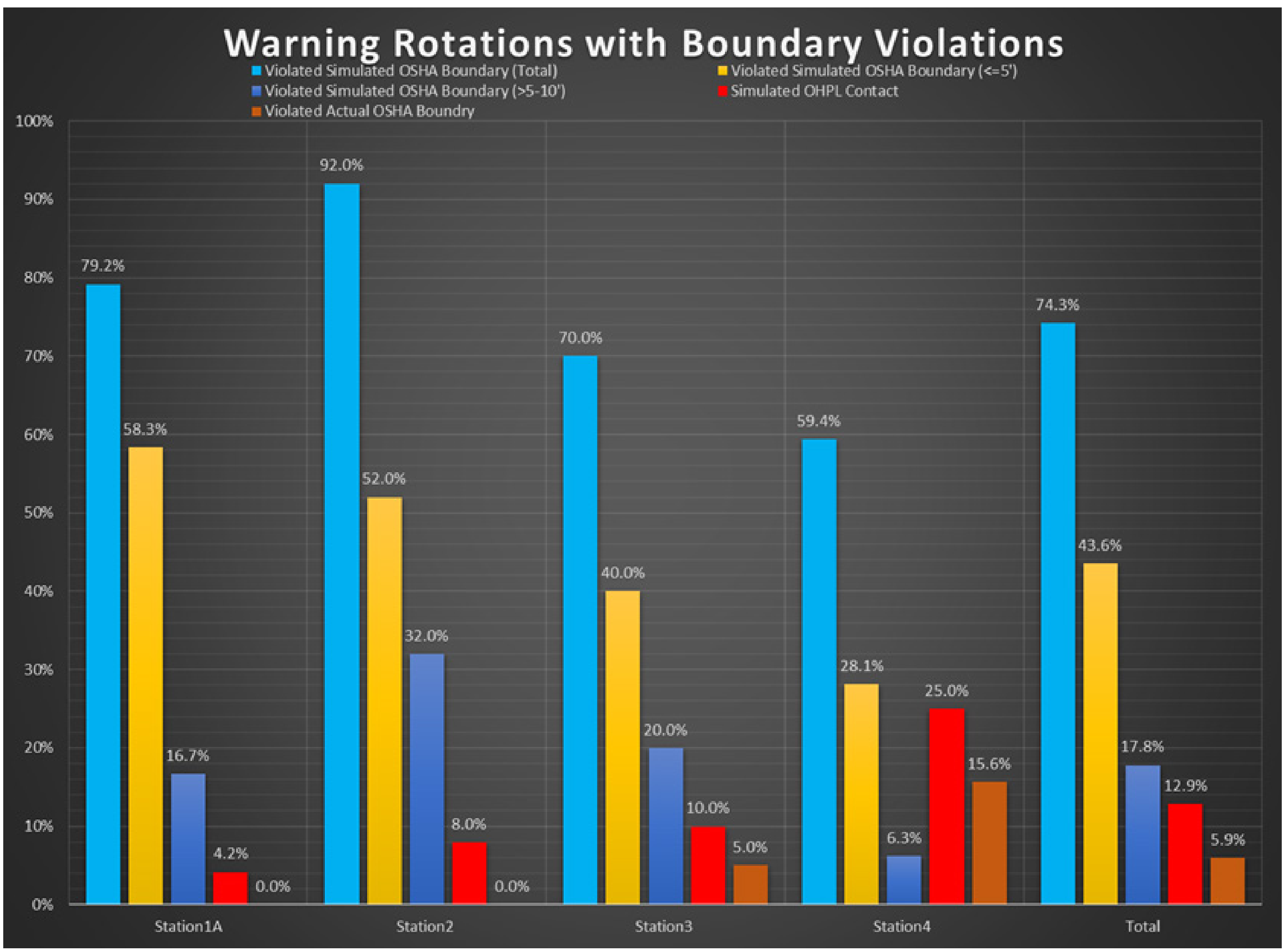

Figure 10
Percentage of PWD2 warning rotations with boundary violations.

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1. Right-side rotation versus the subsequent right-side rotation.

2. Left-side rotation versus the subsequent left-side rotation.

3. Right-side rotation versus the subsequent left-side rotation.

Startup Analysis and Discussion

A startup device was defined as a PWD that would warn the user if OHPLs are in the vicinity. PWD1 was evaluated as a startup device. The subject MEWP was driven away from Pole #3, toward the startup test location shown in **Figure 1**. The subject MEWP was driven far enough away from Pole #3 that PWD1 was not in an alarm condition. There were no sensitivity adjustments available with PWD1.

The subject MEWP was driven toward the OHPL on Pole #3 until the PWD1 alarm sounded. In Test Run #1, the subject MEWP was driven to a location directly beneath the OHPL without an alarm. In Test Runs #2 and #3, with the platform raised, the subject MEWP was driven toward the OHPL, and an alarm did sound. However, the alarm sounded between 21 feet and 26 feet (along the ground) from the OHPL. Earlier testing at Station1 (near the same OHPL) revealed that the PWD1 alarm sounded between 30 feet and 40 feet from the OHPL. The results of the startup test for PWD1 were inconsistent. Inconsistent operation is unacceptable for a device that is supposed to warn of a lethal hazard.

PWD2 was evaluated as a startup device. PWD2 was designed to begin operation at startup in its most sensitive setting. The subject MEWP was driven away from Pole #3, toward the startup test location shown in **Figure 1**. The subject MEWP could not be driven far enough

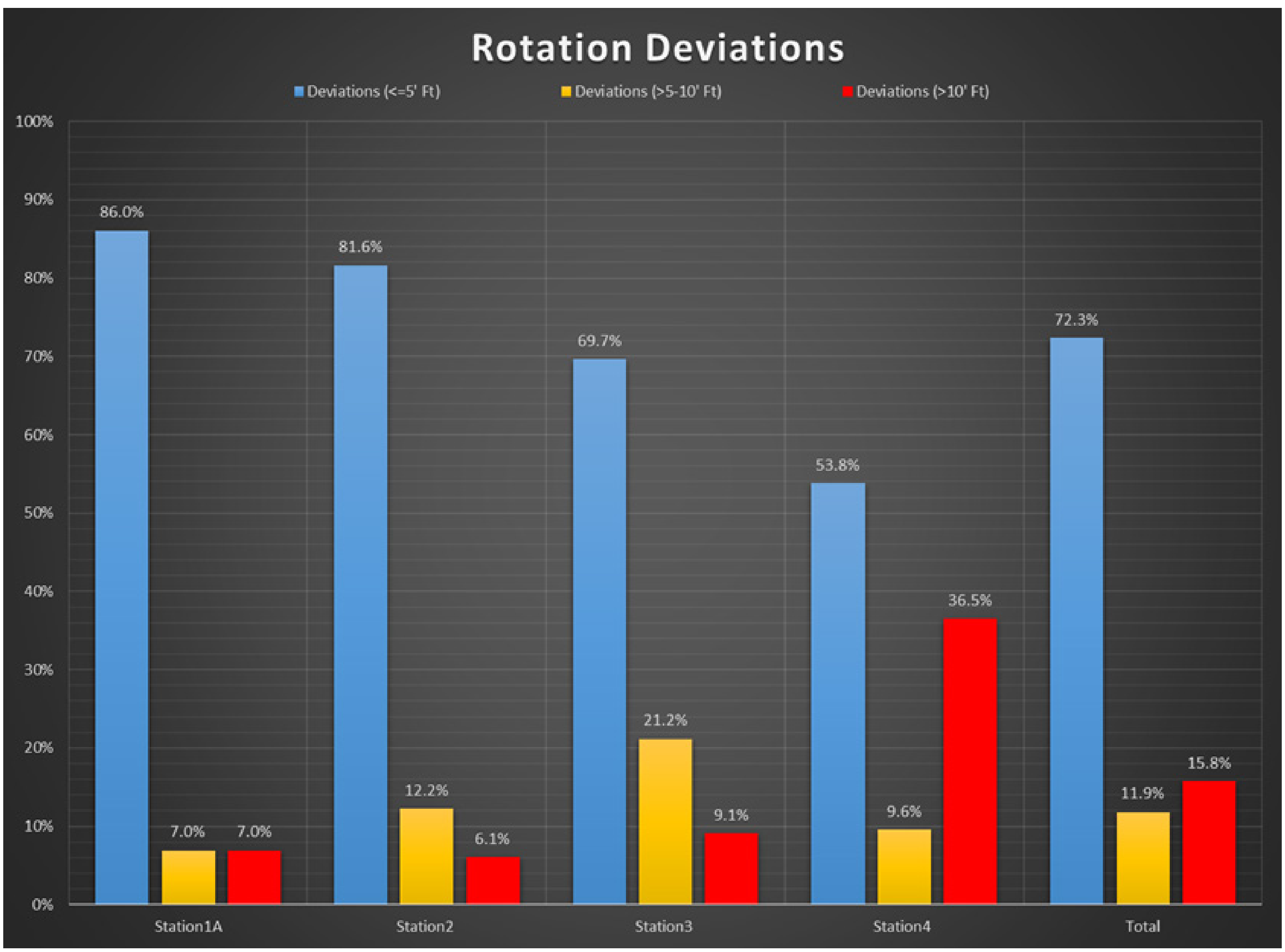

Figure 11
PWD2 rotation deviations.

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away from the OHPL to disengage the PWD2 alarm. The subject MEWP was 451 feet (along the ground) from the OHPL and continued to alarm. The PWD2 manual states: *RANGE OF EFFECTIVENESS, Voltage Detection – Between 10 and 200 feet depending on voltage.*

The PWD2 continued to alarm at over twice the distance from the OHPL that was stated as the range of effectiveness. A constant alarm that continuously sounds (even when over 450 feet from an OHPL) would likely cause confusion for the operator. The occurrence of frequent or constant alarms may lead operators to dismiss all alarms as nuisance alarms.

Safety

The following is stated as the intended use[11] of PWD1: *The PWD1 safety system provides overhead power line and above-the-mast illumination. The built-in high voltage, electromagnetic and electrostatic field detection system automatically stops mast extension, providing added protection for the operator and equipment.* The PWD1 manufacturer agreed to allow PWD1 to be evaluated for an expanded intended use on articulating boom lifts.

PWD1 did not provide a means for the operator to select or create a setpoint. PWD1 showed substantial variability in alarm distance from the OHPLs. PWD1 also alarmed far away from the simulated OSHA boundary of 22 feet. Since it did not provide the capability to adjust the sensitivity of the device, PWD1 could not be operated near the simulated OSHA boundary without an alarm. PWD1 did not allow operation of the subject MEWP within 20 feet of the actual OSHA minimum approach distance. These facts limited the PWD1's practicality as a PWD for use with MEWPs.

The following is stated as the intended use of PWD2: *PWD2 is designed to alert equipment operators and other workers to the danger of contact with a live power line. This device will help protect them from injury or death, as well as preventing expensive damage to equipment.*

The PWD2 website further states: *PWD2's proximity detection alarms are designed to warn workers if they are close to power lines. In the event that work must be conducted near a power line (no closer than OSHA minimums, of course), PWD2 proximity alarms can be set to warn of danger when the equipment enters a preset area.*

Death or serious injury are known consequences associated with the hazard of contact between an MEWP and an OHPL. The OSHA minimum approach distance must not be violated in order to protect the operator and personnel in the vicinity of the equipment. The OSHA boundary is rigid, inflexible, and required. Once within the OSHA boundary, the operators and ground personnel are exposed to critical risk and possible injury or death.

The severity of harm incurred from contacting an OHPL is immediate and tragic, almost assuredly resulting in damage to property, personal injury, and/or death. PWD2 allowed violation of the simulated OSHA boundary on 74.3% of the total rotations without initiating a warning alarm. PWD2 allowed violation of the simulated OSHA boundary on 92.0% of the rotations at Station2, without initiating a warning alarm. PWD2 allowed simulated OHPL contact on 12.9% of the total rotations without initiating a warning alarm. PWD2 allowed simulated OHPL contact on 25.0% of the rotations at Station4, without initiating a warning alarm.

The International Electrotechnical Commission (IEC) is the world's leading organization for the preparation and publication of International Standards for all electrical, electronic, and related technologies[12]. IEC International standards serve as the basis for risk and quality management and are used in testing and certification to verify that manufacturer promises are kept[13]. The Organization for Standardization (ISO) is an independent, non-governmental international organization with a membership of 165 national standards bodies. Through its members, it brings together experts to share knowledge and develop voluntary, consensus-based, market relevant International Standards that support innovation and provide solutions to global challenges[14]. The following excerpts presented in this section, shown in italics, have been extracted from GUIDE ISO/IEC GUIDE 51:2014(E), "Safety aspects — Guidelines for their inclusion in standards."

The term "safe"[15] is often understood by the general public as the state of being protected from all hazards. However, this is a misunderstanding: "safe" is rather the state of being protected from recognized hazards that are likely to cause harm. Some level of risk[16] is inherent in products or systems.

Tolerable risk[17] can be determined by:

- *the current values of society;*
- *the search for an optimal balance between the ideal of absolute safety and what is achievable;*

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- *the demands to be met by a product or system;*
- *factors such as suitability for purpose and cost effectiveness.*

The following procedure should be used to reduce risks to a tolerable level:

a. *identify the likely users for the product or system, including vulnerable consumers and others affected by the product.*

b. *identify the intended use, and assess the reasonably foreseeable misuse, of the product or system;*

c. *identify each hazard (including reasonably foreseeable hazardous situations and events) arising in the stages and conditions for the use of the product or system, including installation, operation, maintenance, repair and destruction/disposal;*

d. *estimate and evaluate the risk to the affected user group arising from the hazard(s) identified: consideration should be given to products or systems used by different user groups; evaluation can also be made by comparison with similar products or systems;*

e. *if the risk is not tolerable, reduce the risk until it becomes tolerable.*

All products and systems include hazards and, therefore, some level of residual risk. However, the risk associated with those hazards should be reduced to a tolerable level.

Industries and standards committees, such as the American Society of Mechanical Engineers, have held reservations regarding the concept of detrimental reliance (when a party is induced to rely on another's promise or commitment resulting in a detrimental outcome to the party) or false sense of security (a feeling of being safer than one really is): *If cage-type boom guards, insulating links, or proximity warning devices are used on cranes, such devices shall not be a substitute for the requirements of this section, even if such devices are required by law or regulation. Electrical hazards are complex, invisible, and lethal. To lessen the potential of false security, instructions related to the devices and hazards shall be reviewed with the crane operator, crew, and load-handling personnel. Instructions shall include information about the electrical hazard(s) involved, operating conditions for the devices, limitations of such devices, and testing requirements prescribed by the device manufacturer*[18].

Reliance on a safety device that does not function consistently and reliably would amplify the existing hazard by instilling a false sense of security in the operators of the equipment who rely upon the safety device in place of alternative operating procedures to reduce the risk.

Inconsistent operation of a safety device that alarms at distances well beyond the OSHA minimum approach distance would result in many "false" alarms. The occurrence of frequent false alarms may lead operators to dismiss all alarms as nuisance alarms.

Given the fact that PWD2 allowed violation of the simulated OSHA boundary on 74.3% of the total rotations (without a warning alarm) — and that simulated OHPL contact occurred on 12.9% of the rotations (without a warning alarm) — the risk associated with use of PWD2 was not reduced to a tolerable risk for the intended use. Having not reduced the risk to a tolerable risk, PWD2 is not safe for the intended use.

Conclusions

The results of the evaluation indicate the following:

1. PWD1 is not practical for use as a PWD on an MEWP that is operated in close proximity to OHPLs.

2. PWD1 does not produce repeatable or reliable alarms when used as an operator warning device on an MEWP operated in close proximity to OHPLs.

3. The results of the startup test for the PWD1 were inconsistent. This is unacceptable for a device that is supposed to warn of a lethal hazard.

4. PWD2 did not produce repeatable or reliable alarms when used as an operator warning device on an MEWP operated in close proximity to OHPLs.

5. The PWD2 manufacturer stated: *PWD2's proximity detection alarms are designed to warn workers if they are close to power lines. In the event that work must be conducted near a power*

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line (no closer than OSHA minimums, of course), PWD2 proximity alarms can be set to warn of danger when the equipment enters a preset area. The results of this evaluation indicated that PWD2 allowed violation of the simulated OSHA boundary, without a warning alarm, on 74.3% of the total rotations.

6. The PWD2 manufacturer stated: *This device will help protect them from injury or death, as well as preventing expensive damage to equipment.* The results of this evaluation indicated simulated OHPL contact, without a warning alarm, on 12.9% of the rotations. Injury or death, along with damage to equipment, would likely occur from MEWP contact with an OHPL.

7. The risk in use of PWD2 was not reduced to a tolerable risk.

8. PWD2 is not safe for its intended use as marketed/sold by the manufacturer.

9. PWD2 was too sensitive to be practical as a start-up alarm system on an MEWP operated in proximity to OHPLs.

PWDs are commercially available products. Owners and users of MEWPs may elect to purchase, install, and operate PWDs. Based upon the results of the testing and analysis outlined in this paper, owners and users that intend to equip MEWPs with a PWD should be fully aware of the limitations associated with such devices and have that device certified in writing by the vendor of that product, by a qualified engineer, or by the appropriate certifying entity, to be safe for use in all foreseeable environments, conditions, and applications.

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