Designation: F3283/F3283M – 18

Standard Specification for the Manufacturing of High-Voltage Proximity Alarm to be used for the Detection of Overhead High Voltage Alternating Current (AC)[1]

This standard is issued under the fixed designation F3283/F3283M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers non-contact high-voltage proximity alarms used to detect high voltage alternating current (ac) on overhead power lines. The high-voltage proximity alarm (HVPA) is limited to the detection of voltage greater than 600 V ac at power system frequencies between 50 to 60 Hz.

1.2 High-voltage proximity alarms provide audible/visual alerts and may have the ability to limit movement of equipment.

1.3 The use, installation, and maintenance of these high-voltage proximity alarms are beyond the scope of this specification. This standard does not purport to address installation, in service care or use.

1.4 This standard demonstrates the high voltage proximity alarm (HVPA's) ability to detect an e-field, and not the effects of various configurations of multiple power lines.

1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* Specific warnings are given in 9.1.4 and 10.9.2.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Terminology

2.1 *Definitions:*

2.1.1 *alternating current (ac) voltage, n*—potential difference in charge between two connected points in which the direction of current flow alternates.

2.1.2 *audible alarm indication, n*—audible alarm that is initiated when a predetermined threshold is met.

2.1.3 *configuration, n*—closely coupled and non-closely coupled equipment. For example, outriggers or steel treads for closely coupled equipment, and rubber tires for non-closely coupled as specified by the HVPA manufacturer. Specifically excludes equipment intended to work closer than 10 ft to an overhead ac power line.

2.1.4 *direct current (dc) voltage, n*—potential difference in charge between two connected points in which the direction of current flow does not change.

2.1.5 *E-field, n*—electric force per unit change.

2.1.6 *equipment, n*—specific types of equipment that the manufacturer endorses.

2.1.7 *function kick out system (optional), n*—system by which the equipment operated is being forcibly shut down by the high-voltage proximity alarm, also known as auto-shutdown.

2.1.8 *high voltage, n*—any measured voltage higher than 600 V ac.

2.1.9 *high voltage proximity alarm, n*—device that provides a warning of general proximity to a power line also referred to as HVPA for proximity warning device.

2.1.10 *information screen, n*—panel area, in which images, data, or both, are displayed to the operator.

2.1.11 *limitation, n*—threshold, parameters on both at which the high-voltage proximity alarm will not reliably function above or below, or both.

2.1.12 *operational check, n*—physical verification of components to be used in conjunction with a self-test function.

2.1.13 *performance test, n*—specific to type of equipment endorsed by the manufacturer and should follow appropriate manual instructions.

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[1] This specification is under the jurisdiction of ASTM Committee F18 on Electrical Protective Equipment for Workers and is the direct responsibility of Subcommittee F18.35 on Tools & Equipment.

Current edition approved Oct. 1, 2018. Published January 2019. DOI: 10.1520/F3283_F3283M-18.

2.1.14 *power line, n*—cable or coductor carrying electrical power typically supported by pylon or poles.

2.1.15 *range control, n*—ability of an operator to modify the threshold settings of a high voltage proximity alarm.

2.1.16 *self-test function, n*—manual or automatic verification process, or both, by the high voltage proximity alarm.

2.1.17 *sensor, n*—device that is used to detect the strength of an E-field.

2.1.18 *SPF, n*—Spruce/Pine/Fir.

2.1.19 *threshold, n*—point at which, based on E-field strength, the high-voltage alarm will enter into an alarm state.

2.1.19.1 *Discussion*—This point may or may not be modifiable by the operator.

2.1.20 *visual alarm indication, n*—sequence of flashing or solid light(s), or both, that notify an operator or ground personnel, or both, of current conditions/status.

3. Significance and Use

3.1 This manufacturing specification establishes requirements for the testing of HVPA used to alert operators and ground personnel of the general proximity to an overhead energized conductor with non-contacting methods.

4. Type of High-Voltage Proximity Alarm

4.1 E-field detection.

5. Material

5.1 Control box should be made from impact-resistant material and be free of defects that might adversely affect the unit's mechanical and electrical properties. The alarm system being tested will differ dependent upon the manufacturer of the product.

6. Performance Requirements

6.1 The manufacturer shall clearly specify the limits of performance of each high voltage proximity alarm within the instructions as follows:

6.1.1 Operating voltage range or ranges,
6.1.2 Operating temperature range,
6.1.3 Operating humidity range,
6.1.4 Storage temperature range,
6.1.5 Storage humidity range,
6.1.6 Any limitations of use,
6.1.7 E-field detection range,
6.1.8 Applicable equipment approved by the manufacturer.

7. Workmanship, Finish, and Appearance

7.1 Workmanship and finish shall be of such quality as to ensure safe operation of the unit. Appearance shall be the prerogative of the manufacturer.

Test Methods

8. Testing Scenario and Rationale

8.1 Demonstrate that the high voltage proximity alarm meets the requirements of providing visual and audio warning to the proximity of an energized conductor based on the minimum rating of the manufacturer's equipment. This testing scenario is meant to create a repeatable E-field for testing purposes only. This controlled E-field environment also gives a corresponding benchmark for the test distance as shown in 8.1.1. The test does not cover the distance that can be achieved for various environmental factors.

8.1.1 *Calculation for the Test Distance Required for Alarm Activation*—This testing scenario is meant to create a repeatable E-field for testing purposes.

$$TD = \frac{TV \times MC}{V} \tag{1}$$

where:

MC = minimum clearance = 10 ft.
V = nominal voltage of overhead power line (based on manufacturer's minimum equipment rating, with consideration from 6.1.1).
TV = actual test voltage (the voltage used by the testing agencies). The test voltage range must be between 50 to 100 % of the manufacturer's voltage rating (V) with an absolute minimum of 2000 V. If the manufacturer's rating is below 2000 V then the *TV* must be set at the minimum rated voltage specified by the manufacturer. Test voltage tolerance of ±2 %.
TD = test distance (radial distance).

NOTE 1—*MC* and *TD* have the same unit of measure.

8.1.1.1 The following example illustrates the required test distance from which the high voltage proximity alarm threshold is reached.

MC = 10 ft

V = 7.2 kV (voltage based on manufacturer's minimum equipment rating).

TV = 4.4 kV (voltage use by the testing agencies due to capacity and availability).

$$TD = \frac{(4.4\ kV)\ (10\ ft)}{7.2\ kV}$$

TD = 6.1 ft = 73.3 in. (radial distance).

8.1.1.2 6.1 ft (*TD*) is the theoretical distance at which the high voltage proximity alarm threshold is reached based on the manufacturer's minimum equipment rating and TV used. The "test pass" is if the alarm provides a visual and audio warning.

8.1.2 *Calculation for Horizontal Distance from the Test Distance*—The radial distance for the E-field as illustrated in Fig. 1. The Pythagorean theorem can be used to derive the horizontal distance to the overhead power line as denoted with *x*.

$$TD^2 = x^2 + 5^2 \tag{2}$$

$$x = \sqrt{TD^2 - 5^2} \tag{3}$$

8.1.2.1 The following example illustrates the horizontal distance the high voltage proximity alarm must activate.

$$12.22^2 = x^2 + 5^2 \tag{4}$$

where:

$x = \sqrt{TD^2 - 5^2}$
$x = \sqrt{12.22^2 - 5^2}$
x = 11.2 ft

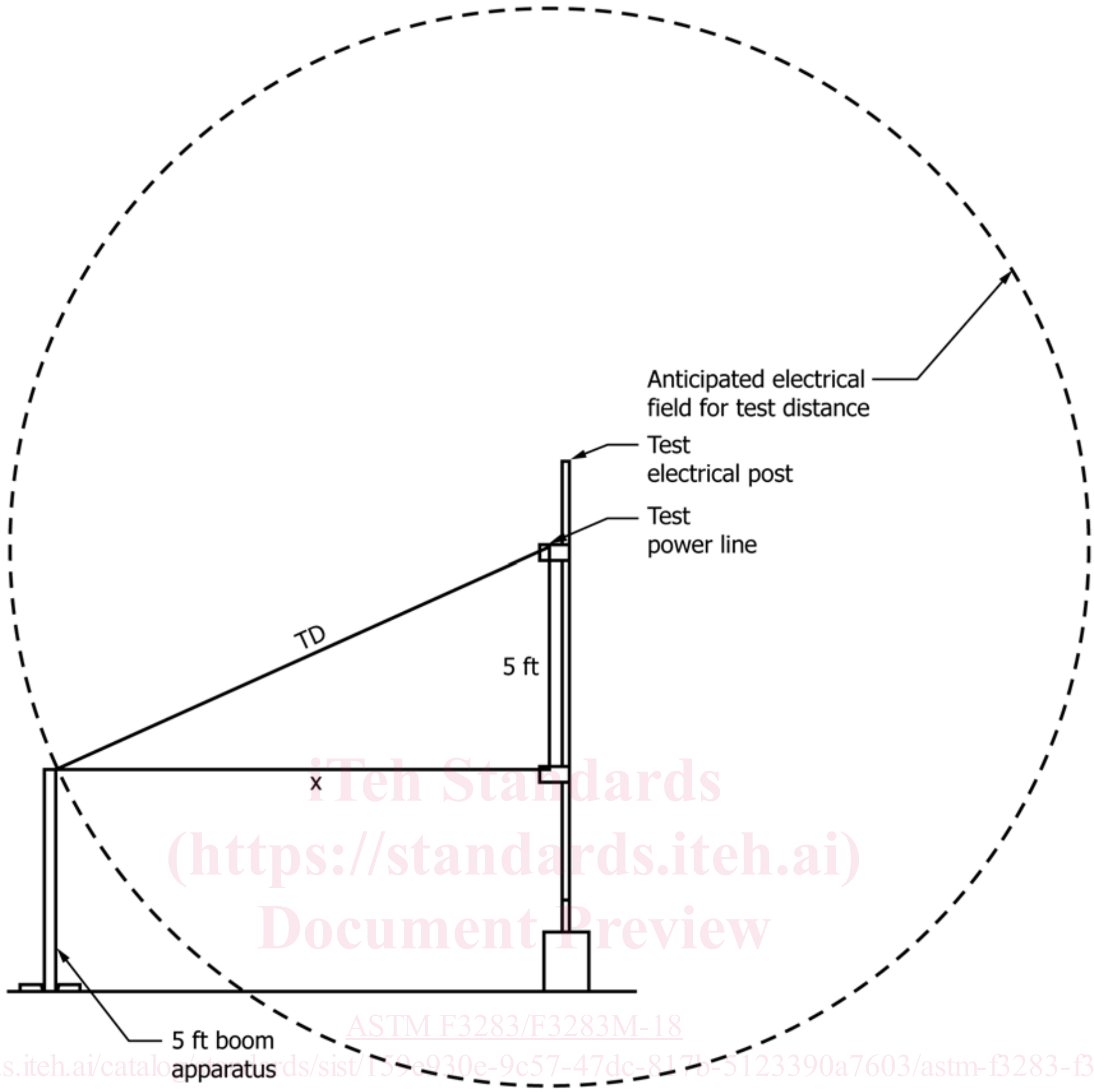

FIG. 1 Illustration of Horizontal Distance Taken from Test Distance

8.1.2.2 Instead of measuring the test distance for each test, a test distance guide (for example String) attached to the overhead power line can be used for the series of tests. This will aid the testing distances due to the spherical nature of the E-field.

8.1.2.3 This series of tests uses the boom's closest top corner for reference, as such all high voltage proximity alarms would be tested to the same reference disregarding the size of the boom or equipment, or both. (See Fig. 2.)

8.1.3 Eq 1 in 8.1.1 will provide a ratio of minimum clearance from the nominal voltage of powerline, minimum clearance, and test voltage. This will serve as a proof of concept that the HVPA will detect an E-field or voltage and therefore the presence of an overhead ac power line.

8.1.4 The saturation test is based on a 32 800 V/m [10 0000 V/ft] and the saturation test distance is calculated by the following equation:

$$SD = TV\left(\frac{1}{32,800}\right) \text{ for metric, } = TV\left(\frac{1}{10,000}\right) \text{ for US customary} \quad (5)$$

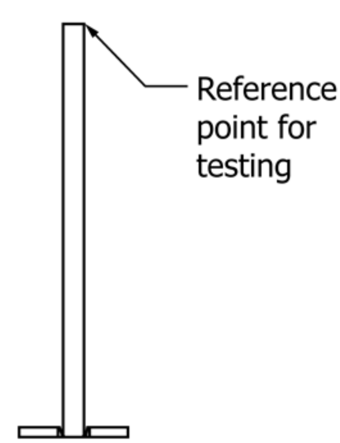

FIG. 2 Testing Reference Point for Boom Apparatus

where:

SD = saturated distance.

8.1.4.1 The saturation test distance is the HVPA's distance away from the test power line that will ensure the HVPA will be fully saturated within the electrical field. For example, the following example illustrates the use of Eq 5.

TV = 4.4 kV (voltage used by the testing agencies due to capacity and availability.

$$SD = 4.4\ \text{kV}\left(\frac{\text{m}}{32.8\ \text{kV}}\right)\ \text{or}\ 4.4\ \text{kV}\left(\frac{\text{ft}}{10.0\ \ \text{kV}}\right)$$

$$SD = 0.134\ \text{m} = 0.4\ \text{ft}$$

8.1.4.2 With the test voltage of 4.4 kV, the required saturation test distance would be 5.28 in. to ensure the HVPA is in full saturation for testing purposes.

8.2 *General Test Layout (Fig. 3):*

NOTE 2—The proximity alarm must be tested outside the E-field generated by the test transformer with an additional 50 % test distance and the high voltage line between the insulated power line apparatus and the test transformer should be insulated with metal liquid tight or metal conduit. The radius of the No Test Zone is one and a half times the test distance.

$$r = 1.5TD \tag{6}$$

8.3 The manufacturer will indicate the applicable installation of their HVPA on equipment and its setup. Test agencies will use this position for the majority of their testing. (This attempts to reduce bias from using the optimal position for testing.) While the other positions will be tested for possible shadowing effect explained in 8.6. Boom apparatus detail is found in 9.1.5. (See Fig. 4.)

8.4 Most tests include the closely coupled and non-closely coupled trials to simulate various equipment ground planes. For example, equipment on tires and equipment with outriggers down will have different ground plane. The boom apparatus simulates this effect from its steel fabrication to concrete, while raising the boom apparatus up with a 2 by 4 SPF simulates a non-closely coupled scenario. (See Fig. 5.)

8.5 *Saturation Rationale:*

8.5.1 This verifies that saturation of the high voltage proximity alarm will not impair the ability of the device to meet the requirements of the standard. (See Fig. 6.)

8.5.2 Position the 5 ft. boom apparatus at saturation test distance (calculated in 8.1.4) away from the overhead power line at 5 ft. line height. Energize the test overhead power for 10 s, then de-energize the overhead power. Two iterations of saturation tests are done at the mid span For in-depth procedure, see 10.10.

8.5.3 *Condition for Passing*—To pass, the high voltage proximity alarm must:

8.5.3.1 Be operated after the saturation test.

8.5.3.2 Provide a visual and audio warning.

8.6 *Shadowing Effect Rationale:*

8.6.1 This verifies the possible shadowing effect caused by the position of the boom.

8.6.2 The proximity alarm is tested at four positions shown in Fig. 7 using the 5 ft boom apparatus at 5 ft of line height. This will verify the general working area 360° around the boom in consideration to possible shadowing effect from the boom. For in-depth procedure, see 10.11.

8.6.3 *Condition for passing*—To pass, the high voltage proximity alarm must:

8.6.3.1 Provide a visual and audio warning in all four positions.

8.6.3.2 Activate within 2 % of the test distance calculated.

8.7 *Variable Boom Length (Telescopic Boom) and Antenna Length Rationale:*

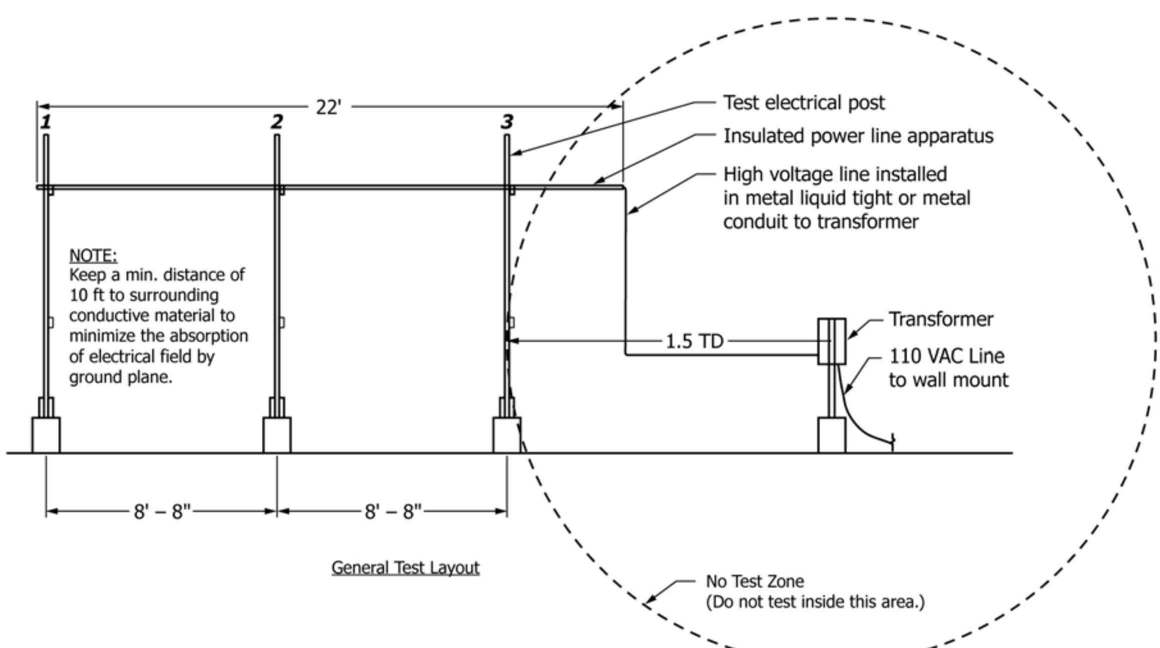

FIG. 3 General Test Layout

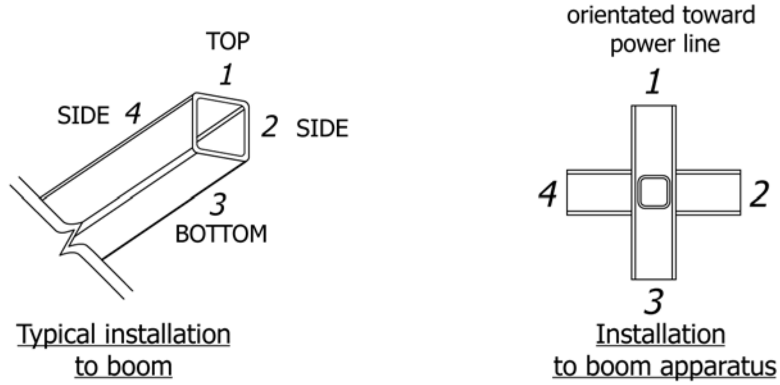

FIG. 4 Typical Installation to Boom and Installation to Boom Apparatus

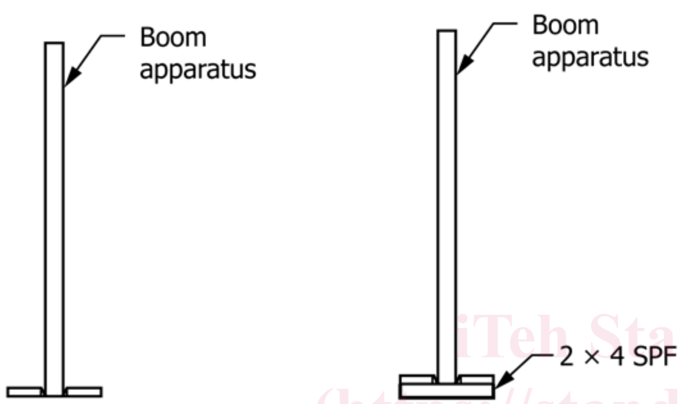

FIG. 5 Closely Coupled and Non-closely Coupled Trials

8.7.1 This determines if the variable boom and antenna length has detrimental effects on E-field detection. The measured E-field is expected to be different.

8.7.2 The proximity alarm is tested at four positions as shown in 8.6, while using the 10 ft boom apparatus at 10 ft of line height. For in-depth procedure see 10.12.

NOTE 3—Depending on the testing facility, there may be degradation to the E-field due to the ground plane as shown from the hatched area in Fig. 9. The degradation would reduce the size of the E-field. Refer to Fig. 8 and Fig. 9.

8.7.3 *Condition for Passing*—To pass, the high voltage proximity alarm must:

8.7.3.1 Provide a visual and audio warning in all four positions.

8.7.3.2 Activate within 2 % of the test distance calculated.

8.8 *Typical Operating Scenario:*

8.8.1 This verifies the high voltage proximity alarm activates for typical operating scenario.

8.8.2 Approach the power line at mid-span between post No. 1 and 2 (see Fig. 10). At mid-span, the E-field has minimal deflection and this testing scenario can serve as the verification to the test distance calculated in Eq 1 in 8.1.1. The alarm system is tested at line height and half line height, double the line height, and the proximity alarm system is recalibrated for the three different test levels. For in-depth procedure, see 10.13.

8.8.3 *Condition for Passing*—To pass, the high voltage proximity alarm must:

8.8.3.1 Have two distinctly different modes of alarm, providing at least two of the following: visual, audible, or *function kick out system* for closely coupled and non-closely coupled boom apparatus.

8.8.3.2 Activate within 2 % of the test distance calculated.

8.9 *Possible Operating Scenario:*

8.9.1 This verifies the high voltage proximity alarm activates with possible electrical field deflection from the test electrical post.

8.9.2 Approach the power line perpendicular to the post No. 2 (see Fig. 11). Test the deflection of the E-field due to the proximity of the test electrical post. Post #2 is chosen for testing due to it simulating a realistic scenario for equipment. The alarm system is tested at line height and half line height, double the line height, and the proximity alarm system is recalibrated for the three different test levels. For in-depth procedure see 10.14.

8.9.3 *Condition for Passing*—To pass, the high voltage proximity alarm must:

8.9.3.1 Have two distinctly different modes of alarm, providing at least two of the following: visual, audible, or *function kick out system* for closely coupled and non-closely coupled boom apparatus.

8.9.3.2 Activate within 2 % of the test distance calculated.

9. Apparatus

9.1 *List of Test Laboratory Apparatus*—The testing apparatus suggested are used for scaled testing. If the testing facility has the capacity, the apparatus could be altered to better simulate actual overhead power line scenarios with considerations from 9.1.9.

Apparatus	Quantity
High voltage proximity alarm	1
Test electrical posts	3
Transformer stand	1
Screws	as required
Insulated power line apparatus	1
5 ft boom apparatus	1
10 ft boom apparatus	1
Test distance guide	as required
Transformer	1
Measuring tape	1
Liquid tight (metal) or metal conduit	as required

Dimensional tolerance: ±2 %.

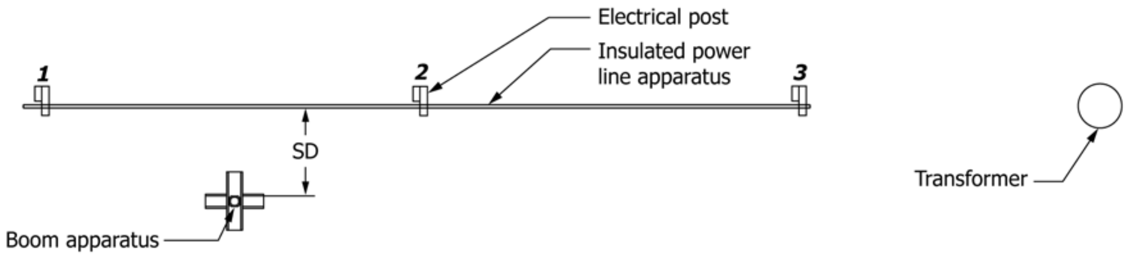

FIG. 6 Layout used for Saturation Test

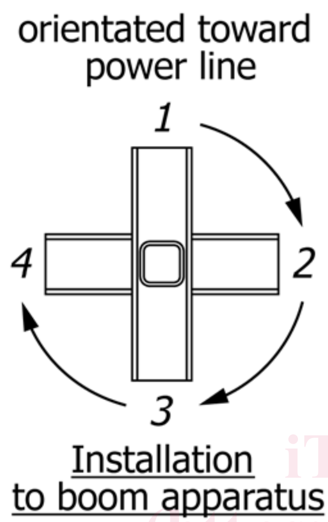

FIG. 7 Four Positions for Testing Shadowing Effects

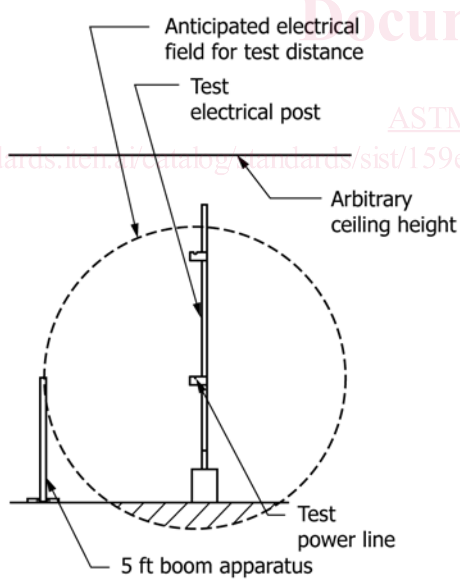

FIG. 8 Degradation to Electrical Due to Ground

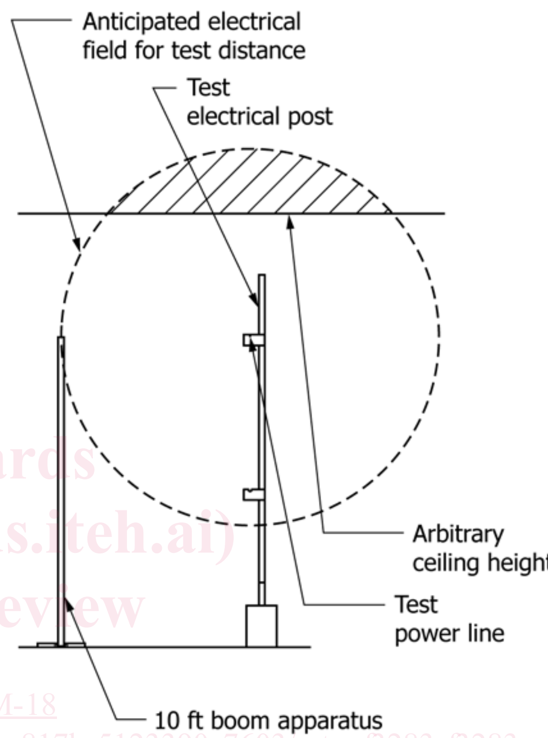

FIG. 9 Degradation to E-field Due to Ceiling

9.1.1 *High Voltage Proximity Alarms* being tested will indicate the information differently dependent upon the manufacturer of the product.

9.1.2 *Test Electrical Posts,* made with SPF (spruce, pine, or fur) and a sturdy support base to ensure stability of the testing apparatus. The electrical post detail allows for easier access to alter the height of the power line apparatus. (See Fig. 12.)

9.1.3 *Test Transformer Stand,* made form SPF (spruce, pine, or fir) and a sturdy support base to ensure stability of the testing apparatus. Other equipment may be used to replace the typical test transformer stand ensuring the transformer is isolated from the ground plane. (See Fig. 13.)

9.1.4 *Insulated Power Line Apparatus* consisting of:

(a) 28 ft of 600 V awg insulated wire (7 strand recommended).**Warning—**Voltage rating of the wire is below the test voltage and may cause electrical shock.

(b) 22 ft of 1 in. PVC tubing.

(c) PVC joiner.

(d) Plastic end cap.

(e) Plastic strain relief.

(f) Pressure connector.

(g) PVC glue.

9.1.4.1 Due to work in close proximity to high voltage lines, the PVC tubing insulating the power line apparatus is required to protect the personnel testing the high voltage proximity alarm. PVC joiner and PVC glue is used as required. Pressure connector is used at the other end of the 600 V 10 awg insulated wire. (See Fig. 14.)