

Case Study

Electrical Protection & Grounding

United Illuminating Hqs. Facility

Orange, Connecticut



PEG Northbrook, IL 2019

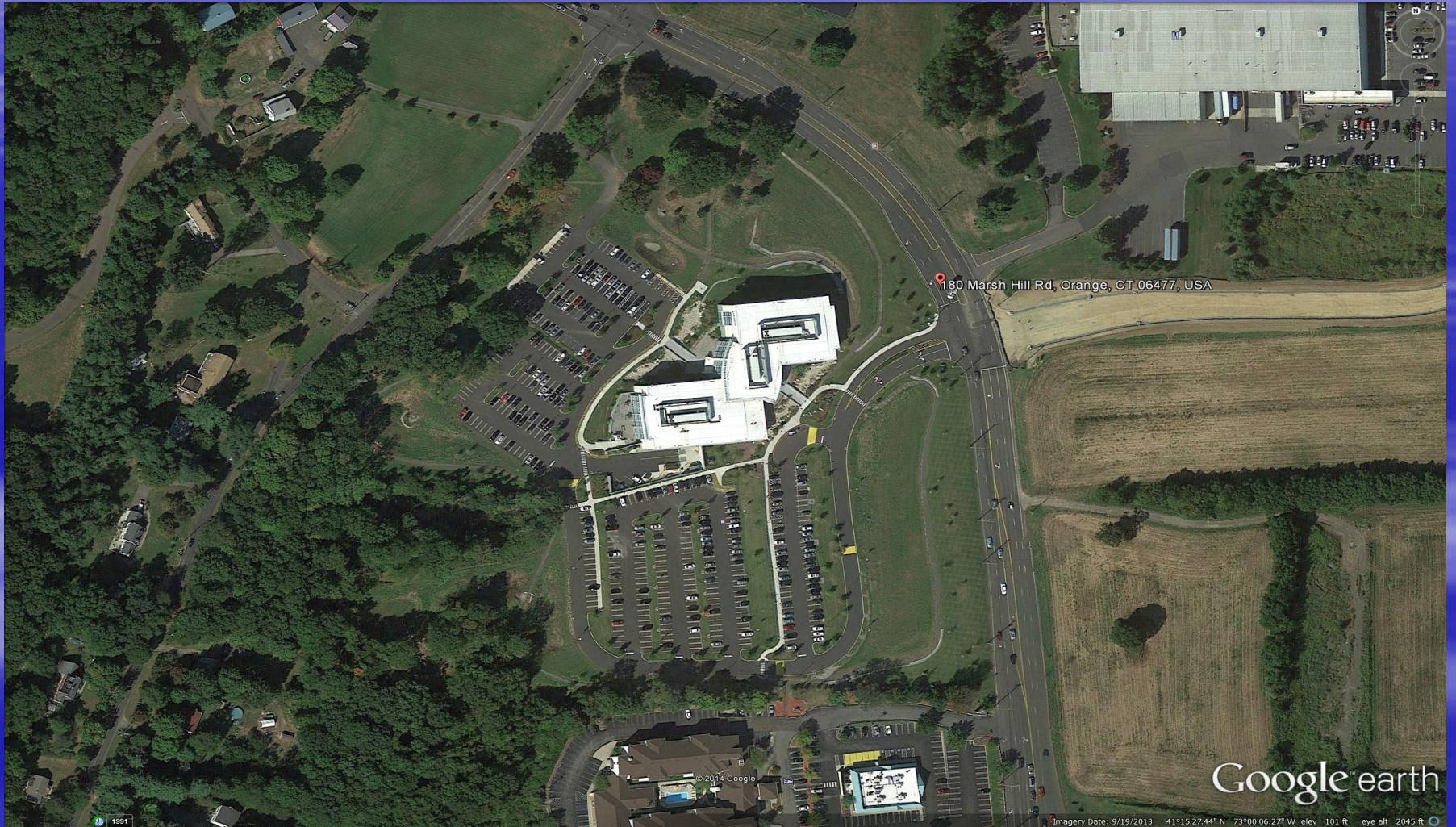
Ernest M. Duckworth Jr., P.E.

President/LPGI & Affiliates

March 6, 2019

United Illuminating Facility

Orange, CT June 2014



180 Marsh Hill Rd, Orange, CT 06477, USA

Google earth

Imagery Date: 9/19/2013 41°15'27.44" N 73°00'06.27" W elev 101 ft eye alt 2045 ft

Study Purpose:

Review the existing lightning installation design and stability for intended purpose. Conduct a site survey to determine lightning installation performance and provide test procedures for measuring grounding system resistance to remote earth.

- Executive Summary: It was reported that on July 11, 2013 at 07:47 EDT a lightning strike occurred on or near the property of United Illuminating at 100 Marsh Hill Road in Orange Connecticut. A report by Black & Veatch indicated at least 23 different systems were damaged that had a total of at least 47 damaged components within those 23 systems.
- On June 25, 2014 a STRIKEnet report verified the presence of five (5) cloud-to-ground lightning strokes detected within one (1) mile of the property for the date of July 11, 2013. All five (5) lightning strokes occurred at 07:47:38 and were directly over the United Illuminating Campus Facility. Two (2) other strokes occurred approximately three (3) minutes earlier within one (1) mile plus of the facility at 07:44:12 and 07:45:33. See attached report from STRIKEnet.
- Three (3) lightning strokes that occurred directly over the radio tower location were very large in magnitude at -79.5 kA, -32.9 kA, and -19.6 kA and may have been hit by all three. There is almost a certainty that the radio tower was struck with one or more of these lightning strokes. Since the radio tower currently has no capacitive radial grounding system, to properly dissipate the lightning stroke energy, the entire stroke currents flowed directly toward the extensive campus facility's grounding system. Thus, the multiple direct lightning strokes to the radio tower energized the campus facility's entire grounding system several times and to a possible maximum magnitude of -79.5 kA.
- Per the existing campus facility grounding design drawings the ring grounding system for the Maintenance Building was theoretically calculated at approximately 0.897 ohms to remote earth, and the U shaped Parking facility was theoretically calculated at approximately 0.3907 ohms to remote earth. If the drawings accurately depict the current grounding installation, these grounding systems provide a very low resistance to remote earth.

Claim or Reference #: UNITED ILLUMINATING RADIO TOWER
Insured/Property Owner:
STRIKE^{net} Report #: 169005
Address: 100 MARSH HILL ROAD, ORANGE, CT
Latitude / Longitude: 41.253038 / -73.00241
Search Period: Wed, Jul 10, 2013 12:00 AM US EDT – Fri, Jul 12, 2013 11:59 PM US EDT
Search Radius: 1 mile(s)/2km

STRIKE^{net} verified the presence of 5 cloud-to-ground lightning strokes detected within 1 mile of the property for the dates inquired.

Thank you for using STRIKE^{net} to validate lightning. Your report was generated by Weather Fusion using data from Vaisala's National Lightning Detection Network[®] (NLDN), the most comprehensive lightning strike archive database in North America.

STRIKE^{net} lightning verification report data is provided by the National Lightning Detection Network (NLDN) and/or Environment Canada's Canadian Lightning Detection Network (CLDN)—operated by Vaisala. STRIKE^{net} is built upon 35 years of scientific heritage and is over 99% accurate at detecting the presence or absence of a lightning event within 5 miles of a U.S. property. Furthermore, NLDN is the most scientifically—referenced, reputable and accurate lightning network available, with lightning data back to 1989. For more information about STRIKE^{net} or the lightning data within the report, please visit Weather Fusion's website and frequently asked questions at <http://www.weatherfusion.com/about-us/faq>

If you have any questions about this report, or would like more information about Weather Fusion, please contact us at [888.929.4245](tel:888.929.4245) or sales@weatherfusion.com

Best Regards,



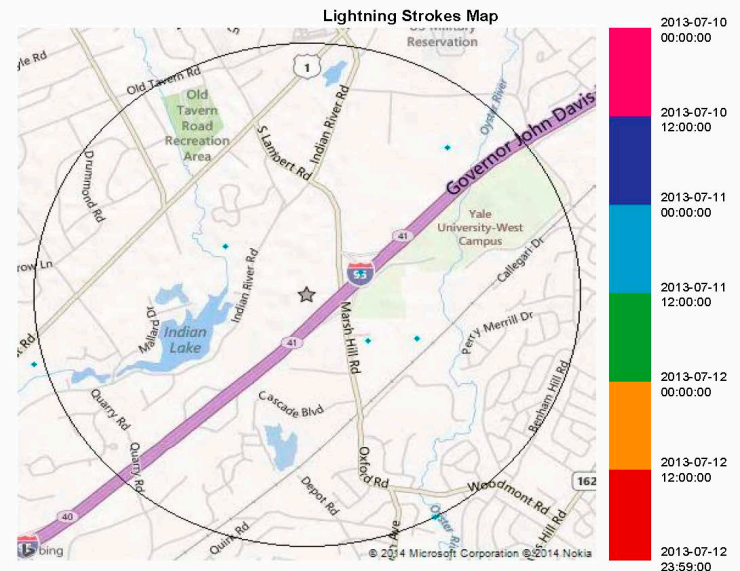
Weather Fusion, LLC
sales@weatherfusion.com
 888.929.4245
 2227 W. Lindsey St., Suite 1213
 Norman, OK 73069

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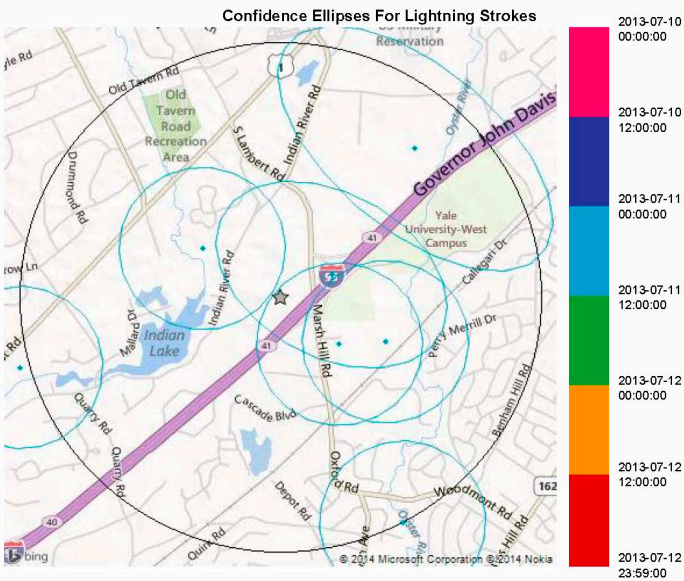


Lightning Strokes Detected within 1 mile(s)/2km: 5

Lightning Strokes between...

Wed, Jul 10, 2013 12:00 AM US EDT to Wed, Jul 10, 2013 12:00 PM US EDT:	0
Wed, Jul 10, 2013 12:00 PM US EDT to Thu, Jul 11, 2013 12:00 AM US EDT:	0
Thu, Jul 11, 2013 12:00 AM US EDT to Thu, Jul 11, 2013 12:00 PM US EDT:	5
Thu, Jul 11, 2013 12:00 PM US EDT to Fri, Jul 12, 2013 12:00 AM US EDT:	0
Fri, Jul 12, 2013 12:00 AM US EDT to Fri, Jul 12, 2013 12:00 PM US EDT:	0
Fri, Jul 12, 2013 12:00 PM US EDT to Fri, Jul 12, 2013 11:59 PM US EDT:	0

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Lightning Confidence Ellipse Map indicates with 99% certainty that the recorded lightning event contacted the ground within the bounds of the ellipse.

Lightning Stroke Table (50 closest strokes)

Date	Time	Peak Current (kA)	Distance From Center (mi/km)	Latitude	Longitude
Jul 11, 2013	07:47:38	-15.7	0.2/0.3	41.25428	-72.99861
Jul 11, 2013	07:47:38	-32.9	0.3/0.5	41.25034	-72.99804
Jul 11, 2013	07:47:38	-19.6	0.4/0.6	41.25577	-73.00814
Jul 11, 2013	07:47:38	-79.5	0.4/0.7	41.25047	-72.99464
Jul 11, 2013	07:47:38	-7.3	0.8/1.3	41.26146	-72.99245
Jul 11, 2013	07:44:12	-17.2	1/1.6	41.24024	-72.99337
Jul 11, 2013	07:45:33	-17.3	1/1.7	41.24902	-73.02161

Claim or Reference #: UNITED ILLUMINATING RADIO TOWER SECOND REPORT
Insured/Property Owner: PROJECT REPORT RTKL 00-13028.06 LPGI & AFFILIATES CONSULTANTS
STRIKE^{net} Report #: 172094
Address: 100 MARSH HILL ROAD, ORANGE, CT
Latitude / Longitude: 41.253038 / -73.00241
Search Period: Fri, Jan 10, 2014 12:00 AM US EST – Sun, Jan 12, 2014 11:59 PM US EST
Search Radius: 1 mile(s)/2km

STRIKE^{net} verified the presence of 3 cloud-to-ground lightning strokes detected within 1 mile of the property for the dates inquired.

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If you have any questions about this report, or would like more information about Weather Fusion, please contact us at [888.929.4245](tel:888.929.4245) or sales@weatherfusion.com

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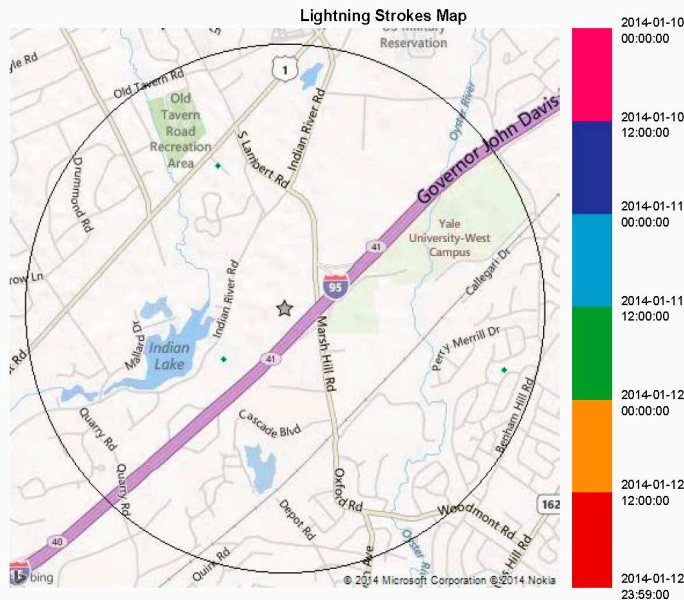
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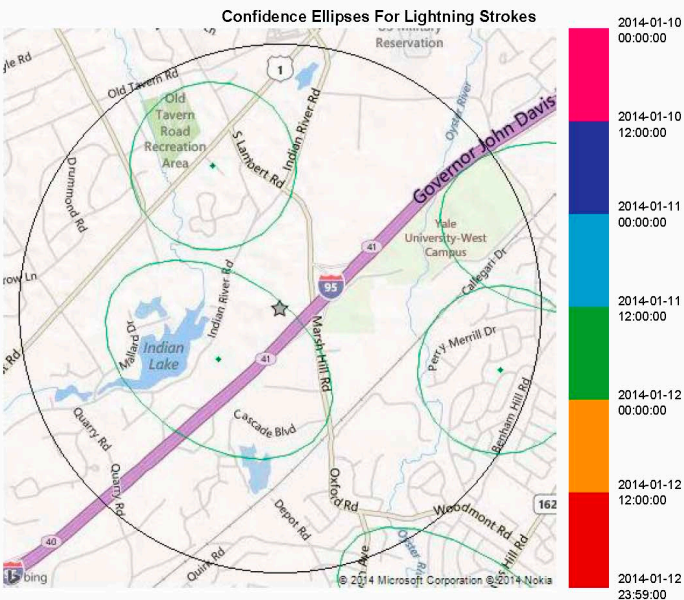


Lightning Strokes Detected within 1 mile(s)/2km: 3

Lightning Strokes between...

Fri, Jan 10, 2014 12:00 AM US EST to Fri, Jan 10, 2014 12:00 PM US EST:	0
Fri, Jan 10, 2014 12:00 PM US EST to Sat, Jan 11, 2014 12:00 AM US EST:	0
Sat, Jan 11, 2014 12:00 AM US EST to Sat, Jan 11, 2014 12:00 PM US EST:	0
Sat, Jan 11, 2014 12:00 PM US EST to Sun, Jan 12, 2014 12:00 AM US EST:	3
Sun, Jan 12, 2014 12:00 AM US EST to Sun, Jan 12, 2014 12:00 PM US EST:	0
Sun, Jan 12, 2014 12:00 PM US EST to Sun, Jan 12, 2014 11:59 PM US EST:	0

Claim or Reference #: UNITED ILLUMINATING RADIO TOWER SECOND REPORT
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Lightning Confidence Ellipse Map indicates with 99% certainty that the recorded lightning event contacted the ground within the bounds of the ellipse.

Lightning Stroke Table (50 closest strokes)

Date	Time	Peak Current (kA)	Distance From Center (mi/km)	Latitude	Longitude
Jan 11, 2014	14:00:32	-10.8	0.3/0.5	41.25021	-73.00689
Jan 11, 2014	14:00:32	-94.4	0.6/1	41.2608	-73.00732
Jan 11, 2014	14:00:32	-20.5	0.9/1.4	41.24964	-72.98861
Jan 11, 2014	14:01:18	18.8	1.1/1.8	41.25741	-72.98143
Jan 11, 2014	14:00:32	-9.8	1.5/2.4	41.23424	-72.98781

REVIEW OF EXISTING LIGHTNING INSTALLATION DESIGN AND STABILITY FOR INTENDED PURPOSE

■ DOCUMENTS PROVIDED FOR REVIEW:

- 1. Whiting-Turner / 01/10/2011 partial Submittal Transmittal is to provide a Lightning Protection System and uses parts manufactured by Independent Protection Co., Inc. of Goshen, IN / Project # 12850-100 / Installing company: Morse-Collins Inc., Auburn, NY
- 2. Black & Veatch / 03//05/2014 Protection Study / Project #180937
- 3. UL Master Label Certificate of Inspection / 03/30/2014 for Lightning Protection Systems / for the Office Bldg., Operations Bldg., Maintenance Bldg. & Covered Truck Parking / Certificate # B1C6-0C9F14
- 4. ACME Lightning Rod Co. / LPI Certified Master Designer Inspection (1074) 04/28/2014
- Black and Veatch (BV) provided general lightning protection recommendations for tower and campus grounding systems by referring to Motorola's R56 and IEEE 1692. The more up-to-date Motorola R56B, "Standards and Guidelines for Communications Sites" 09/01/2005 is recommended in place of the R56 for the protection of the tower cables, ground window, single point ground (SPG), and bonding of the ground rings. Their reference to IEEE Std. 1692-2011 is their most valuable recommendation which is much more recent than the R56 reference, and IEEE Std. 1692 is a more thorough treatise on the electrical protection of equipment from Lightning induced Ground Potential Rise (GPR).
- IEEE Std. 1692-2011 is the most current documentation available today and is a must reference to follow in order to mitigate lightning damage to equipment. A Lightning Protection System Installation using only NFPA 780-2012 per the scope only addresses the traditional lightning protection of ordinary structures, etc. The scope of NFPA 780 does not include towers or the protection of equipment within the structures. Nor does NFPA 780 or R56 even consider the devastating effects of lightning induced GPR and the recommended methods of minimizing its effects.
- Their project task recommendations have merit with exceptions, but are not very specific and require additional documentation providing detailed methods of what products to use and how to place a radial grounding system for the radio tower to adequately dissipate lightning strikes away from the facility's grounding systems.
- Surge protection is very lacking at this facility on most of the electrical systems as outlined by BV. Their recommendations should be followed with the recommendation that all surge protection devices incorporate Silicon Avalanche Diode (SAD) technology.
- Roof lightning protection must be corrected as outlined by BV. The current installation will result in possible arching from a lightning strike and a possible fire to the roof.
- BV recommendation for lightning masts to protect the generators from a direct lightning strike is not necessary. These generators are well protected under the cone of protection by the radio tower and adjacent buildings.

Continuation of DOCUMENTS PROVIDED FOR REVIEW:

- The installation of a lightning detection system for the radio tower in an attempt to minimize lightning strike currents from entering the facility's grounding system is not realistic and would be cost prohibitive. The solution is a well-designed capacitive radial grounding system and opening the bonds between the radio tower & building from the facility grounding. Physically moving the radio tower, with its capacitive radial grounding system directed away from the campus facility, is the best solution to minimize lightning strike energy from directly coupling on to the facility's grounding system. The campus facility's grounding system would then only experience a lightning induced Ground Potential Rise (GPR) from a near by strike.
- UL Master Label Certification found that the Grounding Systems for all of the United Illuminating sites complied with UL96A with the exception that the communication surge protection requirement per paragraph 13.2 was totally omitted for this Master Label Certification. Notwithstanding that UL96A, paragraph 13.2 is so vague that its recommendation for surge protection of equipment is practically nonexistent, not following the requirement of electrically protecting equipment and power supply for lightning surge as well as lightning induced GPR, violates the UL Master Label Certification. The question raised here is: why was surge protection omitted from the Lightning Protection Installation design and thus omitted from the inspection? This alone would negate a UL Master Label Certification.
- UL Master Label Certification should never have been issued, because the current roof installation for the United Illuminating Campus Facility fails UL96A and NFPA 780 cable and down conductor placement requirements.
- ACME Lightning Rod Co focused their inspection entirely on the roof lightning protection system that attempts to direct a lightning strike to the structure's earth grounding system. They did not consider the electrical protection of any equipment from either a lightning surge or a lightning induced GPR event.
- Their inspection addressed issues that they consider pertinent concerning conductor runs, clamping, roof penetrations, bonding the building steel, etc. Their described issues were vague and would require specific evaluation by conducting continuity testing of the roof's conductors and air terminals. They also noted that some roof elements (items) were installed after the lightning protection system was completed, and thus not properly bonded to the lightning protection system.
- Thus, their inspection report disagrees with the UL Master Label Certification that this facility's Lightning Protection System has passed NFPA 780-2012 and has a clean-bill-of-health. Acme's reported issues concerning bonding connections on the roof, clamp issues and the building ring grounding system may be tested with a piece of test gear similar to a Megger-DET 14C – Digital Earth Clamp. This Digital Earth Clamp will quickly determine conductor continuity among other uses.

SITE SURVEY DETERMINING LIGHTNING INSTALLATION PERFORMANCE

- Lightning installation performance at the United Illuminating Campus Facility is poor and will sustain significant equipment damage, throughout the campus facility, every time lightning strikes the radio tower. The possible damage from a lightning strike directly to the campus facility buildings, instead of the tower, will be less significant, because of a smaller more distributed surge being able to enter the facility campus ground.

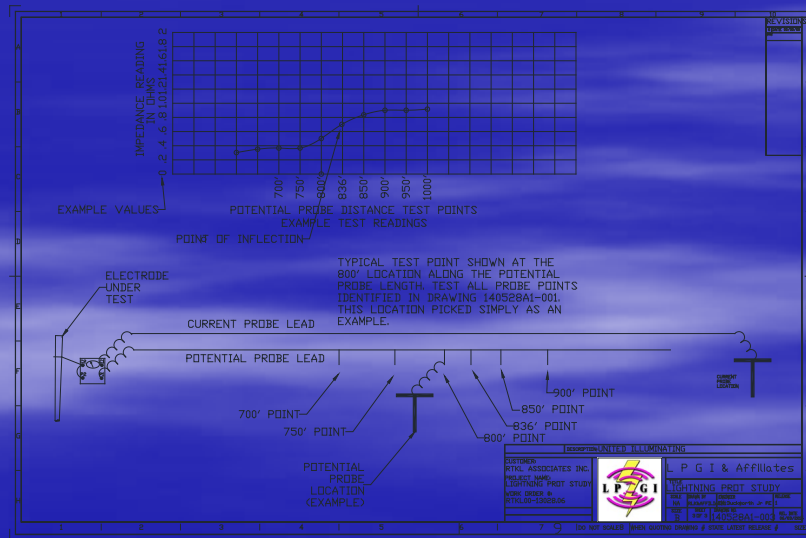
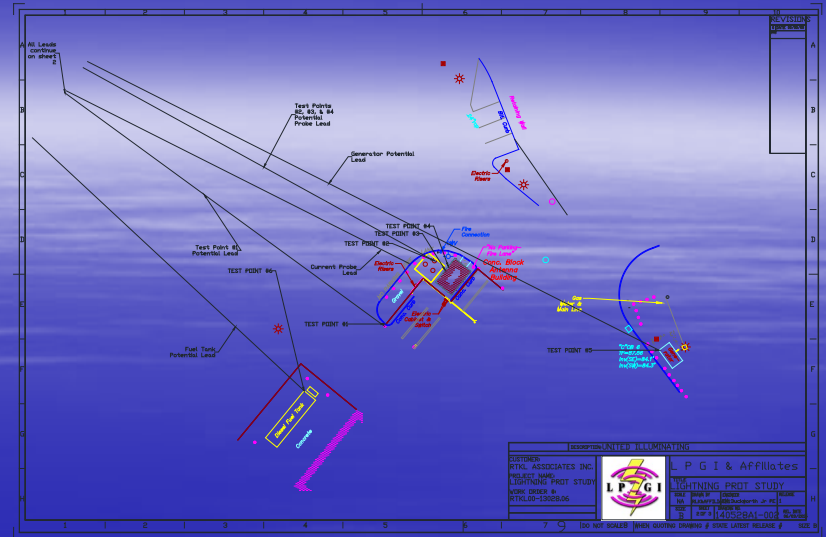
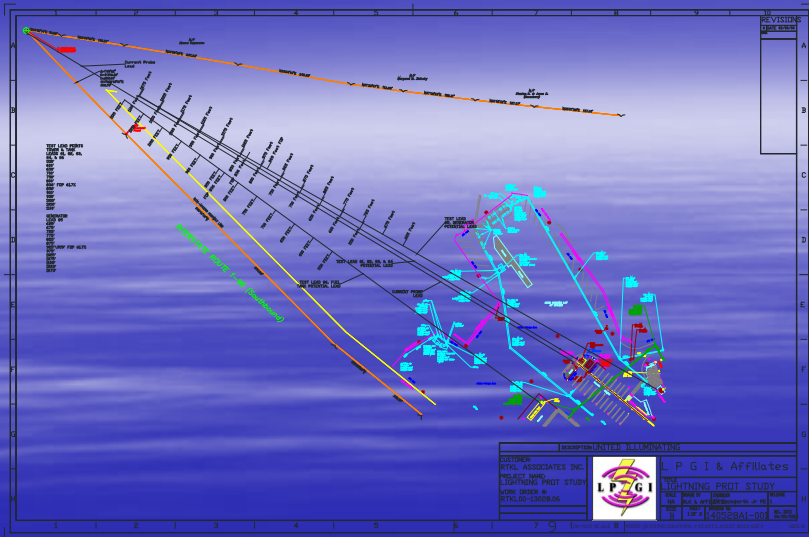
- **The reasons are as follows:**
 - 1. Radio tower has no capacitive radial grounding system required to minimize radio tower GPR and direct currents away from the campus facility grounding system.
 - 2. Radio tower and equipment building may not have a Single Point Ground (SPG)
 - 3. Radio tower's Halo Ground required to minimize the electro magnetic field within the building is not a complete closed circle. Note: it has been cut open and only an equipment ground (IERG) is to be left open at one end.
- **Other issues were noted that require correction.**
 - 4. Radio tower is bonded into the entire campus facility grounding system resulting in the entire magnitude of a lightning strike current flowing throughout the entire campus facility. This is the most significant problem with campus facility equipment damage.
 - 5. A significant lack of AC Power surge current protection throughout the campus facility. No existing surge current protection equipment uses SAD technology on any ac power services either main or subpanels.
 - 6. No surge current protection devices on control circuits using SAD technology
 - 7. No surge current protection devices on guard entry pads, gates, video cameras, etc.
 - 8. No surge current protection devices on video camera equipment power or coaxial cable in the parking facilities.
 - 9. No SAD surge protection on the five generators or their control circuits.

TEST PROCEDURES FOR MEASURING GROUNDING SYSTEM RESISTANCE TO REMOTE EARTH

- IEEE Standard 81-2012, "Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System" provides the only incorporated method of determining the resistance of a 'Grounding System' to remote ground (earth). This method is called the 'FALL OF POTENTIAL' three point method and is found in paragraph 8.2.2.2.
- There is another method that has been developed by LPGI & Affiliates that is much less involved and capable of being applied at this location, but requires that the grounding system design and installation be well known. However, please take note that the three point 'Fall of Potential' method is the only method currently recognized and incorporated in an IEEE Standard.
- The three point fall of potential method requires two very long probe wires (current and voltage probe) and one short grounding electrode probe. The voltage and current probe need to be 5 to 7 times the length of the diagonal distance of the area of the grounding (electrode) system under test. Distances less than 5 times the size of the testing electrode may not be far enough to be out of the influence of the electrode under test. In addition, all AC Power Multi Ground Neutrals (MGN) must be disconnected as well as large communication ground copper conductor shields. Not removing MGN will provide a lower resistance of the electrode under test to remote earth.
- In theory the grounding system under test should look like an "ISOLATED ISLAND" that is not in contact with the rest of the world whatsoever. This isolated grounding system under test will provide an ideal value of resistance to remote earth by conducting a three point fall of potential test per IEEE Std. 81.
- Existing large working facilities may not be able to accommodate this isolation requirement necessary to properly conduct an accurate three point fall of potential test, because it may be totally unworkable and virtually impossible to disconnect all AC Power MGN to the facility as well as any other conductors that bond the facility to distant locations. Thus the resulting resistance of the electrode under test may be lower than what it may actually be.
- Please follow the attached AutoCAD Drawings to complete the 'fall of potential' test method outlined in IEEE Std. 81-2012. If the voltage probe falls within a pond, it may be located to the right or left, but still maintaining the distance to the electrode under test. Also voltage probe distances may be adjusted 10 feet as a deviation from the values provided, except for the one measurement that is 61.7% of the total current probe length. This one measurement should be as close as possible to the current probe length of the six test measurements.
- The objective is to develop a graph, for each test point, as described in IEEE Std. 81 that shows the point of inflection. If a curve does not provide this classic inflection point then we were unable to provide a current probe far enough to be out of the influence of the electrode under test.

TEST LOCATIONS





One sample picture of many showing a bad installation on roof

PIC # 53



